THE HENRY L.
STIMSON CENTER

Space Assurance or Space Dominance?

THE CASE AGAINST WEAPONIZING SPACE

Michael Krepon with Christopher Clary

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Foreword

I am pleased to present the latest publication of the Henry L. Stimson Center, *Space Assurance or Space Dominance? The Case Against Weaponizing Space*. This study examines the outer frontiers of national security policy, where technology and grand strategy meet. As the study explains, space is yet another arena where the United States is the preeminent international player, and that status gives the United States unique opportunities and unique responsibilities. The study focuses primarily on weighing the costs and benefits of weaponizing space, and examines models and concepts from historic arms control that may be useful in managing this challenge. The report proposes useful steps that the United States and the international community can take to avoid the weaponization of space while continuing to utilize space for some military purposes, such as support for deployed troops. This path also facilitates the commercial and economic uses of space.

The Stimson Center's project was careful to consult with a diverse range of experts whose interests were not limited to military issues, since the policy process has to address the competing demands and the multiple constituencies for further development of space.

This study should be seen in the larger context of the enduring commitment of the Stimson Center to examine national and international security issues and to search for achievable policies that reduce the threats from weapons of mass destruction. It complements other works by Michael Krepon, leader of this project and founding president of the Stimson Center, on arms control and cooperative threat reduction.

I want to express my gratitude to the John D. and Catherine T. MacArthur Foundation for supporting this important project. I will welcome hearing from you if you have any questions about this report or about the Stimson Center.

Ellen Laipson
President and CEO
The Henry L. Stimson Center

Abbreviations

ABM	antiballistic missile
ASAT	antisatellite
BWC	Biological Weapons Convention
CD	Conference on Disarmament
CFE	Conventional Armed Forces in Europe Treaty
CWC	Chemical Weapons Convention
DSP	Defense Support Program
EMP	electromagnetic pulse
GEO	geosynchronous orbit
GPS	Global Positioning System
HALEOS	high altitude nuclear detonations against low earth orbit satellites
HAND	high altitude nuclear detonations
IADC	Interagency Space Debris Coordination Committee
ICBM	intercontinental ballistic missile
IncSea	incidents at sea
INF	intermediate-range nuclear forces
ITU	International Telecommunications Union
KE-ASAT	Kinetic Energy Antisatellite
LEO	low earth orbit
LTBT	Limited Test Ban Treaty
MEO	middle earth orbit
MIRACL	Mid-Infrared Advanced Chemical Laser
NASA	National Aeronautics and Space Administration
NTM	national technical means
PDMA	Prevention of Dangerous Military Activities Agreement
PLNS	pre- and post-launch notification system
SALT	Strategic Arms Limitation Talks
SAR	synthetic aperture radar
SLBM	submarine-launched ballistic missile
START	Strategic Arms Reduction Talks
TREE	transient radiation effects on electronics
WMD	weapons of mass destruction

Introduction

The Henry L. Stimson Center convened a series of workshops from April 2002 to February 2003 to explore issues relating to the weaponization of space. We engaged individuals with diverse backgrounds who shared three essential traits: intellectual curiosity, a creative as well as conceptual approach toward problem-solving, and a keen interest in public policy issues relating to space. The following individuals participated in one or more of our workshop discussions: Victor Alessi, Bruce DeBlois, William Durch, Steven Fetter, Charles Ferguson, Peter Hays, Theresa Hitchens, Richard Kessler, Ellen Laipson, Michael Levi, Edward Levine, John Logsdon, Matthew McKinzie, David Mosher, Karl Mueller, Douglas Necessary, Janne Nolan, Michael O'Hanlon, Alan Shaw, Paul Stares, Sherri Stephan, and Peter Zimmerman. These experts participated in an individual capacity, not as representatives of their home institutions or work places. While this effort was underway, the Council on Foreign Relations convened the Study Group on Space Posture for the 21st Century. These deliberations were chaired by Daniel Goldin and guided by Richard Garwin and Bruce DeBlois. The author participated in these discussions and benefited greatly from them.

This monograph draws heavily from and synthesizes working group discussions. Working group participants were not asked to endorse the analysis and conclusions of this monograph, which was written by Michael Krepon, with substantial research and drafting help from Christopher Clary.

Significant inputs to this monograph were provided by Theresa Hitchens, Michael O'Hanlon, Alan Shaw, and Peter Zimmerman. Bruce DeBlois, Rebecca Johnson, Peter Hays, Michael Levi, Jeffrey Lewis, Janne Nolan, and Brad Roberts each reviewed parts of the manuscript and provided helpful comments. Dean Wilkening reviewed the entire manuscript. Because this monograph synthesizes working group deliberations, the views presented here should not be construed as reflecting those of every participant in every respect. Workshop participants might differ on matters of emphasis, and might hold contrary views on some specific points of analysis and recommendations. Any errors that remain in the text are the sole responsibility of the author.

Our workshop deliberations began by comparing current and prospective issues relating to military space policy with the Cold War era. How have these issues changed with the demise of the Soviet Union? Are there still common elements of analysis? What did we mean by space "weaponization" back then, and what do we mean by weaponization today? Is there less or more of a need to weaponize space in an era marked by concerns over asymmetric warfare and terrorism? We then asked whether the weaponization of space was inevitable and, if not, whether it was advisable. These discussions are reflected in Chapters 1 and 2.

We then moved to a discussion of the military-related measures required to increase satellite survivability and to reduce U.S. vulnerabilities in space. There was widespread agreement on measures of a defensive nature, which are described in Chapter 3. Chapter 4 discusses cooperative measures that might well be pursued to reduce threats to satellites and to provide greater assurance to those who currently depend on space assets.

This monograph reaches the following conclusions: First, the weaponization of space is not inevitable. Second, it would not be in the national security or economic interest of the United States to initiate the flight-testing or deployment of space weaponry, since the United States has far more to lose than to gain in the event that space becomes weaponized. Third, far weaker states would also be penalized by the weaponization of space, as the complications to U.S. war-fighting capabilities that would result from space weaponization would not change the outcome, nor lessen the severity, of combat with the United States. Fourth, the initiation of space warfare could trigger dangerous escalatory steps. Fifth, compelling reasons have not yet been advanced for the flight-testing and deployment of space weaponry, especially when the enhancement of terrestrial U.S. war-fighting capabilities by other means are more cost-effective and are more readily available, while posing far fewer downside risks.

The only compelling reason envisioned in this monograph for the United States to flight-test and deploy space weaponry in the foreseeable future is if another state were to cross these key thresholds first. In order to avoid being disadvantaged by the flight-testing and deployment of space weaponry by another country and to enhance deterrence against these unwelcome developments, this monograph proposes a hedging strategy. The U.S. ability to compete in this realm, and to compete effectively, could help persuade weaker states not to initiate the flight-testing and deployment of space weaponry. Further reinforcement of these thresholds could be provided by agreements to avoid dangerous military practices in space and other “rules of the road,” as well as by formal treaty instruments. The reasoning behind, and the elaboration of, these recommendations can be found in Chapters 3 and 4.

Space is already “militarized,” in the sense that satellites provide military support to the armed forces of several countries. Many military and civilian capabilities that have been designed for other purposes could also be applied to space warfare. These “residual” or latent capabilities have long existed. They have not prompted an "arms race" in space during the Cold War. Indeed, these latent capabilities to damage satellites might have attributed to diminished pressures to flight-test and deploy more advanced, "dedicated" means of space combat.

The distinction between the militarization and the weaponization of space has held for four perilous decades. It remains in the national security interest of the United States to reinforce this distinction in far different, but no less dangerous, times. This is because the United States utilizes space for military and commercial purposes far more than any other country and because weaker nations can readily master the techniques of space weaponry. The United States has unparalleled leverage to shape the choices of other states with regard to space warfare. If the United States leads the way in flight-testing and deploying space weaponry, other states will surely follow. Alternatively, U.S. restraint could reinforce prudence by others, given the ability of the United States to compete effectively in this realm.

The elements of the space policy advocated here for the United States might be called a "space assurance" posture, terminology borrowed from workshop participant Douglas Necessary. Space assurance, unlike space dominance, holds the promise that the weaponization of space can be avoided. Space dominance leads inevitably to weaponization, with all its attendant risks. Space weaponization is not a virtual certainty. If it were, this would have already occurred during the Cold War. At the same time, a space assurance regime is anything but a virtual certainty. The creation of a space assurance regime depends heavily, but not solely, on U.S. choices.

Space assurance, unlike space dominance, provides an environment better suited for commercial gain and scientific discovery. Space assurance increases the probability of the continued, unencumbered utilization of space to assist terrestrial U.S. military operations. In contrast, efforts to dominate space will likely elevate into the heavens the hair-trigger environment that plagued the superpowers during the Cold War. Space assurance requires steps to improve "situational awareness" in space, so that troubling developments or anomalous events can be discovered quickly. A space assurance posture requires new initiatives to lessen U.S. vulnerabilities in space or at ground stations servicing space assets. A good defense in space does not require going on the offense.

To help persuade other states not to cross flight-testing and deployment thresholds first, a hedging strategy against space warfare capabilities or unpleasant surprises is advisable. Laboratory research and development programs on space warfare are consistent with a space assurance posture and a hedging strategy. These activities are presumably being carried out elsewhere, and are not likely to be subjected to intrusive monitoring. The well-grounded presumption that these activities are underway in the United States could help reinforce caution by other states against moving these activities outside the laboratory and into flight-testing.

The space policy programming of the Stimson Center has been made possible by a generous grant from the John D. and Catherine T. MacArthur Foundation. The Stimson Center is grateful to Jonathan Fanton, Mitchel Wallerstein, Kennette Benedict and Lukas Haynes for their support of this effort. Thanks also go to Geoff Brown, Min Lee, Yu Sasaki, and Aaron Wessells for their help in editing this volume and to Jake Lefebure and Jane Dorsey for their help with the cover design.

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From Cold War to Asymmetric Warfare

A quarter-century ago, calculations regarding the weaponization of space were necessarily framed by the Cold War. Assessments of potential benefits and risks associated with space weaponry were inseparable from ongoing strategic modernization and nuclear arms control negotiations. These linkages reinforced a cautious approach to flight-testing and deploying antisatellite (ASAT) weapons.

By the late 1970s, the technologies necessary for space launch and utilization were reasonably mature. Men had orbited the Earth and had been to the moon. Deep space probes had been launched. Approximately 150 satellites were circling the earth. Many provided strategic reconnaissance and military communications.[1] Almost all of this activity was carried out by the United States and the Soviet Union. Most of these space applications were for military purposes. Because these activities were deemed vital to national security, they were shrouded in secrecy. Some vital military-related missions were unique to space. Global navigation, ballistic missile launch detection, and, most importantly, observation of Soviet strategic forces would have been impossible or extremely risky without space assets. Governments also pursued some civil space programs, and there were a few commercial, or quasi-commercial, activities on-orbit. Space launch was exclusively a government activity.

A quarter-century ago, the U.S. government was concerned about the flight-testing and potential deployment of a Soviet co-orbital interceptor that could destroy satellites. The Pentagon was examining more advanced ASAT weapon designs to replace the rudimentary, nuclear-armed systems previously deployed and subsequently mothballed. Military strategists focusing on space were beginning to explore concepts of space denial and space defense. The conjunction of resumed Soviet ASAT tests and on-going strategic arms control talks sparked a debate within government and academia over whether it was better to engage the Kremlin in a space arms race or to reach an agreement not to pursue certain ASAT activities. Treaty constraints prohibited the stationing of weapons of mass destruction (WMD) in orbit, testing nuclear weapons in

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[1] Several excellent histories of space programs have been written, including Paul B. Stares, *The Militarization of Space: U.S. Policy, 1945–1984* (Ithaca, NY: Cornell University Press, 1985); and Walter McDougall, *…the Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985).

space, flight-testing and deploying space-based missile defense interceptors, and interfering with satellites used as "national technical means" for monitoring strategic arms control accords. However, many lacunae remained that could be filled with space weaponry, and both superpowers clearly understood that, in the event of a strategic conflict, space would not be exempt from acts of warfare. The key roles that satellites played—facilitating intelligence collection, command and control, and early warning of nuclear attack, to name a few—would also make them lucrative targets during any superpower conflict. In such an event, escalation control would likely become exceedingly difficult if satellites were attacked.

To avoid the uncertainties attending to space warfare, a quarter-century ago President Jimmy Carter decided to pursue negotiations with the Soviet Union for the purpose of "limiting certain activities directed against space objects." At the same time, the Carter administration decided to develop advanced, air-launched ASAT technologies, both to hedge against threatening Soviet activities and to provide a compelling incentive for the Kremlin to avoid a space arms race.[2] President Carter concluded that "verifiable, comprehensive limits on antisatellite capabilities" were in the U.S. national security interest, but this outcome was not universally welcomed within the executive branch. Nor was it easily negotiated. Indeed, the broader the scope of constraints against space weaponization, the harder it was to conceive of adequate verification. And the harder it was to monitor compliance with proposed bans, the more skeptics were drawn to safeguards that undermined the principle of space as a weapons-free zone.

Internal debates within the Carter administration did not yield a consensus on the best negotiating course to adopt, or even the desired outcome of negotiations, when preliminary talks with the Soviet Union began in 1978. When the negotiations were halted after the Soviet invasion of Afghanistan one year later, little progress had been made in resolving these underlying interagency disputes. Basic questions of definition, scope, and verification were never satisfactorily resolved in the ASAT negotiations. Even the elementary task of finding a suitable way to determine ownership of a satellite was not a simple matter, since multinational involvement in satellite construction, launch,

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[2] White House Press Release, "Description of a Presidential Directive on National Space Policy" (June 20, 1978), quoted in Stares, *The Militarization of Space*, pp. 185–86. For the Carter administration's approach to ASAT talks, see John Wertheimer, "The Antisatellite Negotiations," in Albert Carnesale and Richard N. Haass (eds.), *Superpower Arms Control: Setting the Record Strait* (Cambridge, MA: Ballinger Publishers, 1987), pp. 139–163; Donald L. Hafner, "Verification of ASAT Arms Control," in Michael Krepon and Mary Umberger (eds.), *Verification and Compliance: A Problem-Solving Approach* (New York: St. Martin's Press, 1988), pp. 45–73; "Anti-Satellite (ASAT) Arms Control," in Committee on International Security and Arms Control, *Nuclear Arms Control, Background and Issues* (Washington, D.C.: National Academy Press, 1985), pp. 159–187; and Stares, *The Militarization of Space*, pp. 180–200.

and operation was already commonplace. U.S. and Soviet negotiators understood that a bilateral agreement would need to extend some form of "protection" to the satellites of third parties, but that a bilateral agreement could not impose obligations on other parties.

A quarter-century later, there are no ASAT negotiations. The Soviet Union has dissolved, and the United States has no peer competitor. U.S. civil and military space programs dwarf those of other states. The United States alone has 878 satellites in orbit; altogether there are 2,782 satellites circling the globe.[3] U.S. defense planners have greater latitude to consider space control and space denial concepts, especially in an administration that sees little worth in multilateral accords that constrain U.S. military options. No country can match advanced U.S. technology that could be applied to the weaponization of space. However, competitors that cannot challenge the United States technologically or economically would still have the means to counter U.S. initiatives with low-cost and low-tech means. The superpower competition that framed considerations of space warfare a quarter-century ago has now been replaced by calculations of asymmetric warfare—in space, as well as on the ground.

A quarter-century ago, U.S. strategists were anxious about a "bolt out of the blue" attack from Soviet ballistic missiles, missiles that could also be programmed to destroy satellites in low earth orbit, reinforcing concerns over a Soviet preemptive strike. Today, U.S. strategists are anxious about surprise attacks by terrorist groups using conventional explosives, or worse yet, using weapons of mass destruction in unconventional ways. The adversaries U.S. officials are most concerned about today are unlikely to possess space launch capabilities or to operate ASATs. However, even non-state actors are capable today of jamming, hacking, and spoofing[4] space operations that are poorly protected, as exemplified by the Falun Gong's reported interference with Chinese television broadcast satellites.[5] Unlike a quarter-century ago, when space launches were the domain of national governments, today private groups have access to space through commercial providers, sympathetic (or hard-currency needy) national governments, or multinational consortia.[6]

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[3] "2002 Space Almanac," *Air Force Magazine* (August 2002), p. 26.

[4] "Jamming involves the deliberate transmission of a competing signal at the same frequency as the target signal with the intent of interfering with its reception. Spoofing consists of the deliberate transmission of a signal that looks very much like the true target signal with the intent, not of interfering, but of deceiving the legitimate user." George Jelen, "Space System Vulnerabilities and Countermeasures," in William J. Durch (ed.), *National Interests and the Military Use of Space* (Cambridge, MA: Ballinger, 1984), p. 101.

[5] Joseph Kahn, "China Says Sect Is Broadcasting from Taiwan," *New York Times* (September 25, 2002).

[6] See Daniel Gonzales, *The Changing Role of the U.S. Military in Space* (Santa Monica, CA: RAND Corporation, 1999), pp. 1–18; Peter L. Hays, *United States Military Space Into the Twenty-First Century*, INSS Occasional Paper 42 (Maxwell AFB: Air University Press, September 2002), pp. 13–25, 33–39; Linda Haller and

During the Cold War, commercial activity in space was dwarfed by military applications. In the late 1990s, the number of commercial space launches began to exceed national security space missions.[7] In fiscal year 1978, the Pentagon proposed to spend $447 million on satellite procurement; the projection for FY1979 was $490 million.[8] In 2001, by comparison, $14 billion was spent on satellite manufacturing.[9] Twenty-five years ago, private sector space activities were largely confined to building equipment for government agencies. Today, satellites, launch vehicles, ground control stations, and other systems are built on a profit-making basis. Private companies provide launch services and satellite system operations. They own space systems that carry for-fee communication services, and collect imagery and other types of earth observation data.

Increasingly, governments and government agencies worldwide—including the Pentagon and the U.S. intelligence community—contract with private providers for services that a quarter-century ago were obtained by building, launching, and operating their own space systems. A government can (and many governments do) contract with one company to build a satellite, contract with another company to launch that satellite, and enlist yet another to operate the satellite. A government, corporation, or an individual with a credit card can now buy customized satellite imagery from a reseller who buys, collates, processes, and distributes remote-sensing data.[10] Communication services are obtained from companies that lease capacity on another company's satellites; the user may not necessarily be aware of how messages are being routed via space.

Melvin Sakazaki, *Commercial Space and United States National Security* (Washington, DC: Prepared for the Commission to Assess United States National Security Space Management and Organization, 2001); Barry Watts, *The Military Use of Space* (Washington, DC: Center for Strategic and Budgetary Assessments, 2001), pp. 65–73.

[7] Hays, *United States Military Space*, p. 21; also for two important surveys of space commercial activity, see Office of Space Commercialization, Department of Commerce, *Trends in Space Commerce*, prepared by the Futron Corporation (Washington, DC: June 2001) and Satellite Industry Assocation, *2001–2002 Satellite Industry Indicators Survey*, prepared by the Futron Corporation (Washington, DC: 2001).

[8] House Armed Services Committee, *Hearings on the Fiscal Year 1978 Defense Authorization Request*, pt. 2 (Washington, DC: GPO, 1978), p. 361.

[9] Satellite Industry Association, *2001–2002 Satellite Industry Indicators Survey*.

[10] See Yahya Dehqanzada and Ann Florini, *Secrets for Sale: How Commercial Satellite Imagery Will Change the World* (Washington, DC: Carnegie Endowment for International Peace, 2000) and Lt. Col. Larry Grundhauser, "Sentinels Rising: Commerical High-Resolution Satellite Imagery and Its Implications for US National Security," *Airpower Journal* 8, No. 4 (Winter 1998): 61–80. For the first assessment of the emerging security implications of the advent of improved commercial satellite imagery, see Michael Krepon, Peter D. Zimmerman, Leonard S. Spector, and Mary Umberger, *Commercial Observation Satellites and International Security* (New York: St. Martin's Press, 1990). For an examination of how the U.S. government can better utilize commercial imagery, see *The Information Edge: Imagery Intelligence and Geospatial Information in an Evolving National Security Environment* (Washington, DC: Final Report of the Independent Commission on the National Imagery and Mapping Agency, December 2000), pp. 55–60.

A quarter-century ago, the national character of space activities predominated. One market study predicted that total U.S. government spending in space would total $35 billion from FY1977 through FY1981.[11] In FY1978, the Pentagon procured five satellites and five boosters. The projected buy in FY1979 was seven of both.[12] Today, national governments have much company in space, including quasi-public corporations that include government shareholders, as well as private sector entrepreneurs who also depend, in part, on government business. In 2001 alone, space industry revenue was more than $85 billion, more than half of which came from commercial services. Not only is industry larger, it is more multinational. Today, a European firm, Arianespace, controls more than half of the commercial launch business, with U.S. firms a close second, followed by Russia. A substantial fraction of Russian space launches are conducted from a leased facility in Kazakhstan. Similarly, the European Space Agency's Ariane rockets launch satellites from a facility in French Guiana in South America.[13] National governments license private companies to conduct space-based business. Some of these companies are chartered "offshore" in unusual locales, to simplify partnerships or to avoid scrutiny, onerous regulations, or taxes. These arrangements complicate national efforts to control or regulate unwelcome activities.

A quarter-century ago, the word "globalization" was not in common usage. Today, globalization shapes business decisions and the basic structure of commercial activities related to space. As an expert working group on space traffic management noted:

> Many space objects and launch vehicles are now owned by private companies or international consortia, rather than by nations. Applying the UN treaties may be difficult in some cases, or the result of their application may be less than satisfactory. For example, if an Intelsat satellite is launched on a Sea Launch vehicle (Sea Launch is incorporated in the United States, owned by U.S., Ukrainian, Russian, and Norwegian companies, and is launched from a Norwegian-built platform registered in Liberia), it is unclear which 'launching state' should register the launch and who, as the 'launching state,' should be held liable in case of damage caused by the object launched. If the satellite is later sold to a Hong Kong company and subsequently causes damage to another satellite, the original 'launching state' may still be held liable, although there is no relationship between that state and the Hong Kong company. The issue may become even more complicated

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[11] "Industry Observer," *Aviation Week and Space Technology* (July 25, 1977), p. 11.

[12] House Armed Services Committee, *FY78 Authorization Hearings*, pt. 2, p. 362.

[13] Watts, *The Military Use of Space*, pp. 60–64.

> when a satellite produces debris and that debris subsequently damages other satellites, since, in general, states do not register their debris. The potential liability in such cases can be enormous and has yet to be tested, either in national courts or between states on the basis of the Liability Convention.[14]

A quarter-century ago, space "industry" was in its infancy. Today, it is in its early maturity. Markets and market niches are beginning to define themselves, but growth has been slower than projected. Start-up speculation has given way to functioning businesses, consolidations, closures, and realignments. High technology businesses tend to evolve rapidly, but space technology will evolve much more slowly than most other commercial high-tech sectors. The future of space commercialization is difficult to predict, in part because markets and competition are still emerging, and in part because governments are still large players in the business—as customers, partners, regulators, and competitors. The evolution of, or sharp turns in, international politics will have a large effect on the future of an industry whose commercial potential is inextricably linked to geopolitics.

SPACE AND WAR-FIGHTING

A quarter-century ago, U.S. satellites were primarily utilized for pre-conflict planning, for strategic and tactical warning, and for monitoring treaties. U.S. space assets were primarily "tasked" with focusing on the Soviet threat. If deterrence broke down and conflict began, space assets would have been used for communications, command and control, along with battle damage assessment and ballistic missile launch warning. Space assets were modern day analogues to the American Civil War technologies of aerial spotting balloons and the telegraph. They were better at doing their functions than the technologies they replaced, but would not necessarily prove decisive in their impact on the battlefield.[15]

Today, space assets play a much larger role in the real-time enhancement of military operations. Targets can be spotted using satellites, data can be transmitted to the field via satellites, and the bomb used to attack targets can be guided with information from satellites. The timeline for this sequence of events is continually being compressed. As a consequence, the amount of

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[14] "The Working Group on Space Traffic Management," in *International Space Cooperation: Addressing Challenges of the New Millennium*, Report of an AIAA, UN/OOSA, CEAS, IAA Workshop (Reston, VA: American Institute of Aeronautics and Astronautics, March 2001), pp. 8–9.

[15] Barry Watts notes this shift in *The Military Use of Space*, p. 1 and uses the telegraph analogy (p. 31). James Oberg uses the balloon analogy in *Space Power Theory* (Washington, DC: GPO, 1999), pp. 121–22.

communication capacity required for military operations has grown by orders of magnitude in the last two decades.

Twenty-five years ago, this data stream would not only have been much smaller, it would also have been confined almost exclusively to government-owned "pipes." The number of space-faring nations was quite small and the field was dominated by the two superpowers. Today, many of these functions are provided by commercial satellites. Some of these systems are owned or operated by civil government agencies, but increasingly the suppliers are commercial and frequently multinational.[16]

Navigation

A quarter-century ago, U.S. navigation from space was provided by the Transit satellite system. This system provided two-dimensional position accuracy of 200 meters, providing no information about time or velocity. Usage was confined to a relatively small maritime community, most significantly the U.S. ballistic missile submarine fleet. The NAVSTAR Global Positioning System (GPS) was still in its infancy, but promised dramatic improvements: 50 percent of the time, it was expected to provide accuracy of 5 meters horizontally and 7 meters vertically. Ninety percent of time it was expected to provide 8 meters horizontal accuracy and 10 meters vertically.[17] The first satellite in the GPS constellation was launched in February 1978.[18] By comparison, the first satellite of the equivalent Russian system, GLONASS, was first launched in December 1982. Until these systems became operational, navigation problems were frequently solved using older technologies such as inertial guidance or, more prosaically, using a map and compass.

Today, U.S. forces increasingly depend on GPS satellites for navigation. GPS supports reliable, low-cost solutions to absolute and relative navigation problems, particularly over large areas. GPS was originally built by and for the U.S. military, but it has become the worldwide navigation system for shipping

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[16] See Watts, *The Military Use of Space,* pp. 65–73 and "Growth in Non-DoD Space Capabilities," in Gonzales, *The Changing Role of the U.S. Military in Space,* pp. 1–12; Hays, *United States Military Space,* pp. 33–39; Thomas S. Moorman, "The Explosion of Commercial Space and the Implications for National Security," *Airpower Journal* 8, No. 1 (Spring 1999): 6–31; also see Renae Merle, "U.S. Probes Military's Use of Commercial Satellites," *Washington Post* (December 6, 2002), p. E5; for the impact of an increasingly commercialized remote sensing sector, see footnote 8 above.

[17] House Armed Services Committee, *FY78 Authorization Hearings*, pt. 2, p. 567; also Paul B. Stares, *Space and National Security* (Washington, DC: The Brookings Institution, 1987), pp. 32–34.

[18] Paul Stares, "Space and U.S. National Security," in William Durch (ed.), *National Interests and the Military Use of Space* (Cambridge, MA: Ballinger, 1984), p. 49. For more on the Transit system, see Federation of American Scientists, "Transit," available online at http://www.fas.org/spp/military/program/nav/transit.htm.

and air transport. Other commercial and recreational applications have expanded at a rapid rate. While Department of Defense control assures more precise locational information for US. forces than for other users of GPS, increased accuracy is now available to all users—including potential U.S. adversaries.[19]

Navigation aides are likely to become diversified in the future. The European Space Agency has announced plans to orbit a navigation system similar to GPS. Russia is now confronted with decisions about how to maintain its GLONASS navigation system. China is likely to want a navigation capability independent of GPS, either by purchasing into the GLONASS system or developing a constellation of its own.[20]

Remote Sensing

A quarter-century ago, the collection of data from space about the earth's surface was the exclusive domain of national governments. Remote sensing consisted primarily of taking pictures. NASA was pioneering satellites to take scientific measurements of the earth and its atmosphere, useful for weather forecasting, oceanography, and agriculture.

The most important and widely used remote sensing activities for commercial and civil purposes were provided by LANDSAT. In 1972, NASA's LANDSAT civil remote imagery program had its first satellite successfully launched into orbit. With a spatial resolution of 40 meters, LANDSAT imagery was much coarser than that of classified systems. This NASA program pioneered multi-spectral imaging, which permitted the extraction of information that did not appear in panchromatic imagery. Images of the same scene taken at different times in the same or different spectral bands could be combined or compared to produce evidence of significant changes over time.

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[19] See Watts, *The Military Use of Space*, pp. 41–46; "Appendix E: Position, Velocity, Time, and Navigation," in Joint Chiefs of Staff, *Joint Doctrine for Space Operations*, Joint Publication 3-14 (August 9, 2002), pp. E-1–E-4; for a more technical assessment see Scott Pace, Gerald Frost, Irving Lachow, David Frelinger, Donna Fossum, Donald K. Wassem, and Monica Pinto, *The Global Positioning System: Assessing National Policies* (Santa Monica, CA: RAND, 1995), particularly chapter 3.

[20] Barry Watts, *The Military Use of Space: A Diagnostic Assessment* (Washington, DC: Center for Strategic and Budgetary Assessments, 2001), pp. 34–37; for a discussion of the European system, see European Space Agency, *Galileo: The European Programme for Global Navigation Services* (May 2002), available online at http://ravel.esrin.esa.it/docs/GalileoBrochure.pdf; for a discussion of Chinese current and future capabilities, see Stephanie Lieggi, "China's Space Capabilities and the Strategic Logic of Anti-Satellite Weapons" (Washington, DC: Presentation at the Center for Nonproliferation Studies, Monterey Institute for International Studies, June 13, 2002) and Mark Stokes, *China's Strategic Modernization: Implications for the United States* (Carlisle Barracks, PA: Army War College, September 1999), pp. 181–182.

In the late 1970s, the collection of imagery from space was dominated by the intelligence and national security agencies of the United States and the Soviet Union. The first successful mission of the highly secretive U.S. CORONA imagery collection satellites occurred on August 18, 1960 when the Discoverer XIV satellite ejected a capsule containing pictures obtained over the Soviet Union.[21] The data contained in the initial capsule was still very rough, with resolution in the area of 15 to 30 meters. By the Carter administration, resolution had been improved to an estimated 15 centimeters.[22] The Soviet Union, by comparison, launched its first imaging satellite in 1962 and was able to improve capabilities at a rate roughly parallel to the United States until the late 1980s.

A quarter-century ago, the goals of civil and military imaging programs were quite different. Both were interested in "details," but they were different types of details. The military was primarily interested in viewing equipment, installations, and activities of interest with as fine a resolution as possible, while civil users were generally interested in larger phenomena such as weather patterns, ocean currents, and agricultural production.

Today, high-resolution imagery is reported to enable photo analysts to see objects in detail on the ground of 15 centimeters or more in near real-time, while infrared sensors and space-based radar can provide less than 1-meter resolution.[23] Moreover, the number of countries with dedicated capabilities to observe activities on Earth has increased dramatically. Some countries have pursued cooperative endeavors of remote sensing. China and Brazil have collaborated on an earth resources satellite, while India and Israel are developing a high-resolution imaging satellite. Barriers to entry into the remote sensing club are much lower than a quarter-century ago.

Today, there has been a vast growth in the availability of commercial imagery from space. Commercial satellite imagery can now be purchased from at least six different vendors.[24] As the economic value of remotely sensed data became known, a space-imaging industry began to grow. Commercial interests

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[21] The following discussion draws from Jeffrey Richelson, *America's Secret Eye's in Space: The U.S. Keyhole Spy Satellite Program* (New York: Harper & Row, 1990), along with his subsequent work *The U.S. Intelligence Community,* 4th ed. (Boulder, CO: Westview Press, 1999), particularly the chapter on "Imagery Collection, Interpretation, and Dissemination" (pp. 150–179); David Lindgren, *Trust but Verify: Imagery Analysis in the Cold War* (Annapolis, MD: Naval Institute Press, 2000); Curtis Peebles, *Guardians: Strategic Reconnaissance Satellites* (London: Ian Allan, 1987); and Dwayne Day, John Logsdon, and Brian Latell, *Eye in the Sky: The Story of the Corona Spy Satellites* (Washington, DC: Smithsonian Institution Press, 1998).

[22] "Space Reconnaissance Dwindles," *Aviation Week and Space Technology* (October 6, 1980), p. 18.

[23] Jeffrey Richelson, "The Satellite Gap," *Bulletin of Atomic Scientists* (January–February 2003), p. 49–50.

[24] Dehqanzada and Florini, *Secrets for Sale*, pp. 38–39.

now design, build, launch, and operate satellites. Privately owned companies distribute imagery and imagery products. High-resolution imagery is now available, with several companies offering less than 2-meter resolution and Space Imaging's IKONOS satellite offering 0.82-meter resolution. While commercial systems still do not provide resolution comparable to that produced by national technical means, it is more than sufficient for many intelligence and national security applications.

Today, partnerships are being formed between intelligence communities and commercial ventures, including contractual arrangements to buy and use commercial imagery and cooperative programs to develop next generation multi-spectral systems.[25] Collaborative ventures include synthetic aperture radars (SAR). Real-time downlink of collected imagery is the trend for newer systems, and near real-time tasking is becoming a reality.[26]

Linkages between commercial and national security applications raise crosscutting opportunities and concerns. During crisis or wartime, Washington will be reluctant to depend on sources that are beyond the direct control of the U.S. government. However, Washington has willingly opted to receive data from commercial sources because U.S. data needs are not satisfied solely by national technical means. Reliance on a mix of national and commercial satellites also provides for a system of data collection that is less susceptible to catastrophic failure or surprise attack. As the number of imagery satellites increases, the consequences of losing one satellite decline. Moreover, as multinational backing of imagery satellites increases, the negative ramifications to a potential attacker multiply, since a singular attack could make multiple enemies. On the other hand, imagery collected by the U.S. government from commercial satellites could become available to others, including America's adversaries. A multinational, globalized industry could mean a reduction in Washington's influence over "shutter control."

A quarter-century ago, the first Geostationary Operational Environmental Satellite was launched to observe and predict weather. Today, no nightly newscast is complete without imagery from weather satellites. Polar-orbiting satellites, first launched forty years ago, continue to be improved and allow for long-range weather forecasting. Today, both types of satellites are utilized in the Defense Meteorological Support Program to help schedule military

[25] See Edward Robinson, "The Pentagon Finally Learns How to Shop," *Fortune* (December 21, 1998), p. 174.

[26] For example, the Air Force's Eagle Vision program provides real-time downlink: The Mitre Corporation, "Eagle Vision," available online at http://www.mitre.org/technology/eaglevision/. ImageSat International is just one of many firms that provides priority tasking, see "Priority Acquisition Request Service," available online at http://www.imagesatintl.com/1024/services/pars.html.

operations and to prepare for severe weather. Additionally, scientific satellites make a wide variety of measurements, including the temperature of the ocean to forecast El Niño conditions. Specialized geodetic surveying satellites measure perturbations in the Earth's gravitational field, crucial to plotting ballistic missile flight trajectories.

During the Cold War, the collection of signals intelligence was essential to learn more about Soviet strategic and military capabilities. U.S. officials considered themselves fortunate when they could hear the Kremlin's deliberations. Today, U.S. officials consider themselves fortunate when they can listen in on al Qaeda leaders and operatives.

A quarter-century ago, the United States began to rely upon satellites in the Defense Support Program (DSP) to provide early warning of ballistic missile launches. These satellites provided the means for national leaders to respond quickly to a bolt-out-of-the-blue attack, thereby clarifying to an adversary that an attempted first strike would prompt a devastating response. Upgraded DSP satellites remain the backbone of U.S. missile launch detection capabilities.[27] Their replacement, the Space-Based Infrared System–High constellation of satellites, has encountered significant program delays and cost overruns. Today, the primary concern of U.S. officials is to obtain launch detection information of shorter-range ballistic missiles that could be used against U.S. expeditionary forces, friends, and allies.

Communication

Space-based national security support functions provide the means to "look, listen, and talk." "Look" and "listen" refer to the collection of imagery and signals intelligence. The third function is provided by communication satellites. A quarter-century ago, communication satellites in the West were owned by governments or large international consortia, such as INTELSAT and INMARSAT. Today, as RAND analyst Daniel Gonzales has noted, the communications satellite market "is undergoing a fundamental transformation from a market composed of government-sponsored consortia to one dominated by international joint ventures whose primary stakeholders are private firms."[28]

Satellite-facilitated communication has now become a mainstay for military and commercial operations. In the last decade, modern fiber-optic networks

[27] Federation of American Scientists, "Defense Support Program," available online at http://www.fas.org/spp/military/program/warning/dsp.htm. For a detailed history of the program see Jeffrey Richelson, *America's Space Sentinels: DSP Satellites and National Security* (Lawrence: University of Kansas Press, 1999).

[28] Gonzales, *The Changing Role of the U.S. Military in Space*, pp. 1–6.

have significantly expanded capacity and consequently reduced costs. This has dramatically increased competition for civil applications, but military forces require autonomous and separate channels of communication, as well as relying on commercial networks. According to a U.S. Department of Defense study, commercial satellites were used for 45 percent of all communications between the United States and the Persian Gulf during Operations Desert Shield and Desert Storm.[29] Subsequently, during Operation Allied Force, 80 percent of the spaceborne communications used in the Kosovo campaign traveled on commercial systems.[30] Much of this commercial capacity is owned and operated by a variety of companies, most of which are multinational.[31]

A quarter-century ago, the second generation of military communication satellites was in operation. Today, the U.S. military uses third and fourth generation dedicated satellites with robust anti-jamming technology and far greater bandwidth. This capacity is still insufficient, particularly during times of conflict, and is supplemented by leased capacity on commercial systems that are significantly more vulnerable to interference.

Space Weaponry

A quarter-century ago, U.S. officials were concerned about the Soviet Union's flight-testing of a co-orbital ASAT after the last operational U.S. antisatellite capability—Program 437—had been officially terminated in 1975.[32] The outgoing Ford administration directed the Pentagon to pursue work on a kinetic-kill vehicle that would be launched from a fighter aircraft and carry out direct ascent attacks on Soviet satellites. In an extraordinarily direct speech

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[29] General Accounting Office, *Critical Infrastructure Protection: Commercial Satellite Security Should Be More Fully Addressed* GAO-02-781 (Washington, DC: August 2002), p. 1; also Haller and Sakazaki, *Commercial Space and United States National Security*, p. 79 have similar figures.

[30] Peter Grier, "The Investment in Space," *Air Force Magazine* (February 2000), p. 50.

[31] By 2010, the National Defense Industrial Association predicts that foreign companies could provide 80 percent of commercial communication satellite services. GAO, *Critical Infrastructure Protection*, p. 7.

[32] This section draws from Col. Robert Giffen, *U.S. Space System Survivability: Strategic Alternatives for the 1990s* (Washington, DC: National Defense University Press, 1982), pp. 25–52; George Jelen, "Space System Vulnerability and Countermeasures," in William Durch (ed.), *National Interests and the Military Use of Space* (Cambridge, MA: Ballinger, 1984), pp. 89–112; Office of Technology Assessment, U.S. Congress, *Antisatellite Weapons, Countermeasures and Arms Control* (Washington, DC: OTA, September 1985), pp. 49–75; Stares, *The Militarization of Space*, pp. 201–215; Stares, *Space and National Security*, pp. 73–119; David Tanks, Principal Study Investigator, *Future Challenges to U.S. Space Systems* (Cambridge, MA: Institute for Foreign Policy Analysis, 1998); and Tom Wilson, *Threats to United States Space Capabilities* (Washington, DC: Prepared for the Commission to Assess United States National Security Space Management and Organization, 2001); *Report of the Commission to Assess United States National Security Space Management and Organization* (Washington, DC: Commission to Assess United States National Security Space, January 11, 2001), pp. 17–25.

before the Air Force Association, the Pentagon's research chief, Malcolm R. Currie announced that,

> The Soviets have developed and tested a potential war-fighting anti-satellite capability. They have thereby seized the initiative in an area which we hoped would be left untapped. They have opened the specter of space as a new dimension for warfare, with all that this implies. I would warn them that they have started down a dangerous road. Restraint on their part will be matched by our own restraints, but we should not permit them to develop an asymmetry in space.[33]

The incoming Carter administration inherited this choice. It continued work on the Ford administration's initiative, while seeking to avoid an ASAT competition by entering into talks with the Soviet Union.

Today, the threat environment to satellites is both broader and shallower. It is broader because the technology necessary for attacking satellites is more accessible. It is shallower, however, because the United States does not face a peer competitor with the resources and the ambitions of the Soviet Union. While asymmetric warfare can be carried out in space, it is more easily and effectively waged on the ground. And unlike the superpower competition in the Cold War, when space warfare had the potential to alter the terms and outcomes of conflict, space warfare initiated by a weaker foe will not alter the outcome of a conflict with the United States.

The globalization and commercialization of space activities provides opportunities as well as problems for the United States and its potential foes. Commercial services, many of which did not exist twenty-five years ago—principally communications, imagery collection, and navigation aids—could be used to support the conduct of, and the preparation for, a conflict. Indeed, for many adversaries the United States might face, their primary or only access to these functions would likely be through commercial providers.

The United States can influence commercial providers to deny these services during a conflict. Means of suasion could include legal measures, financial inducements, and diplomatic pressure. U.S. companies are already subject to a public law, passed in 1992, that allows the U.S. government to prohibit companies from taking pictures of certain areas "during periods when national security or international obligations and/or foreign policies [of the United States] may be compromised, as defined by the Secretary of Defense or the Secretary of State, respectively."[34] This provision of law has not yet been

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[33] Quoted in "Warning to Soviets," *Aviation Week and Space Technology* (November 8, 1976), p. 13.

[34] U.S. Department of Commerce, National Ocean and Atmospheric Administration, *Application to Operate a Commercial Land Observation System*, Section B, part 1.

invoked. Instead, the United States has opted to exercise "checkbook shutter control," purchasing all of Space Imaging's pictures of Afghanistan and its environs during the campaign against al Qaeda.[35] The multilateralization and globalization of the satellite industry pose a new set of complications to ASAT use that did not exist during the Cold War. As Daniel Gonzales has noted, the use by Washington of destructive ASATs "could well lead to sanctions against the United States and preclude future use of the consortium's assets by U.S. military forces or even by U.S. commercial interests."[36]

Weapons for Attacking Satellites

The primary ASAT threat a quarter-century ago was a crude device that first orbited the earth before sidling up to its intended victim. This mode of operation took more than ninety minutes to attack U.S. satellites in low earth orbit, thereby negating the element of surprise.[37] The Soviet co-orbital ASAT did not fare well during its flight tests, failing 11 of its 20 tests.[38] Nonetheless, it galvanized the Pentagon to respond with a more flexible and effective counter that would be launched by fighter aircraft.

A quarter-century ago, there was considerable fear that the Soviets were stealing a march on the United States in the development and flight-testing of ASATs. The incoming Carter administration sought dramatic increases in space defense spending: from $61 million in fiscal year 1977, to $126 million in fiscal 1978, and $265 million in fiscal 1979.[39] Today, in the absence of ASAT flight tests, U.S. officials are concerned about covert foreign ASAT programs. With the demise of the Soviet Union and the absence of a near-peer competitor, Pentagon officials worry about asymmetric attacks by low cost, low-tech means, such as space mines or the placement of debris in the path of U.S. space assets. Today, the United States spends more on space—in excess of $30 billion annually—than most nations spend on their entire military budgets.[40]

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[35] Michael Gordon, "Pentagon Corners Output of Special Afghan Images," *New York Times* (October 19, 2001), p. B2. For more on U.S. policy options see Dehqanzada and Florini, *Secrets for Sale*, pp. 27–30 and Laurence Nardon, *Satellite Imagery Control: An American Dilemma* (Paris: Ifri, March 2002), available online at http://www.csis.org/nardon_ang.pdf.

[36] Gonzales, *The Changing Role of the U.S. Military in Space*, p. 38.

[37] Lupton, *On Space Warfare*, p. 90, endnote 29.

[38] Stares, *Space and National Security*, p. 88.

[39] Drew Middleton, *New York Times* (February 15, 1977), p. 8. These amounts do not include spending for high-energy laser R&D, which had multiple non-space uses as well. See *Defense/Space Daily* (March 1, 1977), p. 1.

[40] Marcia Smith, *U.S. Space Programs: Civilian, Military, and Commercial*, CRS Issue Brief IB92011 (Washington, DC: Congressional Research Service, updated January 22, 2003).

The current threat spectrum to satellites, as characterized by the U.S. Joint Chiefs of Staff, reflects a continuum of possibilities:

> Disruption: Temporary impairment (diminished value or strength) of the utility of space systems, usually without physical damage to the space system. These operations include the delaying of critical, perishable operational data to an adversary.
>
> Denial: Temporary elimination (total removal) of the utility of an adversary's space systems, usually without physical damage. This objective can be accomplished by such measures as interrupting electrical power to the space ground nodes or computer centers where data and information are processed and stored.
>
> Degradation: Permanent partial or total impairment of the utility of space systems, usually with physical damage. This option includes attacking the ground, control, or space segment of any targeted space system. All military options, including special operations, conventional warfare, and information warfare are available for use against space targets.
>
> Destruction: Permanent elimination of the utility of space systems. This last option includes attack of critical ground nodes; destruction of uplink and downlink facilities, electrical power stations, and telecommunications facilities; and attacks against mobile space elements and on-orbit space assets.[41]

This continuum from disruption to destruction can be accomplished through a variety of means, including nuclear detonations, kinetic kills, the use of directed energy as well as spoofing, hacking, jamming, and other forms of interference. Except for hacking into computer networks supporting satellite operations, all of these methods of attacking satellites were clearly within view a quarter-century ago. The threat environment, however, has changed significantly.

Nuclear Threats

A nuclear warhead lofted into low earth orbit and detonated there constitutes a devastating antisatellite weapon.[42] Depending on the satellite's proximity to the explosion, the immediate effects could produce damage through

[41] Joint Chiefs of Staff, U.S. Department of Defense, *Joint Doctrine for Space Operations*, Joint Publication 3-14 (August 9, 2002), pp. IV-7–IV-8.

[42] This is clearly a less attractive option for a state with a limited number of nuclear weapons. Whether such a state is likely to use a nuclear weapon against satellites in low earth orbit is examined in Chapter 2.

thermomechanical shock, ionization burnout, or a system-generated electromagnetic pulse. Additionally, if the explosion were in low earth orbit, the electrons generated would be trapped in Earth's magnetic field, destroying all non-hardened satellites within weeks or months. The STARFISH nuclear test in 1962, a 1.4-megaton blast detonated 400 kilometers above Johnston Island in the Pacific Ocean, disabled seven satellites in seven months in low earth orbit and disrupted power, telephone service, and radio stations in Hawaii, 1,300 kilometers away.[43]

A quarter-century ago, there were five nuclear weapons states: China, France, Great Britain, the Soviet Union, and the United States. Today, an additional three states—India, Israel, and Pakistan—have nuclear stockpiles. North Korea might have one or two weapons and could add to this number relatively quickly. Further, the U.S. intelligence community has judged that Iraq and Iran continue to pursue nuclear weapons technology and the means to deliver them.[44] All of these states, with the possible exception of Iraq, have sufficient ballistic missile capabilities to be able to loft a warhead into outer space. The space launch capabilities of India and Israel are particularly advanced.

Kinetic Energy ASATs

Among the ways to kill satellites are by means of a direct collision or by means of an explosion that produces shrapnel and debris. Kinetic kill vehicles can be launched from space, land, sea, or aircraft. Technology developed for offensive or defensive missiles can be adapted for this task. "Direct ascent" interceptors take the most direct route to their targets. Kinetic kills can also be accomplished by "parking" ASATs into orbits, either close to the target or far away, for subsequent attack. ASATs during the Cold War were flight-tested openly, and thus were quite visible. Today, the Pentagon worries that ASATs might be hard to find. Any nation that has the ability to place a satellite into a selected orbit could have the means to build and operate an ASAT. Kinetic kills could also be carried out by "parasitic" ASATs—small explosive packages that covertly maneuver and attach themselves to their intended victims. Another

[43] See Stares, *Space and National Security,* pp. 74–75; Advanced Systems and Concepts Office, Defense Threat Reduction Agency, Department of Defense, *High Altitude Nuclear Detonations (HAND) Against Low Earth Orbit Satellites ("HALEOS")* (Defense Threat Reduction Agency, April 2001); and Dennis Papadopolous, "Satellite Threat Due to High Altitude Nuclear Detonations," presentation for the Center for Nonproliferation Studies, Monterey Institute of International Studies (July 24, 2002).

[44] *Unclassified Report to Congress on the Acquisition of Technology Relating to Weapons of Mass Destruction and Advanced Conventional Munitions, 1 July Through 31 December 2001*, available online at http://www.cia.gov/cia/publications/bian/bian_jan_2003.htm.

approach would be to deploy space mines in orbit that do not affix themselves to satellites, but constitute ASAT fields that could be detonated on demand. The concept of deploying space mines could be employed for all satellite orbits, since time is not of the essence in resorting to such tactics. Another means of killing satellites through contact would be by spreading debris fields in space. All kinetic kill mechanisms would, of course, create their own debris fields.

A quarter-century ago, the Carter administration allocated $82.5 million in FY1981 for a kinetic kill vehicle launched from an F-15 fighter aircraft.[45] The George W. Bush administration has also taken an interest in kinetic energy ASATs. Project managers in the Army's Kinetic Energy Antisatellite (KE-ASAT) program were hopeful of receiving an additional $60 million in funding for a flight test in FY2004,[46] but the Pentagon's leadership subsequently backed away from this request. The FY2004 budget submission contains $14.7 million for research and development on "space control" and $82.6 million for "counterspace technologies."

A quarter-century ago, work on kinetic energy ASATs was largely confined to the United States and the Soviet Union. The proliferation of ballistic missile technology, wider availability of space launch capabilities, the growing list of owners and operators of satellites, and the dispersion of telemetry, tracking, and control capabilities, raise the number of states that could develop and operate ASATs.

In addition to some member states of the European Space Agency, China, India, Israel and Japan have the infrastructure and capabilities to pursue ASATs. Of these states, China has the strongest incentive to develop kinetic energy ASATs as a hedge against U.S. space warfare programs and as a means to complicate attacks on its deterrent.[47] India and Israel could also take interest in ASATs if regional antagonists develop, acquire, or deploy space assets. Japan could also take an interest in ASATs in the context of a marked deterioration in its regional security environment.

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[45] Stares, *The Militarization of Space*, p. 209.

[46] Kerry Gildea, "Possible Funding Boost In FY '04 Budget Could Lead To KE-ASAT Flight Test," *Defense Daily* (December 17, 2002).

[47] For a discussion of Chinese motivations to develop antisatellite weapons, see Mark Stokes, *China's Strategic Modernization: Implications for the United States* (Carlisle Barracks, PA: U.S. Army War College, September 1999), pp. 117–123, 186–187 and Phillip Saunders, et al, "China's Space Capabilities and the Strategic Logic of Anti-Satellite Weapons" (Monterey, CA: Center for Nonproliferation Studies, Monterey Institute for International Studies, July 22, 2002), available online at http://www.cns.miis.edu/pubs/week/020722.htm.

Directed Energy Weapons

A quarter-century ago, the United States was exploring the military utility of lasers and other directed energy weapons at a leisurely pace. In FY1978, the Defense Department's Advanced Research and Projects Agency received approximately $25 million for work on high-energy lasers.[48] The Pentagon's entire outlay for high-energy laser research and development was $150 million in FY1978.[49] Despite these modest outlays, some Pentagon officials were quite optimistic about the weaponization of this technology. Air Force Lt. Gen. Thomas Stafford predicted that a prototype of an ASAT system using high-energy lasers could be ready in four or four and half years, "If we really wanted to push on it."[50] Towards the end of the Ford administration, directed energy ASATs began to receive increased attention, a trend that continued during the Carter administration.[51] Predictions of the revolutionary war-fighting potential of directed energy weapons are not new. A quarter-century ago, the head of the Defense Advanced Research and Projects Agency, Dr. George H. Heilmeier, opined that the launch of a high-energy laser "could represent a Sputnik-like event."[52]

Significant funding was subsequently devoted to directed energy weapons, including space-based weaponry, in the Reagan administration, but technical predictions of success proved to be difficult to realize. Directed energy weapons, including ASAT weapons, require a beam that is sufficiently intense to destroy the intended target during the time the target can be engaged. A ground-based directed energy device must compensate for energy lost in transmission through the atmosphere. Beams must be focused and remain steady on the target. Singular kills by directed energy weapons could not justify the expense involved; multiple kills would require a significant power source. The protection of directed energy weapons against attack would also represent a significant challenge.

Putting lasers on transport aircraft operating at altitudes of 9,000–12,000 meters might simplify some of these problems, but the range of this platform is likely to be limited and its vulnerability to attack would consequently be very great. Other technological problems must be solved, notably reducing the size of the components so that they can fit into the aircraft.[53]

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[48] *Aviation Week and Space Technology* (December 5, 1977), p. 61.

[49] *Defense/Space Daily* (March 1, 1977), p. 1.

[50] Fred Hoffman, *Philadelphia Inquirer* (November 1, 1979), p. 18.

[51] Stares, *The Militarization of Space*, pp. 213–215.

[52] *Defense/Space Daily* (March 17, 1977), p. 1.

[53] The Airborne Laser, designed for missile defense purposes, faces identical challenges. See "The Airborne

Notwithstanding these challenges, interest in deploying directed energy weapons remains high in some quarters. Research and development programs that were nascent during the Carter administration continue today. High-energy lasers, for instance, are included in the Bush administration's research and development on missile defense, with $598 million appropriated for the Airborne Laser and $24.8 million for the space-based laser in FY2003.

A quarter-century ago, only the Soviet Union and the United States had the means to establish significant research and development programs on directed energy weapons. Soviet test beds at Dushanbe and Sary Shagan were of great concern to some, who argued that the facilities had antisatellite and ballistic missile defense missions.[54] The threat posed by Russian expertise in directed energy technologies has markedly declined. Both the Dushanbe and Sary Shagan sites are now located outside of the Russian Federation, one in Tajikistan and the other in Kazakhstan. Publicly available data show Russian funding for all space-related activities was less than $500 million in 2002.[55] Although the Soviet Union's space budget was opaque during the Cold War, every indicator of effort showed it to be a peer competitor with the United States. Today, Russia's space budget is smaller than India's.[56]

Interference and Threats to Ground Segments

A quarter-century ago, jamming, spoofing, and other means of electronic warfare were already significant threats to U.S. space systems, and much effort was devoted to countermeasures against these threats. Varied methods of interference have become more widely available and now constitute the most likely threats that U.S. satellites might encounter. In some cases, inexpensive, commercially available systems could be employed to cause disruptions.[57]

Hacking and other cyber attacks could also disrupt or interfere with satellite operations—a threat that was remote a quarter-century ago. The number of

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Laser Received Mixed Review From Its Program Office On Readiness To Proceed To Development," *Aviation Week and Space Technology* (July 29, 2002), p. 57.

[54] See, for instance, *Soviet Military Power: An Assessment of the Threat, 1988* (Washington, DC: GPO, 1988), p. 56.

[55] "Russia's Budget for Space Programs," *Aerospace Daily* (January 16, 2002), p. 2; and Dmitry Pieson, "Space Spending Goes up in Russian Budget for 2002," *Aerospace Daily* (January 15, 2002), p. 6.

[56] "Russia's Space Programme in the Doldrums, Aerospace Chief Laments," *BBC Monitoring International Reports* (December 10, 2002).

[57] *Report of the Commission to Assess United States National Security Space Management and Organization* (Washington, DC: Commission to Assess United States National Security Space, January 11, 2001), pp. 19–22; William B. Scott, "Innovation Is Currency Of USAF Space Battlelab," *Aviation Week and Space Technology* (April 3, 2000), p. 52.

probes and scans of U.S. Department of Defense computer systems has been increasing, with 22,000 in 1999 and 26,500 in the first eleven months of 2000.[58] The General Accounting Office reported that critical commercial satellite systems relied upon by federal agencies, civilians, and the Pentagon are potentially vulnerable to a variety of sophisticated cyber attacks that could cause service disruptions or even send a satellite spinning out of control.[59] Because of the networked nature of critical infrastructures, it is not always necessary for a hacker to gain access to a well-defended government or commercial system in order to cause significant disruption. Surprise attacks are more likely to come about by a hacker than by a space mine or kinetic energy ASAT. Attacks to critical infrastructure offer relatively low barriers to entry, multiple paths of disruption, and potential difficulty in assessing responsibility for the crime.[60]

During the Cold War, the most serious threat to ground segments controlling satellite operations was considered to be Soviet nuclear strikes. Perhaps because of this concern, little was done to protect ground stations. Today, U.S. ground stations remain a point of weakness, not to a bolt-out-of-the-blue attack, but to acts of domestic terrorism. Homeland security now requires improved protection of ground facilities that support U.S. military and commercial space systems. Foreign ground stations supporting space operations are also vulnerable to terror—as well as to conventional U.S. power projection capabilities.

Defending Satellites

A quarter-century ago, the Pentagon began research and development for a number of satellite survivability measures, driven by concerns over the resumption of Soviet ASAT tests. Press reports indicated that the Pentagon initiated programs to improve detection of an impending attack, to add maneuverability for satellites to take evasive action in the event of an attack, and to fund spares on the ground that could be quickly launched in the event of an attack.[61] Presumably, funding for these programs, which began at the end of the Ford administration, was continued during the Carter administration, given concerns by the Joint Chiefs of Staff that a negotiated ASAT agreement would generate a false sense of security and subsequent reductions in congressional

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[58] Wilson, *Threats to United States Space Capabilities,* p. 21.

[59] Kevin Poulson, "Satellites at Risk of Hacks," *Security Focus On-line* (October 3, 2002), Internet: http://online.securityfocus.com/news/942 and GAO, *Critical Infrastructure Protection,* pp. 12–13.

[60] Bruce Wald, "Space Control Issues: Plausible Threats and Assurance Strategies" (Alexandria, VA: Center for Naval Analyses, January 1997), annotated briefing.

[61] Thomas O'Toole, "U.S. Draws Up Plans for War in Space," *Washington Post* (January 10, 1977), p. 1.

funding for satellite survivability measures.[62] An even greater level of effort on satellite survivability programs was presumably undertaken during the Reagan administration, given its keen interest in space warfare. It is not possible to assess how much progress was achieved in satellite survivability measures, as these initiatives were highly classified. It is striking, however, how much these concerns continue to be raised in contemporary discussions, suggesting that insufficient progress has been made.

Satellites can be defended by passive measures, semi-active defenses, and active defenses—or a combination thereof. Passive measures are design features that make satellites less vulnerable to the effects of attacking weapons. For most, if not all satellites, armoring against impact or explosion is not practical or effective against kinetic energy weapons. To some degree, satellites can be hardened against directed energy weapons, by employing measures for heat dissipation, or by shielding the more delicate subsystems against direct exposure to laser (or other) beams. Similarly, passive defenses against jamming and other forms of electronic interference are quite advanced, and could be applied to satellites as they are to other defense electronic systems. Passive protective measures can be ongoing and automated.

Semi-active measures are also possible. These could include sensors that can be activated by specific threats, shutting down subsystems in response. For example, hypersensitive antennas and associated processors that are looking for very small signals could be damaged by trying to process a signal that is several orders of magnitude larger than what the receivers are designed to handle. Rapidly detecting the incident signals and shutting down the receivers might provide protection. Similarly, a satellite could be given maneuvering capability so that it could move out of the path of an interceptor, or could turn sensitive elements to face away from a laser beam.[63]

Supporters of seizing the high ground of space are likely to find passive or semi-active defenses insufficient. In this view, active measures, such as arming satellites, are also needed. Armed satellites could shoot first at suspect objects in space rather than waiting to be victimized. Or satellites could be protected by armed escort satellites.[64] Armed escorts could be deployed alongside satellites to be protected, or they could act as sentries over a broad region. There are no

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[62] Stares, *The Militarization of Space,* p. 199.

[63] For more on countermeasures, see Paul Nordin, "Other Hostile Environments," in Wiley Larson and James Wertz, *Space Mission Design and Analysis,* 2nd ed. (Microcosm Inc. and Kluwer Academic Publishers, 1992), pp. 197–210.

[64] Tom Wilson, *Threats to United States Space Capabilities* (Washington, DC: Prepared for the Commission to Assess United States National Security Space Management and Organization, 2001), pp. 45–46.

practical distinctions between the armed defense of satellites in space and space warfare for offensive purposes.

THE ROLE OF SPACE ARMS CONTROL

A quarter-century ago, space arms control was a contentious subject. The primary source of contention was not whether the United States ought to negotiate on this subject, but what the proper scope of a negotiated agreement should be. The core divide over space arms control in the Carter administration was whether an agreement ought to be as comprehensive as possible—a position favored by the Department of State and the U.S. Arms Control and Disarmament Agency—or whether an agreement ought to be narrowly drawn, focusing primarily on "rules of the road" for space.[65] This internal, executive branch debate was mooted by the Soviet invasion of Afghanistan.

Today, U.S. troops are in Afghanistan, and there is no internal, executive branch debate over the value of ASAT arms control. The Arms Control and Disarmament Agency was disestablished during the Clinton administration. The State Department in the Bush administration now joins the Pentagon in opposing ASAT negotiations.

Throughout the Cold War, sentiment in the U.S. Congress was largely opposed to space warfare initiatives. During the Reagan administration, congressional majorities took blocking action against the initiation of ASAT testing, while affirming U.S. treaty obligations to prevent the testing and deployment of directed energy weapons in space. Today, arms control protections against space warfare embedded in the Anti-Ballistic Missile Treaty have been swept away by the George W. Bush administration, and Congress has not been exercised by U.S. research and development programs on space warfare. Reports of a request by the Pentagon for $14 million for a space test-bed for ballistic missile defense in the FY2004 budget could prompt more critical scrutiny about U.S. space policy by the Congress and the public.[66] These reports will certainly draw focused attention by foreign governments.

The ramifications of U.S. initiatives for space warfare require careful consideration, as are discussed in the chapters that follow. Space commerce,

[65] Accounts of the ASAT negotiations can be found in Wertheimer, "The Antisatellite Negotiations," in Carnesale and Haass (eds.), *Superpower Arms Control*, pp. 139–163; Donald L. Hafner, "Verification of ASAT Arms Control," pp. 45–73; "Anti-Satellite (ASAT) Arms Control," Committee on International Security and Arms Control, *Nuclear Arms Control, Background and Issues*, pp. 159–187; and Stares, *The Militarization of Space*, pp. 180–200.

[66] See, for instance, Kerry Gildea, "Congressional Democrats Gearing Up To Scour MDA Budget For Areas To Cut," *Defense Daily* (February 5, 2003) and Marc Selinger, "MDA Plans to Develop New Radar to Track Missiles," *Aerospace Daily* (February 4, 2003), p. 3.

U.S. relations with major powers such as China and Russia, critically important cooperative threat reduction programs, non-proliferation, and alliance relations could all be adversely affected by U.S. space warfare initiatives. There are no reports of a debate on these subjects within the Bush administration, which is preoccupied with the war against terrorism and new proliferation challenges. Nor has a debate on space warfare begun on Capital Hill, which is also preoccupied with these challenges to national security.

Before adding to these challenges by embarking on the production of new ASATs, the adverse ramifications of space warfare initiatives need to be fully vetted and weighed against the claimed advantages of embarking on this significant venture at a time when U.S. military superiority on the ground, sea, and air is unchallenged, and when U.S. power projection capabilities have never been stronger, quicker, or more capable to range over long distances.

Why should the United States initiate the flight-testing, production, or deployment of ASATs? What new military requirements would now mandate the weaponization of space? What would be gained by such an undertaking and what conceivably might be lost? These questions and others are addressed in the pages that follow.

2

Is the Weaponization of Space Inevitable?

Is the weaponization of space inevitable? If other states are bound and determined to develop, test, and deploy antisatellite (ASAT) weapons, or weapons in space that can attack objects on earth, why should the United States exercise forbearance? Indeed, a commission headed by the soon-to-be-appointed Secretary of Defense, Donald H. Rumsfeld, argued precisely this case in January 2001. The congressionally mandated Commission to Assess United States National Security Space Management and Organization concluded that space warfare was "a virtual certainty." This report concluded that the lessons of history demonstrated that "every medium—air, land, and sea—has seen conflict. Reality indicates that space will be no different." In order to avoid a "Space Pearl Harbor," this report called for the United States to develop "superior" capabilities for "power projection in, from, and through space" in order to "negate the hostile use of space against U.S. interests."[1]

If war-fighting in or from space is inevitable, it then follows that the United States should have the panoply of military capabilities not just to deter warfare in the heavens, but also to actively defend satellites in orbit that are essential for the conduct of U.S. military operations on the ground. "Space control," however, is a far more demanding pursuit. It requires the protection of satellites against attacks in space, as well as the ability to carry out offensive strikes, whether from platforms orbiting the earth or from those on the ground, sea, and air. Moreover, if the weaponization of space is a virtual certainty, it also follows that arms control efforts, whether broadly or narrowly defined, to foreclose this competition are without merit. If such a competition is foreordained, America should compete to win.

Historical inevitability is a heavily freighted and much contested concept. History can certainly repeat itself, at least in thematic terms. Consequently, knowledge of history can be a useful reference for policy formulation. But every historical chapter also contains its unique passages that are read and weighted differently by historians. Moreover, the "historical record" usually contains many blank pages reflecting unanswered questions. Even heavily

[1] "Executive Summary," in *Report of the Commission to Assess United States National Security Space Management and Organization* (Washington, DC: Commission to Assess United States National Security Space, January 11, 2001), pp. vii–xxxv.

studied episodes, such as the Cuban missile crisis, yield new insights with the release of additional interviews and archival material. We also know that historical parallels can be forced and made to conform to policy preferences. Those committed to the study of history, and thus keenly aware of its intricacies, tend to shy away from arguments that begin with the words, "History teaches." Policy advocates who employ this line of argument usually majored in other subjects. Hstorical determinism can therefore be a flawed and dangerous enterprise. As Bernard Brodie has noted, "History is at best an imperfect guide to the future, but when imperfectly understood and interpreted it is a menace to sound judgment."[2]

WHAT CONSTITUTES WEAPONIZATION?

This inquiry into the weaponization of space begins not with an assumption of historical inevitability, but with a working definition of "weaponization." Those who wish to seize the high ground of space find it useful to blur the distinction between the militarization and weaponization of space. Steven Lambakis posits that weaponization started in September 1944, "when the first German V-2 missile came rocketing down from the edge of space and exploded on the residents and buildings of London."[3] Surely, this constitutes too expansive a definition of weaponization, since the missiles in question were launched from the ground and were designed to demoralize city dwellers. This is also true for modern-day ballistic missiles. The few minutes these military instruments traverse through the heavens hardly constitute the weaponization of space, since the ballistic trajectories begin and end on the earth's surface, where psychological or military impacts are designed to be felt.

The militarization of space has proceeded steadily and inexorably since the launch of *Sputnik* in October 1957. Subsequently, many satellites have been launched to assist, enhance, or empower ground, sea, and air forces. These satellites provide targeting and weather information, as well as communication support for war fighters. The use of satellites to assist military operations is, however, far different from the flight-testing and deployment of platforms specifically designed to fight a war in or from space, or military capabilities on the ground specifically designed to kill satellites in space. Surely, these military activities would constitute space weaponization by any reasonable definition.

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[2] "War in the Atomic Age," in Bernard Brodie (ed.), *The Absolute Weapon, Atomic Power and World Order* (New York: Harcourt, Brace and Company, 1946), p. 28.

[3] Lambakis, "Putting Military Uses of Space in Context," in James Clay Moltz (ed.), *Future Security in Space: Commercial, Military, and Arms Control Trade-Offs*, Occasional Paper No. 10 (Monterey, CA: Monterey Institute of International Studies, Center for Nonproliferation Studies and University of Southhampton, Mountbatten Centre for International Studies, July 2002), pp. 23–24.

Advocates of maintaining space as a sanctuary against war-fighting view the distinction between militarization and weaponization as vital, even if the precise crossover point remains a contentious subject.

During the Cold War, the Soviet Union advanced a most peculiar and self-serving definition of space weaponization. Beginning in 1981, the Kremlin proposed a ban on stationing weapons in space, while permitting terrestrially based ASAT weapons. The active pursuit of space warfare capabilities by the Reagan administration persuaded the Kremlin to endorse more expansive constraints on weaponization.[4] Efforts by non-governmental groups to prevent the weaponization of space during this period focused on activities to be banned, rather than on specific types of weapons. Prohibited activities included deploying weapons for "destroying, damaging, rendering inoperable, or changing the flight trajectory of space objects" as well as deploying weapons in space that could damage objects in the atmosphere or on the ground.[5]

A more recent definition of a space weapon, offered by the Canadian Government, is "any device designed or modified to inflict physical or operational damage to an object in space through the projection of mass or energy."[6] This definition is certainly serviceable, as it helps to differentiate between "dedicated" weapons for space warfare that are specially designed to do harm to objects in space, as opposed to weapons or platforms designed for other purposes, such as intercontinental ballistic missiles or ballistic missile defense interceptors, that could be put to such use *in extremis*.

Designing arms control approaches that capture all such "residual" space warfare capabilities is not feasible as this would require the complete abolition of, among other things, medium- and long-range ballistic missiles, advanced missile defense interceptors, space launch capabilities for peaceful purposes and space exploration, as well as the space shuttle. At the same time, a narrow-banded approach that focuses solely on dedicated space weapons may be insufficient, if restraint in deploying dedicated ASATs is accompanied by the avid pursuit of such capabilities under other guises.

The absence of a singular, commonly accepted definition clearly suggests that space weaponization exists along a continuum, with the power projection

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[4] Office of Technology Assessment, US Congress, *Anti-Satellite Weapons, Countermeasures, and Arms Control* (Washington, DC: GPO, September 1985), p. 97.

[5] See "Appendix B: A Treaty Limiting Anti-Satellite Weapons," in John Tirman (ed.), *The Fallacy of Star Wars* (New York: Vintage Books, October 1984), pp. 280–284. In particular, see articles I and II of the proposed treaty text.

[6] "Food for Thought, The Non-Weaponization of Outer Space," Canadian non-paper, May 1, 2002, p. 5 (mimeo).

capabilities deemed necessary by the Rumsfeld Commission constituting one end of this spectrum. Some actions, such as wartime attacks on an adversary's satellites, or the destruction of targets on the ground by weapons deployed in space, clearly constitute weaponization. The initial building blocks for such capabilities, in the form of episodic, limited, and rudimentary testing of ASAT capabilities, were laid during the Cold War. The last such reported test by the Soviet Union occurred in June 1982.[7] The last reported ASAT test by the United States was in September 1985.[8] The information gleaned from these tests presumably remains accessible, and it is possible that mothballed capabilities could be reconstituted. Nonetheless, the conduct of a few ASAT tests two decades ago cannot reasonably be presumed to have constituted an irreversible watershed that cannot henceforth be dammed. Indeed, advocates of U.S. space weaponry predicate their proposals on the insufficiency of prior efforts.

Similarly, the testing to date of lasers to gauge their destructive or disabling capabilities against satellites, as well as to test the ability of satellites to withstand attack by lasers, has so far been of the most minimal kind, contrary to fears expressed during the Cold War. Soviet concerns over the potential use of U.S. directed energy weapons during the Cold War were quite pronounced after President Ronald Reagan's proposed Strategic Defense Initiative, but the technical challenges, architectural dilemmas, cost consequences, and political constraints associated with these efforts proved to be insurmountable barriers at the time.

Likewise, Reagan administration and U.S. intelligence community officials expressed serious concern over Soviet directed energy programs, predicting that,

> In the late 1980s, [the Soviets] could have prototype space-based laser weapons for use against satellites. In addition, ongoing Soviet programs have progressed to the point where they could include construction of ground-based laser antisatellite (ASAT) facilities at operational sites. These could be available by the end of the 1980s and would greatly increase the Soviets' laser ASAT capability… They may deploy operational systems of space-based lasers for antisatellite purposes in the 1990s, if their technology developments prove successful, and they can be expected to pursue development of space-based laser systems for ballistic missile defense for possible deployment after the year 2000.[9]

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[7] Michael Getler, "Soviet Missile Test: Scenario for War," *Washington Post* (June 21, 1982).

[8] Bill Keller, "Air Force Missile Strikes Satellite in First U.S. Test," *New York Times* (September 14, 1985).

[9] Department of Defense, *Soviet Military Power*, 5th ed. (Washington, DC: Government Printing Office,

These dire predictions turned out to be vastly exaggerated. The Soviet Union dissolved at about the time the Kremlin was predicted to be able to seize the high ground of space.

The reported testing to date of U.S. laser capabilities has been of a rather pedestrian kind, carried out by a laser prototype developed in the early 1980s. Originally developed as part of the Navy's SeaLite program, the Mid-Infrared Advanced Chemical Laser, or MIRACL, was considered to be of possible use in protecting aircraft carriers. This laser has a reported power output of 2 megawatts and can potentially be used to disable conveniently positioned satellites or destroy their on-board sensors. After the Congress decided there were cheaper and less technologically difficult ways to protect carriers, the MIRACL was moved to the White Sands Missile Range in New Mexico where it has been used in a variety of missile defense-related experiments. In October 1997, the Army Space and Missile Defense Command used the MIRACL to illuminate an aging Air Force satellite in the hope of gaining useful information on the vulnerability of satellites to ground-based lasers.[10] Additional, unpublicized tests to gauge the durability of U.S. satellites to directed energy attacks might subsequently have been carried out.

Considerable time and distance remain before new space warfare capabilities by means of lasers or by other directed energy weapons can be deployed. The strongest testimony as to the extent of this distance comes from frustrated proponents of the development and testing of such capabilities. The same hurdles that bedeviled directed energy programs during the Reagan administration continue in place.

The Inevitability of Militarization, Not Weaponization

At present, the crucial distinction between the militarization and weaponization of space remains in place. The militarization of space was certainly inevitable during the Cold War, because both superpowers needed satellites to observe each other's strategic capabilities and to enhance the

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1985), p. 44.

[10] Federation of American Scientists, "Mid-Infrared Advanced Chemical Laser (MIRACL)," available online at http://www.fas.org/spp/military/program/asat/miracl.htm; "Conference Urges Laser Program Termination," *Aviation Week and Space Technology* (August 15, 1983), p. 21; Michael A. Dornheim, "Laser Engages Satellite, With Questionable Results," *Aviation Week and Space Technology* (October 27, 1997), p. 27.

effectiveness of their terrestrial war-fighting capabilities.[11] Both nations orbited satellites to glean targeting information, to learn of meteorological conditions in theaters of combat, and to communicate with widely dispersed forces. Navigation satellites, although not nearly as accurate as the global positioning system (GPS) of today, were crucial for improving the accuracy of ballistic missiles. And space systems were indispensable for obscure but necessary functions like geodesic surveying, which facilitated ballistic missile accuracy by measuring perturbations in the earth's gravitational field. Satellites provided early warning of missile launches and detection of nuclear detonations. In other words, over the course of the Cold War, space became an essential adjunct for war-fighting on the ground, without becoming another theater of combat. While the militarization of space proceeded apace, the weaponization of space was avoided.

The continuum to characterize space warfare capabilities employed by the Joint Staff of the Office of the Joint Chiefs of Staff provides a useful typology in this regard. Within the domain of space operations, the Joint Staff define four primary mission areas: space control, force enhancement, space support, and force application.

> <u>Space control</u> operations provide freedom of action in space for friendly forces while, when directed, denying it to an adversary, and include the broad aspect of protection of U.S. and U.S. allied space systems and negation of enemy adversary space systems. Space control operations encompass all elements of the space defense mission and include offensive and defensive operations by friendly forces to gain and maintain space superiority and situational awareness if events impact space operations.
>
> <u>Space force enhancement</u> operations multiply joint force effectiveness by enhancing battlespace awareness and providing needed warfighter support. There are five force enhancement functions: intelligence, surveillance, and reconnaissance; integrated tactical warning and attack assessment; environmental monitoring; communications; and position, velocity, time, and navigation.

[11] See Ashton Carter, "The Current and Future Military Uses of Space," in Joseph Nye, Jr. and James Schear (eds.), *Seeking Stability in Space: Anti-Satellite Weapons and the Evolving Space Regime* (Lanham, MD: University Press of America, 1987), pp. 29–69; Paul Stares, "Space and U.S. National Security," in William Durch (ed.), *National Interest and the Military Use of Space* (Cambridge, MA: Ballinger Publishing Co., 1984), pp. 35–59. For a more recent survey see, Barry Watts, "The Current American Advantage in the Military Use of Near-Earth Space," in *The Military Use of Space: A Diagnostic Assessment* (Washington, DC: Center for Strategic and Budgetary Assessments, February 2001), pp. 33–46.

> Space support operations consist of operations that launch, deploy, augment, maintain, sustain, replenish, deorbit, and recover space forces, including the command and control network configuration for space operations. Support operations consist of spacelift, satellite operations, and deorbiting and recovering space vehicles, if required.
>
> Space force application operations consist of attacks against terrestrial-based targets carried out by military weapons systems operating in or through space. Currently, there are no space force application assets operating in space.[12]

This typology can be condensed further into three fairly distinct categories:

1. Activities that involve the direct application of force either from space, within space, or directed against objects in space from the earth's surface or atmosphere. Space force application and much of space control fall into this category.
2. Activities that clearly involve no use of force, primarily space support activities.
3. Activities that do not involve the direct application of force but that can support and enhance other activities that destroy or disable an adversary's capabilities in space, on the earth's surface, or in the atmosphere.

Clearly, category 1 activities involving space force application would constitute the weaponization of space. Additionally, space control activities resulting in the denial or negation of an adversary's spacecraft would also constitute weaponization. Included in this definition of weaponization are dedicated ASAT weapons, "defensive" weapons carried on satellites or other space objects that could be used for offensive purposes, and attacks against terrestrial-based targets carried out by military weapon systems operating in or from space. Excluded in this definition are military and civilian capabilities such as long-range ballistic missiles, space launch vehicles, and the space shuttle, which could be used as ASATs but which have clearly been designed to carry out other missions. Also excluded from this definition are category 2 and 3 activities listed above.

This construct of space weaponization falls between overly broad definitions that are unhelpful and overly narrow definitions that are insufficient. Several nations now have the capability to do significant damage to satellites in orbit, perhaps by utilizing ocean-spanning ballistic missiles, or long-range

[12] Joint Chiefs of Staff, U.S. Department of Defense, *Joint Doctrine for Space Operations*, Joint Publication 3-14 (August 9, 2002), pp. ix–x.

missile defense interceptors, or space-launch vehicles to detonate nuclear weapons above the earth's atmosphere. Space assets face other threats. The U.S. space shuttle was designed to repair and refurbish satellites, not to purposefully damage them. But it has this inherent capability. Commercially available communications equipment can be used to jam satellite uplinks and downlinks. The U.S. Air Force's Space Aggressor Squadron, which "red teams" the possible behavior of potential adversaries, assembled a satellite jamming device for $7,500 using readily available equipment. Space warfare need not take place in space, since satellite ground-control stations are susceptible to hacking and to direct attacks by air power, ground forces, and commando operations.[13]

In other words, space-faring nations or consortiums, as well as states possessing long-range missile capabilities have long possessed the capability to create havoc in space by reorienting weapon systems designed for other purposes. The deployment of advanced missile defense interceptors and the airborne laser could provide additional capabilities against satellites. These residual capabilities do not, however, constitute the weaponization of space because they have not been used for this purpose. The acquisition of new military capabilities that could be applied to space warfare increases the necessity to prevent their flight-testing in "an ASAT mode," if the distinction between militarization and weaponization is to be maintained. Cooperative monitoring arrangements are essential for this purpose.

Put another way, because it is not possible to ban military technologies and capabilities that could be used for space warfare does not mean that the weaponization of space has already occurred. This barrier remains intact as long as versatile military technologies are not used against objects in space. The existence of versatile technologies and military capabilities means that any state using them against U.S. satellites can reasonably expect retaliation in kind or other unwanted consequences. Rather than constituting an insuperable problem, residual ASAT capabilities can help deter ASAT use. Residual ASAT capabilities also can help states to conclude that they do not need to pursue dedicated ASATs in order to deter space warfare.

The essential distinction between the militarization and weaponization of space currently remains in place. Dedicated ASAT capabilities of Cold War vintage are not now deployed. Newer models are presumably in research and development behind closed doors, but flight tests of new "kinetic kill" ASATs or space mines have not been reported. And dedicated platforms for offensive

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[13] *Report of the Commission to Assess United States National Security Space Management and Organization*, pp. 19–22; William B. Scott, "Innovation Is Currency Of USAF Space Battlelab," *Aviation Week and Space Technology* (April 3, 2000), p. 52.

military operations from space remain closer to gestation than to adolescence. The Pentagon has affirmed that there are no U.S. "force application" assets now operating in space, and there are no reported weapons in space orbited by other nations. The absence of flight tests and deployments of instruments of space warfare affirm that we have not yet crossed critical thresholds associated with the weaponization of space.

COLD WAR CAUTION IN SPACE

Based on the evidence to date, a healthy degree of skepticism is warranted concerning the future inevitability of space weaponization. The strongest counter-factual argument to this deterministic hypothesis is that space weaponization has yet to occur, notwithstanding U.S. and Soviet capabilities to do so during the Cold War. During these decades, both superpowers competed intensely on military technologies that were perceived to offer significant payoffs. Unstinting efforts were devoted to the flight-testing, production, and deployment of weapon systems that had a bearing on the strategic balance. In a typical year during the Cold War, the United States and the Soviet Union conducted, on average, over 30 nuclear tests. They averaged even more missile flight tests annually. Each superpower typically produced hundreds of these missiles every year.[14] Money was not a serious constraining factor in this competition. One new nuclear warhead design followed the next, and new generations of missiles (or considerably improved variants of existing missiles) typically appeared every decade. During this intense competition for strategic advantage—or to avoid being placed at a strategic disadvantage—the United States and the Soviet Union produced approximately 125,000 nuclear weapons.[15]

In contrast, the United States and the Soviet Union proceeded with great caution to avoid the weaponization of space. The United States deployed 1,000 intercontinental ballistic missile launchers for most of the Cold War's duration. Between 1964 and 1975, Washington deployed exactly two ASAT interceptors on Johnston Island in the Pacific. During the Cold War, both superpowers tested nuclear weapons over 1,700 times. In contrast, they tested rudimentary

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[14] Throughout the Cold War, the USSR conducted 715 nuclear tests, compared to 1,015 by the United States, which equates to one nuclear test every three weeks during the Cold War. See "NRDC's Nuclear Data – Table of Known Nuclear Tests Worldwide, 1945–1996," available online at http://www.nrdc.org/nuclear/nudb/datab15.asp. For missile-related data see "NRDC's Nuclear Data - Table of US ICBM Forces from 1959–1996," available online at http://www.nrdc.org/nuclear/nudb/datab3.asp and "NRDC's Nuclear Data - Table of USSR/Russian ICBM Forces, 1960–1996," available online at http://www.nrdc.org/nuclear/nudb/datab4.asp.

[15] "NRDC Nuclear Notebook: Global Nuclear Stockpiles, 1945–2002," *Bulletin of the Atomic Scientists* 58, No. 6 (November–December 2002), pp. 103–104.

ASAT weapons 53 times, with U.S. tests mostly confined to between 1963 and 1970 (with one test of the air-launched miniature homing vehicle in 1985). Soviet flight-testing of ASATs was confined to two periods, 1968–1971 and 1976–1982.[16] ASAT capabilities remained rudimentary, at best, a pale shadow of military advances in other spheres.

Rather than elevate the superpower competition into space, Moscow and Washington tread lightly in this domain. Both superpowers deployed a total of more than four thousand satellites, but neither is known to have parked satellite killers in orbit.[17] Instead, Washington and Moscow chose to limit their competition in space by means of tacit and formal agreements. The 1963 Partial Test Ban Treaty prohibited signatories, led by the United States and the Soviet Union, from carrying out nuclear tests in the atmosphere and outer space. The 1967 Outer Space Treaty banned the placement of weapons of mass destruction in space or on celestial bodies. A 1968 multilateral agreement attended to the rescue and return of astronauts. A 1971 bilateral agreement called for notification of signs of interference with early warning systems and related communication systems associated with missile launches. Many of these critical nodes resided in space. The 1971 Hotline modernization accord predicated improved superpower communication on the protection of satellites. The 1972 Anti-Ballistic Missile Treaty expressly prohibited interference with monitoring satellites.

These accords, negotiated during a period of intense superpower competition, as well as other agreements that followed in due course, reflected deliberate decisions to refrain from turning space into a battlefield. At the same time, U.S. national space policy from the administration of President Dwight David Eisenhower through the presidency of William Jefferson Clinton, prepared for the possibility of space warfare and refused to accept U.S. disadvantages in such a competition. With the exception of the first Reagan administration, however, U.S. preferences clearly lay on the side of protecting space from warfare.

Many reasons can be deduced for such uncommon restraint amidst an intense Cold War military-technical competition in other environments. To begin with, satellites during the Cold War were primarily viewed and widely

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[16] Paul Stares, *The Militarization of Space: U.S. Policy, 1945–1984* (Ithaca, NY: Cornell University Press, 1985), pp. 117–129; Bill Keller, "Air Force Missile Strikes Satellite in First U.S. Test," *New York Times* (September 14, 1985).

[17] From 1957 to 2000, Moscow placed 3,718 payloads into orbit. The corresponding figure for the United States was 980. This disparity is not quite as stark as it may seem since Soviet satellites were designed to last for shorter time periods and hence had to be replaced with far greater regularity. See "2001 Space Almanac," *Air Force Magazine* (August 2001), available online at http://www.afa.org/magazine/space/0801alm.pdf.

understood to be closely linked to nuclear deterrence. They provided early warning of missile launches, and thus constituted the first line of defense against strategic surprise. Satellites also provided targeting information, communication, and weather data associated with nuclear war plans, and they monitored observance of nuclear arms control treaties. To blind, disable, or destroy these satellites could signal the onset of a nuclear war in which escalation was unlikely to be controlled. The nuclear force postures of both superpowers were primed to launch massive attacks quickly, so as not to be severely disadvantaged by a surprise attack. Under these circumstances, adopting first-strike postures for space warfare in the form of deployed ASAT systems to accompany first-strike postures for nuclear forces would have compounded risks for political and military leaders. Widespread, instinctual public opposition to the weaponization of space reinforced caution.

In addition, space warfare capabilities during the Cold War appeared to be either far too crude or too futuristic. One crude approach would be to detonate nuclear weapons in space. This could unquestionably create havoc with enemy satellites, but it could also create havoc with friendly satellites as well as manned space flight, as was evident with U.S. and Soviet atmospheric nuclear test programs prior to the 1963 Partial Test Ban Treaty.

Other elementary, but more discriminating, means to kill satellites were also achievable, involving direct ascent or co-orbital maneuver of dedicated ASATs, followed by a direct collision or a nearby explosion to destroy an adversary's satellite. During the Cold War, these means were demonstrated sufficiently to clarify capability, but there was little technically "sweet" or militarily efficient about them. Instead, their mission profile was entirely without subterfuge. Even limited attacks by such means, whose point of origin could not be mistaken, could open up a Pandora's Box of unintended escalation. In the time within which a successful satellite intercept could take place—if not minutes afterward—terrible retribution might be expected. In addition, satellite collisions or explosions would produce a field of debris that would be unhelpful, to say the least, to other satellites operating in a similar orbital space or path.

Technically advanced options involving space-based lasers, particle beam weapons, and other futuristic concepts did not, at least on paper, face these same roadblocks. In theory, attacks by means of futuristic, space-based technologies could be carried out quickly, without signaling hours in advance that strike preparations were underway. In addition, attacks by directed energy weapons could, in theory, effectively disable opposing satellites without creating large debris fields within orbits. However, the transfer of these concepts from paper to the laboratory and from the laboratory to the field presented significant obstacles. The cost of lifting weighty objects into space and figuring out how to defend them once they got there presented serious challenges. The technical barriers to developing directed energy weapon systems in space were quite considerable, as were problems of maintenance in the event that these challenges could be surmounted.

In addition, domestic and international political barriers against the pursuit of advanced war-fighting concepts in space were quite high. The Anti-Ballistic Missile Treaty stood in the way of testing and deployment of advanced concepts. The Treaty either needed to be artfully reinterpreted, renegotiated, or abrogated before the unfettered pursuit of these technologies could proceed. The first approach was tried during the presidency of Ronald Reagan, without success. Indeed, the Reagan administration's attempt to reinterpret the ABM Treaty to permit space-based testing and deployments of futuristic war-fighting concepts only reinforced the views of strict constructionists on Capitol Hill. Treaty renegotiation or "clarification" was effectively pursued for far less contentious matters, but was not in the cards for military options that would fundamentally nullify the treaty's core commitments. The third alternative approach—treaty abrogation or withdrawal—was not deemed feasible in a Cold War context. To do so would presumably open the sluice gates for an even more intensified strategic competition that both superpowers appeared unwilling to pursue.

Consequently, during the Cold War, advanced concepts were funded sufficiently to clarify the technical challenges involved and to generate strenuous blocking strategies. Both superpowers pursued research and development of advanced space war-fighting concepts, but these necessarily took the form of hedges rather than deployable weapons. The technologies, financial costs, and political constraints involved were too daunting to make technically advanced space warfare options realizable in a divided world dominated by two superpowers. Throughout this period, satellite vulnerability was great, but the dictates of deterrence were greater.

THEN VS. NOW

Because the weaponization of space was avoided during the Cold War, it does not necessarily follow that weaponization will continue to be avoided in a new era of asymmetric warfare. Indeed, the "virtual certainty" of space weaponization predicted by the Rumsfeld Commission report and by advocates of U.S. space dominance is presumed to be a consequence of disproportionate and growing U.S. military power. In this view, space will become another arena of asymmetric warfare because U.S. vulnerabilities and dependency on space are pronounced, both with respect to space-dependent military operations, and the vast increase in global commerce that depends upon transmissions to, in, or from space. Weaker states might therefore be sorely tempted to develop and employ space warfare capabilities in order to neutralize or degrade U.S. military advantages.

Asymmetric warfare is, of course, a two-way street. The United States could also be sorely tempted to exploit its advantages in military and space technology to accentuate terrestrial military superiority, to further reduce prospective casualties in combat, and to protect and extend U.S. advantages in space-dependent commerce. Space warfare capabilities could also be used for preemptive attack, complementing U.S. terrestrial military doctrine.

The Rumsfeld Commission's report did not dwell on, or even mention, these possibilities. Instead, it focused on foreign threats while citing historical examples and future projections. One keen analyst of U.S. space policy, Karl Mueller of the RAND Corporation, argues that the Commission's conclusion that space warfare was virtually inevitable is "based on a smattering of evidence and logic, extrapolated into facile overgeneralizations that are well-suited for television talk-show punditry but which are a poor basis for national policymaking." In this view, human nature has not filled every vacuum with weapons or warfare, with some environments and regions escaping this fate entirely. Nor is the postulate that warfare follows commerce correct in all cases. Indeed, air warfare preceded commercial aviation.[18]

The use of space to enhance military operations on Earth has, without question, accelerated since the demise of the Soviet Union. The military benefits of utilizing space have been quite lop-sided, however. By any measure, during the past decade, America's utilization of space to assist military operations has increased many fold.[19] For example, during the 1991 military campaign against Saddam Hussein, none of the U.S. air-delivered munitions were guided to their target by satellite. By the time of U.S. operations in Kosovo, they constituted 3 percent of all such munitions. That figure jumped to 32 percent by the time of operations against the Taliban and Al Qaeda in Afghanistan.[20] According to the RAND Corporation, during Operation Desert

[18] Karl P. Mueller, "Is the Weaponization of Space Inevitable?" Paper delivered at the International Studies Association Annual Convention, March 27, 2002, p. 4ff.

[19] As Barry Watts has noted, this quantitative increase was brought about by a qualitative change in how space systems are used: "Whereas U.S. space efforts had concentrated on *pre-conflict* aspects of central nuclear war and the military competition in central Europe during 1957–91, over the last decade the U.S. military has sought to redirect space efforts toward the *real-time* enhancement of ongoing, nonnuclear military operations within the earth's atmosphere [emphasis in original]." *The Military Use of Space*, p. 1, emphasis in original. Paul B. Stares forecast such a shift in *The Militarization of Space*, pp. 242–3

[20] Peter Hays, "Current and Future Military Uses of Space," presentation at Outer Space and Global Security Workshop (Geneva: November 26, 2002); also see "Defense Watch," *Defense Daily* (August 19, 2002).

Storm, the U.S. armed forces used approximately 100 megabits per second of capacity. Today, estimates of the demand for a major regional conflict range from 1.25 to 10 gigabits per second, in other words, somewhere between 10 to 100 times the amount used during the 1991 Gulf War.[21] More and more of these data will be traveling over commercial networks. During the Kosovo campaign, for example, 80 percent of the space-borne data traveled on commercial systems.[22] There is every reason to believe that assets in space will continue to help the United States to refine and accentuate its conventional war-fighting capabilities, and that other states will lag behind, seeking to utilize space to a far lesser degree for similar ends.

Given this growing disparity in utilizing space to enhance conventional war-fighting capabilities, it would not be surprising if weaker space powers were covertly developing ASAT programs. A staff background paper to the Rumsfeld Commission prominently featured a *Xinhua* news agency report on how China's military plans on defeating the U.S. military in a future conflict. The *Xinhua* article noted, "For countries that could never win a war by using the method of tanks and planes, attacking the U.S. space system may be an irresistible and most tempting choice."[23] In January 2000, the *Sing Tao* newspaper based in Hong Kong quoted Chinese sources saying that China was developing a "parasitic satellite" to be used in an ASAT mode**.** This article reported that ground testing was complete and planning had already begun to test the system in space.[24] Russia has far more ASAT capability than China, having benefited from research and development into the co-orbital interceptor during the 1960s and 1970s. Russia also pursued development of an air-launched ASAT in the late 1980s and early 1990s.[25] Both Russia and China

[21] Daniel Gonzales, *The Changing Role of the U.S. Military in Space* (Santa Monica, CA: Rand, 1999), pp. 18–23.

[22] Watts, *The Military Use of Space*, p. 41.

[23] Al Santoli, "Beijing Describes How to Defeat U.S. in High-Tech War," *China Reform Monitor* No. 331 (September 12, 2000), available online at http://www.afpc.org/crm/crm331.htm cited in Tom Wilson, *Threats to United States Space Capabilities* (Washington, DC: Prepared for the Commission to Assess United States National Security Space Management and Organization, 2001), p. 5.

[24] Cheng Ho, "China Eyes Anti-Satellite System," *Space Daily*, January 8, 2000. In January 2001, two additional articles in the Hong Kong press discussed development and testing of "parasitic" or "piggyback" ASATs. See Philip Saunders, et al, "China's Space Capabilities and the Strategic Logic of Anti-Satellite Weapons," Center for Nonproliferation Studies, Monterey Institute of International Studies (July 22, 2002), available online at http://cns.miis.edu/pubs/week/020722.htm.

[25] "Russians Alter MiG-31 For ASAT Carrier Role," *Aviation Week and Space Technology* (August 17, 1992), p. 63.

presumably are exploring directed energy weapons technology, but significant time and resources will need to be invested to field useful weapon systems.[26]

The Bush administration is also working on ASAT programs, according to published reports. The FY2004 budget request contains $14.7 million for research and development on "space control" and $82.6 million for "counterspace technologies."[27] The Defense Advanced Research Projects Agency is reportedly working on "microsatellites" that could be used in an ASAT role.[28] These circumstances, which are alarming to some and woefully insufficient to others, do not yet suggest that the weaponization of space is a virtual certainty. Indeed, the advocacy of space "dominators" and the blocking strategies of their critics have barely begun.

Ongoing research and development programs related to space warfare also suggest a continuation of hedging strategies, not unlike those adopted by the United States and the Soviet Union during the Cold War. That is, selected countries are working on research and development programs behind closed doors, either to exploit the offensive potential of space warfare, or to avoid being placed at a disadvantage by ASAT flight tests carried out by a potential adversary. In the absence of newly tested, dedicated space warfare systems, these states can continue to fall back on space warfare capabilities that are inherent in weapon systems designed for other military missions.

Contemporary circumstances are, however, significantly different from Cold War hedging strategies. Back then, over fifty ASAT tests were carried out. Since the demise of the Soviet Union, no ASAT flight tests have been reported. During segments of the Cold War, rudimentary, dedicated ASATs were overtly deployed or they were reported to be covertly deployed. At present, dedicated ASAT deployments, whether overt or covert, have not been reported. Judging by these yardsticks, space warfare is less of a virtual certainty now than during the Cold War.

Who Benefits from Asymmetric Warfare in Space?

While the conditions under which space weaponization might now occur are quite different than during the Cold War, basic questions regarding cost, benefit, and risk remain unchanged. A Reagan-era study of U.S. space policy

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[26] Robert Wall, "Directed-Energy Threat Inches Forward," *Aviation Week and Space Technology* (October 30, 2000), p. 70.

[27] The FY2004 research and development budget request is available online at http://www.dod.mil/comptroller/defbudget/fy2004/fy2004_r1.pdf.

[28] "DARPA Initiative Exploring Micro-Satellites," *Aviation Week and Space Technology* (July 29, 2002), p. 23.

options highlighted one of the fundamental questions bearing on our inquiry: Do we value the safety of our own satellites more than we value the ability to destroy satellites belonging to others?[29] Put another way, would the perceived benefits of a dominant U.S. war-fighting posture in space be durable, and would they exceed downside risks? Would military gains outweigh diplomatic, commercial, and national security losses?

After a decade of tentative multilateralism during the 1990s, it has become fashionable in some quarters to take pride in defining national security in more narrow terms. From this perspective, the first and foremost question is whether a particular course of action advances U.S. national security interests. U.S. leadership, in this view, will generate followers. How, then, does the world's sole remaining superpower wish to lead in space?

Space leadership in the past has resulted from national endeavors. But the leadership initiatives that have captured popular imagination have mostly been outside the military realm, most notably the moon landings undertaken by the United States. National leadership of this kind has not precluded multinational cooperation. Indeed, in the vast expanse of space, far more than on earth, multilateral approaches have produced strikingly successful results. The scientific exploration of space is a shared endeavor, exemplified by the International Space Station. The International Telecommunications Union has established mechanisms to allocate slots and frequencies for communication satellites, while the more *ad hoc* Inter-Agency Space Debris Coordination Committee has led the way in establishing "best practices" to mitigate the potential danger from orbiting space debris.[30]

Those who are drawn to space for exploration, science, and commerce tend to reject narrow conceptions of national interest in this domain. Non-military pursuits in space are, by their nature, inclusive as well as expansive enterprises. Indeed, Article II of the 1967 Outer Space Treaty explicitly rejects the proposition that outer space is "subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means." A balanced assessment of the net effects of space weaponization requires a broad-angle view of what national security means, and how the attempted

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[29] Office of Technology Assessment, *Arms Control in Space, Workshop Proceedings,* OTA-BP-ISC-28 (Washington, D.C.: U.S. Congress, Office of Technology Assessment, May 1984), p. 4.

[30] For a discussion of the International Telecommunications Union, see Peter Hays, *United States Military Space Into the Twenty-First Century,* INSS Occasional Paper 42 (Maxwell Air Force Base, Alabama: Air University Press, 2002), pp. 62–64. For a discussion of space debris and coordination efforts, see Nicholas L. Johnson, "Space Debris: Its Causes and Management," Presentation for the Center for Non-Proliferation Studies, Monterey Institute of International Studies (Washington, DC: July 24, 2002).

appropriation of space for warfare relates to on-going and prospective non-military pursuits that enrich our daily lives.

Others think differently. Proponents of space weaponization argue in the narrowest of terms, focusing on possible threats without evaluating their probability and keying on potential military benefits without weighing these benefits against the probable consequences of their favored pursuit.[31]

The necessity to weaponize space in order to extend U.S. military superiority on the ground, sea, and air is well worth questioning. If terrestrial military superiority can continue to be extended without taking the lead in weaponizing space, is the latter warranted? And might it be possible that U.S. terrestrial military dominance could be greatly and unnecessarily complicated by weaponizing space? Put another way, how much dominance is enough?

Basic questions also need to be asked regarding the interconnections of space weaponization and space-dependent commerce. The process of globalization and its positive distributed effects have been far more evident in space than on earth. The commercial utilization of space has been central to communications, navigation, remote sensing, timekeeping, and direct broadcasting. U.S. Space Command projects that by 2003, the Global Positioning System alone will generate $16 billion per year in revenues. In 2001, during the downturn in the telecommunications sector, the worldwide satellite industry still earned $85 billion in revenues. Before the downturn, some observers, such as space policy expert James Oberg, expected that by 2010, the cumulative U.S. investment in space could reach $500 billion to $600 billion—equaling the value of all current U.S. investments in Europe.[32]

Is the flight-testing and deployment of space warfare capabilities the best way to protect and expand these investments? Would we think the same way about protecting the banking system, telephone landlines, fiber-optic cables, electrical grids, or stock markets? Common sense suggests that the flight-testing and deployment of space warfare capabilities would not be conducive to commerce that depends on the unhindered utilization of space. Instead,

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[31] Colin Gray and John Sheldon shrug off costs, arguing that while they are debatable, they are largely irrelevant for making strategic decisions. See "Space Power and the Revolution in Military Affairs: A Glass Half Full?" *Airpower Journal* 13, no. 3 (Fall 1999), 23–38. For an example of a "capabilities-based" approach to planning, see Wilson, *Threats to United States Space Capabilities*.

[32] Also, see the testimony of General Richard B. Myers before the Subcommittee on Strategic Forces of the Senate Armed Services Committee (March 22, 1999); Satellite Industry Assocation, "Satellite Industry Indicators Survey, 2001–2002," prepared by the Futron Corporation, available online at http://www.sia.org/papers/Satellite%20Industry%20Indicators%20Survey-02.pdf; James Oberg, *Space Power Theory* (Washington, DC: GPO, 1999), pp. 15–16 available online at http://www.jamesoberg.com/books/spt/spt.hml.

insurance rates for satellite launches would likely rise, and investors in space commerce would likely become more leery.

The drive toward space weaponization would have percussive effects on space commerce. Since the vulnerabilities of commercial satellites are very great and the costs of protective measures are open-ended, cost-benefit calculations of commercial investments in space would become more problematic. Space commerce requires the minimization of space debris. The growth of commerce in space therefore requires a peaceful environment. This environment has been nurtured over the past decade by the absence of space weapons' flight-testing and deployment. Is the nurturing and expansion of space commerce now to proceed on an entirely different premise? How would proponents of the flight-testing and deployment of U.S. space warfare capabilities propose to assure commercial markets?

The United States has become so dominant militarily that any threat it faces is, *ipso facto*, asymmetric in nature. It follows that neither the United States nor its future adversaries seek or expect a level playing field. Washington will continue to utilize its military dominance to deter, defend, and defeat adversaries, while weaker foes, whether nations or terrorist cells, will seek to catch the United States off balance, either at home or at its foreign outposts. Consequently, asymmetric warfare now constitutes the basis for military strategy, whether in Afghanistan, Iraq, Aden harbor, or other outposts and symbols of American power at home and abroad.

The very nature of American power and its extraordinary extension, here on Earth as well as in space, offers a wide range of targets for adversaries. An open society whose power is built upon advanced technology networks and whose defenders maintain forward posts in dangerous neighborhoods present multiple targets that are extremely hard to defend. The potential targets for attack are so varied and numerous that priorities must be set for their protection. Where do U.S. space assets fit within this "target rich" environment for asymmetric attack? What are the most effective as well as cost-effective ways to foreclose such attacks? If preventive diplomacy and deterrence strategies fail, what are the best insurance policies to minimize adverse consequences? And where do space weapons fit within strategies to deter, defend, and defeat adversaries that engage in asymmetric warfare?

The Rumsfeld Commission's assumption that the "relative dependence of the U.S. on space makes its space systems potentially attractive targets" is not contestable.[33] Cell phones, pagers, ATM and other banking transactions, and

[33] "Executive Summary," in *Report of the Commission to Assess United States National Security Space Management and Organization*, p. viii.

the need for precise position location information have been transformed from luxuries to basic necessities for a growing number of American citizens, thanks to satellite operations. Effective and swift military operational success with a minimum of casualties and collateral damage also rest, to an unprecedented degree, on information provided by satellites. Disrupting satellite operations therefore offers adversaries multiple opportunities to generate mass inconvenience or complications in the conduct of U.S. military operations. Proponents of space weaponization argue that weaker nations unable to compete militarily with the United States on land, sea, and air, might in the future choose to do so in space.

It does not necessarily follow, however, that future adversaries will place a high priority on attacking or disrupting satellites. In the event they might, it is essential to adopt measures to increase "situational awareness" of possible threats to U.S. satellites, and to lessen U.S. vulnerabilities in space or at ground stations servicing space. These central elements of a space assurance posture can help detect and deter attacks in space on U.S. assets. They are essential to guard against disabling single-point failures and over-dependency on individual communication nodes and satellites.

If the United States adopts sensible insurance policies, most would agree that asymmetric attacks on U.S. satellites would become less likely and less successful. If, however, the United States unwisely fails to adopt these insurance policies, would asymmetric warfare in space necessarily become more likely? Whether or not these sensible measures are undertaken, other vulnerabilities and targets will continue to present themselves to U.S. adversaries. Our cities remain vulnerable, as are our ports, mass transit centers, and airports. Our computer networks continue to invite hackers. Adding to this list requires little imagination. These terrestrial targets are far more accessible to adversaries than satellites orbiting the earth. Moreover, if the object of terrorist attacks is the United States, why would an attacking country or terrorist group choose a distant target that provides services to many nations, rather than focusing on a distinctly American target?

Conventional explosives, which account for the greatest number of victims resulting from asymmetric warfare, are far easier to acquire than ASAT capabilities. Fissile material, combined with conventional explosives, can cause longer lasting disruption than acts to interfere with satellite signals. The use of a radiological weapon or a "dirty" bomb in a U.S. city center is likely to cause more profound psychological injury than the covert, temporary disruption of pagers or cell phones.[34] In other words, close-to-home scenarios of asymmetric

[34] See Michael Levi and Henry Kelly, "Weapons of Mass Disruption," *Scientific American* (November 2002), pp. 76–81; and Charles Ferguson, Tahseen Kazi, and Judith Perera, *Commercial Radioactive Sources:*

attack are far more likely to occur, and are thus likely to be far more consequential than space warfare against U.S. assets. It is also easier in most cases for the perpetrator to remain anonymous if the attack is on the ground rather than in space. And why would an adversary plan an attack in space when there are so many "soft" targets nearby?

Space warfare initiated by a far weaker adversary offers the prospect of mass disruption, whereas terrestrial attacks offer the prospect of mass disruption and mass casualties. Is poking a much stronger foe in the eye, ear, cell phone, or pager a particularly compelling strategy for those who wish to harm the United States? Terrorists and their state sponsors have chosen far different categories of targets in the past, with disturbingly successful results. Have efforts to counter terrorist designs been so successful that sworn foes would need to move from terrestrial to space warfare? It stretches credulity to argue that asymmetric warfare in space is a virtual certainty by the weak against the strong when the powerful have better means to compensate for vulnerabilities in space than on Earth.

The prioritization of threats facing the United States and U.S. friends and allies is essential for developing appropriate countermeasures. A wide spectrum of asymmetric threats continues to plague U.S. citizens and preoccupy the U.S. armed forces. These threats and appropriate responses are not in the heavens; they are thoroughly terrestrial.

Space Warfare and Regional Military Contingencies

Let us assume that a maverick leader who is a sworn foe of the United States has acquired satellite disruption or destruction capabilities. Might such a foe, fearing a U.S. invasion, initiate covert space warfare to degrade U.S. military capabilities and to signal readiness to defend supreme national interests? Let us also presume that a maverick leader possessed a nuclear weapon and a long-range missile. Might this leader detonate a nuclear weapon in low earth orbit to disable observation satellites and to greatly interfere with other U.S. military support functions?[35]

In the event of covert attacks on satellites, the perpetrator would have the choice of directing the attacks solely against U.S. space assets or disrupting

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Surveying the Security Risks, CNS Occasional Paper No. 11 (Monterey, CA: Monterey Institute of International Studies, January 2003).

[35] See Advanced Systems and Concepts Office, Defense Threat Reduction Agency, Department of Defense, *High Altitude Nuclear Detonations (HAND) Against Low Earth Orbit Satellites ("HALEOS")* (Defense Threat Reduction Agency, April 2001). Also Dennis Papadopolous , "Satellite Threat Due to High Altitude Nuclear Detonations," presentation for the Center for Nonproliferation Studies, Monterey Institute of International Studies (July 24, 2002).

multinational satellite operations, as well, either in an attempt to mask the real purpose of the attack, or in recognition that the United States would turn to other satellites for data in the event that U.S. satellites were harmed. If the first path were chosen, it would greatly narrow the list of suspect nations. The international political context in which the attacks were undertaken would provide further clues, and if the U.S. intelligence community were doing its job properly, it would be able to sift through collected data to identify the culprit. If the second path were chosen, there would be even more data points to identify the perpetrator of preemptive space warfare. The perpetrator would find little sympathy from the international community when U.S. retribution began. While these scenarios cannot be rejected out of hand, they lack plausibility because the attacker has little to gain and much to lose by attempting covert, preemptive space attacks against the United States.

There is even less to be gained and far more to lose if a maverick leader carries out preemptive space warfare by means of one or more nuclear detonations. Again, this scenario cannot be completely discounted, in part because insurance policies to protect satellites in such circumstances, such as satellite redundancy, hardening, and prompt launch capabilities, are nullified if space is purposefully irradiated in this fashion. But the "logic" behind this extremely dangerous scenario rests on the premise that it is somehow "safer" to kill satellites than to kill soldiers. As Barry Watts has noted, "Satellites may have owners and operators, but, in contrast to sailors, they do not have mothers." Killing satellites, unlike killing many American soldiers or civilians, might therefore not generate a strenuous U.S. response, or so this line of reasoning goes.[36]

In these scenarios, the distinction between killing satellites and soldiers is without practical meaning. To begin with, by killing U.S. satellites, the perpetrator would also be seeking to kill U.S. military personnel, who would be deprived of satellite-derived information in battle. Moreover, the perpetrator would cross two critically important international thresholds: the initiation of space warfare and the initiation of nuclear warfare. It is inconceivable that in these circumstances the severity of the resulting conflict would be lessened.

Proponents of testing and deploying space warfare capabilities would argue that the above, much-abbreviated analysis is far too rational and analytical.

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[36] Watts, *The Military Use of Space*, p. 29. A similar point was made by Paul Stares: "Destroying the satellite ensures denial of the benefits it gives and may be seen as less escalatory and more attractive than attacking the ground segment, because the destruction would not involve the loss of life" ("Nuclear Operations and Antisatellites," in *Managing Nuclear Operations*, p. 692). It should be noted, however, that neither observer argues that the use of nuclear weapons in space is likely. Watts argues that the costs of using a nuclear weapon in space probably outweigh the benefits for most potential adversaries (Watts, *The Military Use of Space*, p. 102).

They would argue that rational analysis does not apply to "irrational" actors who are dismissive of the reasoned dictates of deterrence theory. Two rebuttals might be offered in response. The record of maverick leaders to date suggests that they are, indeed, capable of surprising steps but, above all, they are keenly interested in maintaining power. To initiate space warfare against the United States is not a good way to maintain power. But if irrationality rules behavior, and if a maverick leader were intent on using a nuclear weapon in a losing cause, why would that leader target satellites instead of an invading army?

Asymmetric warfare in space does not favor the weak against the strong. The strong have greater means to reduce their weaknesses in space and to exploit the weaknesses of others. Moreover, weaker states have a greater chance of causing harm to the United States on the ground than in space. Attacks by weaker states against U.S. satellites would complicate and perhaps extend somewhat the Pentagon's military campaigns, but they would not change the outcome of warfare, given the dominating and growing power projection capabilities enjoyed by the United States.

Nor would attacks in space by a far weaker foe serve to protect that which the initiator of space warfare holds dear on the ground. Acts of warfare initiated in space do not grant to the perpetrator greater dispensation or relief from retaliatory strikes. Moreover, the perpetrator would find it hard to conceal his handiwork; if concealment were essential, some forms of terrestrial covert attack would offer better prospects of plausible deniability than the initiation of space warfare. In addition, attacks in space against U.S. assets are likely to prompt a fierce and devastating response, especially if the means of attack were one or more nuclear detonations.

The use of nuclear weapons in space warfare would be a widely reviled act. It would break the taboo against nuclear warfare that has withstood almost six decades of extended and costly regional warfare, including grueling land wars in Korea and Vietnam, and more than 150 lesser military engagements.[37] Nuclear testing in the atmosphere was stopped four decades ago against the backdrop of public revulsion generated by increased radiation levels. A "Space Pearl Harbor," whether or not it involves nuclear detonations in space, would leave the attacker with little international protection to face a near-term, devastating military response.

Current preoccupations about sneak attacks in space revolve less around nuclear detonations than on covert, small satellites that could serve as space mines. These satellites could be maneuvered to "park" nearby U.S. satellites,

[37] James Ciment (ed.), *The Encyclopedia of Conflicts Since World War II* (Armonk, NY: M.E. Sharpe, 1999), p. 105.

where they could be detonated on command. Alternatively, an adversary could have the means to launch, maneuver, and attach "parasitic" ASATs to U.S. platforms in space. The military effectiveness of satellite attacks by conventional means would be a function of the number and type of satellites harmed. The greater the ambitions of an adversary to harm U.S. space assets, the easier it becomes to identify the attacker. Alternatively, disabling attacks could be carried out in a more limited, covert, and plausibly deniable fashion. However, the more limited the attack, the less militarily effective it is likely to be.

None of these scenarios can be dismissed out of hand, but all appear to be far less plausible than a wide variety of asymmetric attacks that could cause widespread disruption or death by covert means here on Earth. Attacks by a weaker adversary in space would not yield military gains, except perhaps for the most temporary kind. A "Space Pearl Harbor" could, however, increase U.S. casualties on the battlefield, which would prompt a more ferocious response with superior U.S. conventional military capabilities. To further reduce the likelihood of a weaker adversary initiating space warfare against the United States, the executive and legislative branches could invest in space assurance policies that reduce U.S. vulnerabilities and risks. These insurance policies, such as improved U.S. situational awareness in space and initiatives to increase redundancy for space assets, are discussed in Chapter 3.

The possibility of a space attack by the weak against the strong warrants hedging strategies; the improbability of such an attack does not warrant the initiation of flight-testing and deployment of space weaponry. Asymmetric warfare is far more probable and worrisome on Earth than in space. The remote possibility of a "Space Pearl Harbor" should not serve as the basis for a national policy that calls for the weaponization of space.

Asymmetric Space Warfare and Preemption

Asymmetric warfare in space by the weak against the strong might temporarily complicate the attacking plans of a more powerful foe, but it would not alter the devastating result of such a contest. In contrast, asymmetric warfare in space by the strong against the weak offers the prospect of even more devastating and quicker results. As Karl Mueller has rightly noted, "[T]he only argument [for space weaponization] that can plausibly stand on its own" relates to military utility.[38] The argument of historical inevitability is too slippery a concept for space warriors to advance their agenda, and resting one's case on the vulnerability of space assets is problematic, since this implies the insufficiency

[38] Mueller, "Is the Weaponization of Space Inevitable?" p. 10.

of deterrence and ameliorative measures. The diplomatic, political, and financial costs of vigorously pursuing space weaponization can only be justified by the unvarnished magnification of U.S. military dominance.

After canvassing the arguments of proponents for space warfare capabilities, a recent RAND study cited four presumed advantages of space weapons: an ability to attack inaccessible targets, a rapid response capability, a long-range attack capability from protected distances, and a high likelihood of assured kills.[39] These capabilities could prove especially useful, in the view of advocates, in targeting hardened, underground bunkers far distant from U.S. power projection capabilities. In addition, Simon Worden and others have argued that precision, space-based weapons could provide the basis for a new deterrence strategy built on space and information dominance, thereby avoiding dilemmas associated with nuclear deterrence.[40] Might these presumed benefits against weaker foes warrant space weaponization?

These presumed benefits have already been demonstrated by U.S. power projection capabilities featuring conventional munitions of increasing range and lethality. Further advances can be expected, so advocates of U.S. space warfare capabilities have the added burden of explaining why these terrestrial advances are insufficient to support a dominant U.S. military capability, and what added value would accrue from even greater increases in lethality, promptness, and reach from space. Moreover, further improvements in the range, promptness, and lethality of terrestrial weapons are likely to come far sooner, and at a fraction of the diplomatic, political, and financial cost, than the advent of "space strike" capabilities.

Are space weapons needed to destroy hardened, underground bunkers? Existing or improved conventional weapons can serve to deny access to such facilities, thereby rendering the weapons inside unusable. The nullification of such threats could thereby be accomplished at a small fraction of the multiple costs associated with flight-testing and deploying space warfare capabilities. For the same reasons, the rationale for "improved" nuclear weapons designed for this purpose is deeply suspect.

The presumed additional deterrent value of U.S. space weapons is also questionable. If existing U.S. conventional military and nuclear superiority prove insufficient to deter, it is doubtful that the addition of space warfare capabilities would make an appreciable difference in an adversary's calculus of

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[39] Bob Preston, Dana J. Johnson, Sean Edwards, Michael Miller, and Calvin Shipbaugh, *Space Weapons Earth War* (Santa Monica, CA: RAND, 2002), pp. xx, 48.

[40] Simon P. Worden and Martin E.B. France, "Towards an Evolving Deterrence Strategy: Space and Information Dominance," *Comparative Strategy* 20, no. 5 (October–December 2001), pp. 453–466.

decision. The search to strengthen or supplant nuclear deterrence by means of space warfare capabilities will therefore appear to many as a quest to escape from, rather than "enhance," deterrence. When viewed though this lens, the pursuit of space weapons appears designed less for strengthening deterrence and more for negating the deterrents of potential adversaries.

To the extent that this perception holds, the flight-testing and deployment of space weapons is unlikely to raise the nuclear threshold, as proponents claim. To the contrary, the use of conventionally armed "space-strike" weapons could prompt unwanted escalation by threatening the nuclear forces of a weaker foe. In this event, the United States will receive little or no applause of the choice of weaponry used in preemptive strikes.

Common sense suggests that these risks be avoided and that the presumed military advantages of space warfare be pursued at far lesser cost by other war-fighting means. Dissatisfaction with Cold War era concepts of deterrence and containment appears to provide the subtext for breaking down barriers against space warfare. In this view, space weapons could help place at risk an adversary's deterrent, or help compel an adversary not to use weapons of mass destruction in the event of a military confrontation with the United States. Space-based weapons could reinforce a military posture that places importance on preventive war and preemptive strikes. Space weapons could amplify U.S. military dominance on the ground, at sea, or in the air, reducing U.S. and allied casualties in regional military contingencies against a weaker foe.

These rationales for space warfare capabilities are politically sensitive. They are not mentioned in the Bush administration's national security strategy document which elevated preemption from an option to a core element of U.S. military doctrine. Instead, the administration's national security strategy pointedly but elliptically declares that, "as a matter of common sense and self-defense, America will act against such emerging threats before they are fully formed."[41] Bush administration officials have certainly not excluded space warfare from the logic of preventative war and preemption.

Space Warfare and the Taiwan Scenario

More definition can be provided to these abstractions by analyzing the scenario of a possible crisis between the United States and China over the future of Taiwan.[42] If China possessed imaging satellites capable of locating forward-

[41] *The National Security Strategy of the United States of America* (September 2002), p. iv, available online at http://www.whitehouse.gov/nsc/nss.pdf.

[42] This discussion draws heavily from discussions with Michael O'Hanlon, a working group member and senior fellow at the Brookings Institution, who does not exclude the possible utility of ASAT use by the United States in this contingency.

deployed U.S. aircraft carriers, this targeting information could then be relayed to platforms carrying long-range, anti-ship missiles. As a consequence, U.S. aircraft carriers could be placed at acute risk. Heavy U.S. casualties could result, and depending on the status of forces in the theater, China might initially secure some military gains against Taiwan. Based on this scenario, a U.S. ASAT capability might be viewed as necessary to protect carrier operations in high-threat environments along China's periphery. By extension, just as surface combatants and submarines provide a defensive screen for carriers on the high seas, ASAT capabilities might provide a defensive screen in space. In this view, the United States might be willing to tolerate an ASAT arms competition in which its own satellites were placed at greater risk in order to ensure incapacitation of the potential enemy's ability to strike high-value American targets at sea.

To be sure, China might not need satellite capabilities in order to identify the location of U.S. carriers during a crisis over Taiwan. Indeed, satellite capabilities would provide only the most infrequent location information regarding the whereabouts of U.S. aircraft carriers, and only then, if the satellites were cued where to look by other means. In addition, the stipulated assumption of carrier vulnerability in high-threat regions is not new, since it was a staple of the Cold War. What is new in this regard is the assumption that U.S. carriers would be vulnerable to attack by China.

In this scenario, preemption, like asymmetric warfare, is a two-way street. While China could seek to carry out preemptive strikes against U.S. carriers, thereby seeking to facilitate war objectives regarding Taiwan, the United States could seek to carry out preemptive strikes against Chinese satellite capabilities and trailing ships, thereby foiling China's war plans and limiting U.S. casualties. If China were to strike preemptively against U.S. carriers, it would incur devastating retaliation by U.S. military forces, swiftly by U.S. air power, and subsequently by U.S. sea power. If China were able to secure beachheads on Taiwan, these would be pummeled unmercifully. There can be no doubt but that, in the event of a Chinese attack against U.S. naval forces in the Pacific, Washington would undertake a fearsome military response, and China would need to contemplate the prospect of Taiwan becoming independent.

In this scenario, the potential benefits of space warfare are far greater when initiated by the stronger adversary than by the weaker foe. A preemptive U.S. strike against Chinese satellites could increase the prospect of a decisive military victory with minimum casualties. A preemptive U.S. strike limited to Chinese space assets would, however, leave much to chance. If the United States were serious about limiting casualties and pursuing damage limitation in the event of a war with China across the Taiwan Strait, preemptive strikes would need to extend to other Chinese targets that could do harm to American military forces and the U.S. homeland. These strikes could also be executed from space, as well as by terrestrial means.

SATELLITE WARFARE AND ESCALATION CONTROL

The inherent escalatory potential of satellite warfare between the United States and a major power such as China is exposed by such anodyne calculations. Any analysis of this scenario for preemptive attacks on space assets—whether initiated by the United States or by China—cannot assume that strikes would be confined to satellites. Moreover, escalation control in this scenario must be considered a highly dubious proposition. After all, the purpose of attacking objects in space, or attacking terrestrial targets from space, is to affect the conduct of military operations on Earth. It is therefore exceedingly hard to envision warfare in space that does not spread elsewhere, whether by asymmetric, conventional, or unconventional means. The resulting combat is likely to be less discriminating and proportional, and far more lethal, either because the stronger party has lost satellites used for targeting and precision guidance, or because the weaker party is unlikely to be concerned about collateral damage.

Concepts of limited warfare and escalation control that were intimately associated with nuclear deterrence during the Cold War have not been propounded by U.S. advocates of space warfare. To engage in tit-for-tat, controlled warfare against satellites would suggest that the first kill of a satellite in the history of armed conflict would reflect a mere quest for balance or a novel form of message sending. The rationales provided by proponents of space control are notably different. The object of acquiring space warfare capabilities is to win, not to tie. In other words, U.S. advocates of space warfare capabilities are less interested in deterrence than in dominance and compellance.

Unlike nuclear weapons, ASAT capabilities have been tested infrequently and deployed (using a generous definition of deployment) minimally. Nuclear deterrence was based on large numbers of overt deployments of lethal capabilities regularly demonstrated at nuclear test sites that made the earth shake. ASAT capabilities, in contrast, are mostly inferential. The basic message of deterrence of space warfare during the Cold War—the prospect of mutual loss exceeding potential gains—was therefore accomplished without the heavy encumbrances and trappings of nuclear deterrence. Library shelves groan under the amount of intellectual effort devoted to deterrence theory written during the Cold War, but there has been little application of these concepts to space warfare. With respect to escalation control, however, nuclear deterrence and space warfare had, and continue to have, much in common: Both rely on threats that leave something to chance. Escalation control becomes very problematic once the threat is used.

The quest for preemptive space warfare capabilities alongside dominant conventional military capabilities is therefore bound to be viewed in worrisome terms by potential adversaries. The flight-testing and deployment of space weaponry is thus likely to generate low-cost blocking action, comparable to the countermeasures likely to be employed by states fearing the viability of prospective U.S. missile defenses. Space weaponry, like missile defenses, can be designed and sized for the limited purpose of dealing with maverick leaders. Both need not be confined to specific locations; they can go where directed. Additional deployments can be added rather quickly from covert stocks. Moreover, the goal sought by advocates of U.S. space weaponry, as well as missile defenses, is not deterrence but dominance.

Space weapons have another thing in common with missile defenses: They are both vulnerable to countermeasures. The deployment of dominating, yet vulnerable, capabilities by one state will not go unanswered by potential adversaries with access to space. Therefore, the deployment by the United States of satellite killers or battle stations in space would naturally generate company in the form of space mines or other countermeasures. Space would thus become a mixed venue, populated by satellites and satellite killers. Because of their presumed military value and because of trailing space mines, deployed space weapons would require considerable protection against attack, like the screening by surface combatants and submarines that accompany aircraft carriers at sea. An alternative to this expensive panoply of defensive measures could be to attack preemptively space mines before their deployment, but this would not only constitute the "appropriation of space" that is prohibited by international law and customary practice, it would also constitute an act of warfare against a space-faring nation or consortium claiming to exercise legitimate rights protected—or at least not prohibited—by international law.

Space warfare capabilities and preemption strategies are therefore linked, as well as inferentially advertised by the Bush administration's national security strategy. Because the prospective military utility of preemptive strikes from space, added to U.S. terrestrial strategic capabilities and prospective missile defenses, is sufficiently great to threaten the viability of the Chinese and perhaps the Russian nuclear deterrents, countermeasures could be expected. Preemption capabilities would thus become a two-way street in space. The weaker adversary would be able to gain only temporary advantage by the first use of ASAT weapons, but this would be better than ceding all advantage to the side with stronger space and terrestrial warfare capabilities. The hair trigger that characterized nuclear deterrence during the Cold War would be elevated to the heavens through the deployment of ASAT weapons. As one close observer of U.S. space policy, Bruce DeBlois of the Council on Foreign Relations, has asked, "Will this generation's legacy be to provide a constant threat of space weapons, just as the constant threat of nuclear weapons has diminished?"[43]

PROSPECTS FOR RESTRAINT

The exercise of restraint by the United States in the flight-testing and deployment of space warfare capabilities is critical for space assurance. With U.S. restraint, prospects for avoiding the elevation of a hair trigger into space grow appreciably. Conversely, by initiating the flight-testing and deployment of space warfare capabilities, or by testing military capabilities designed for other purposes in an "ASAT mode," the United States would do much to make the weaponization of space an accomplished fact.

Prospects for restraint are enhanced because the United States does not require preemptive strike options in space alongside similar terrestrial capabilities. To argue otherwise, one must believe that considerable added benefits derive from first strike options in space, and that these benefits override downside risks. Advocates of space strike capabilities must explain why such options are required atop U.S. conventional and nuclear superiority, as well as why they have confidence in the U.S. ability to control escalation and prevent significant damage to the U.S. homeland after engaging in space warfare. In the case of the Taiwan Strait scenario discussed above, advocates must explain how prospective escalation is to be controlled, and why the alternative U.S. means to negate Chinese satellite capabilities—such as by destroying satellite ground stations or by disrupting satellite transmissions—are insufficient. And if the China threat does not constitute a sound basis for taking the lead in testing and deploying space weapons, why would lesser regional contingencies constitute a more compelling rationale for "seizing" the high ground of space?

American restraint in the flight-testing and deployment of space warfare capabilities is possible because of unchallenged U.S. military dominance. While superior U.S. conventional military capabilities provide ample grounds for weaker states to hedge their bets by conducting research and development on space warfare capabilities, the U.S. ability to compete effectively in space makes it most unwise for weaker states to trigger a competition. The distinction between hedging one's bets and demonstrating capabilities through flight-testing and deployments remains crucial and maintainable with wise U.S. leadership.

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[43] Bruce DeBlois, "Space Sanctuary: A Viable National Strategy," *Airpower Journal* 12, No. 4 (Winter 1998), p. 50.

Put another way, the dominant position of the United States provides agenda-setting powers in space. The flight-testing and deployment of space warfare capabilities is surely inevitable if the United States takes the lead in this pursuit, but not if Washington maintains prudent hedges against unwelcome developments in the form of a readiness to respond in kind to any flight tests or deployments of space weapons by weaker states. These hedges, as discussed in Chapter 3, should be sufficiently persuasive to foreclose such a competition, unless weaker space-faring nations make very unwise choices.

While a hedging strategy is necessary, it is also insufficient. Hedges against the flight-testing and deployment of space warfare capabilities need to be accompanied by initiatives that underscore the positive and affirming uses of space for the benefit of humankind. Space assurance, broadly defined, also requires the reaffirmation of existing norms against the weaponization of space.

3

Hedging Against Weaponization

The growing importance of satellites for domestic and international commerce, as well as for the conduct of U.S. conventional military operations, requires assurance of quality performance. Consequently, space assurance requires steps to reduce the vulnerability of U.S. satellites and to guard against catastrophic failure. Space assurance requires many steps of a purely defensive, precautionary nature to decrease the vulnerability of U.S. satellites in the event of hostile action. These initiatives could lessen the likelihood that an adversary would seek to damage, disable, or destroy U.S. space assets by means of weapons in space or on the ground. Space assurance initiatives could also lessen the damage done to U.S. satellites if some forms of space warfare were to occur. Moreover, steps to reduce the vulnerability of U.S. satellites are necessary because other elements of a space assurance posture, particularly those relating to cooperative measures, broadly defined, might be difficult to negotiate or to implement effectively.

Vulnerability reduction can be accomplished by offensive, as well as defensive, measures. Offensive measures to reduce satellite vulnerability are defined here as the initiation of actions that disable, defeat, or destroy objects that could do U.S. satellites harm. Offensive measures can be carried out on a broad scale, including the destruction of facilities that support antisatellite (ASAT) operations, such as ground stations and launch facilities. Weapons designed to disable or kill satellites constitute one narrow subset of offensive U.S. military operations to protect U.S. satellites. This narrow subset of offensive activities presents very considerable downside risks for U.S. military, commercial, scientific, environmental, and diplomatic interests. Space warfare is antithetical to space assurance.

A hedging strategy can help minimize risks associated with refraining from the initiation of flight-testing and deployment of dedicated space warfare capabilities, while encouraging similar restraint by potential adversaries. A range of defensive measures that do not entail the use of force in or from space will be described in this chapter. The twin purposes of a hedging strategy would be to minimize any adverse consequences in the event of space warfare initiatives by other states, and to deter other states from first crossing the critical thresholds of flight-testing and deployment. Deterrence would be served by the certain knowledge of potential adversaries that negative initiatives on their part would be met by prompt and effective rejoinders by the United States. Thus, a hedging strategy requires readiness to respond purposefully in the event of unwelcome or hostile activities in space by another nation.

No aspect of a space assurance posture is more important than the identification of current and future vulnerabilities of U.S. space assets. This, in turn, mandates increased situational awareness of potential threats in space, as well as plans and programs to reduce current and future vulnerabilities. The possibility of "single point failures"—the loss of a single component or a single satellite that would result in significant or long-lasting losses of critically important data—must be dramatically reduced. Compensatory steps must be readied in the event of cyber warfare that could disrupt satellite operations. Quick and agile responses to the jamming, dazzling, or spoofing of U.S. satellites are needed.

In the future, satellites could become vulnerable to a wider variety of threats, including space mines, interceptors derived from long-range ballistic missiles and missile defense programs, or directed energy weapons, such as ground-based lasers. Rudimentary ASAT capabilities, such as those tested by the United States and the Soviet Union during the Cold War, might also reappear. These techniques are replicable, and others are achievable by a growing number of countries. For example, it is not technically challenging for many states to develop crude space mines that could lurk nearby high-value U.S. satellites.

ASAT capabilities were not tested frequently during the Cold War, perhaps owing to the critical roles satellites played as linchpins of strategic nuclear stability between the superpowers, providing hotline links for crisis diplomacy, early-warning systems of nuclear attack, and military communications central to deterrence. Attacks on these satellites would presumably be linked to an attack on deployed nuclear forces—the "bolt out of the blue" that so preoccupied U.S. strategic planners. Consequently, space was widely viewed as an environment exempt from the testing of war-fighting capabilities. Treaty provisions were negotiated seeking to affirm the maintenance of space as a global commons for the peaceful use of all nations.

The uses of space, both military and commercial, have changed dramatically since the end of the Cold War. These changes raise the possibility that the utility of space warfare might be reconsidered anew, not just by powerful states, but also by weaker states that resort to asymmetric warfare against far more powerful adversaries. Satellites are now increasingly important to global commerce and to tactical military operations. For now, these applications primarily benefit the United States and its closest allies. U.S. space assets providing reconnaissance, information processing, and communication activities are central to what has been called a "revolution in military affairs."[1] For example, during the 1991 military campaign against Saddam Hussein, none of the U.S. air-delivered munitions were guided to their target by satellites. By the time of U.S. operations in Kosovo, they constituted 3 percent of all such munitions. That figure jumped to 32 percent by the time of operations against the Taliban and al Qaeda in Afghanistan.[2] As time progresses, other nations, including potential adversaries of the United States, will increasingly be able to enhance military effectiveness on the ground through information gathered or denied from space. States able to reap these benefits will enjoy appreciable growth in military capabilities and war-fighting options. Analysts talk of "information dominance," "dominant battle space knowledge," and lifting the fog of war through use of such information networks.

While this particular revolution in military affairs was underway during the 1990s, U.S. military space policy continued along well-worn paths, reflecting a curious duality marked by a political reluctance to pursue avidly space weaponization alongside a more forward-leaning military space doctrine. Doctrine has endorsed offensive capabilities, but practice has been conservative. As the utility of satellites for conventional war-fighting purposes are repeatedly demonstrated and as the implications of this revolution in military affairs become increasingly apparent, U.S. military doctrine could begin to shift practice toward space dominance. One driver for this shift could be demonstrated or presumed efforts by weaker states to neutralize U.S. advantages in space. The second driver could be U.S. ambitions in space, freed from Cold War-era risks and constraints. For these and other reasons, a serious debate over ASAT weapons is likely to resurface for the first time since the 1980s.

Unlike Cold War arguments over ASATs, which were fueled by concerns over satellite vulnerability, a new debate will be shaped by satellite dependency, and how best to derive the benefits of unparalleled U.S. military superiority. U.S. satellites have been vulnerable for many decades against countries possessing nuclear weapons, long-range ballistic missiles, space launch, and jamming capabilities. Satellites in low earth orbit have been particularly

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[1] See William S. Cohen, *Report of the Quadrennial Defense Review* (Department of Defense, May 1997), pp. 39–51; Admiral William A. Owens with Ed Offley, *Lifting the Fog of War* (New York: Farrar, Straus, and Giroux, 2000); Stuart E. Johnson and Martin C. Libicki (eds.), *Dominant Battlespace Knowledge* (Washington, DC: National Defense University Press, 1996); Daniel Goure and Christopher M. Szara (eds.), *Air and Space Power in the New Millennium* (Washington, DC: Center for Strategic and International Studies, 1997); John Arquilla and David Ronfeldt (eds.), *In Athena's Camp: Preparing for Conflict in the Information Age* (Santa Monica, Calif.: RAND, 1997); and Admiral Arthur K. Cebrowski and John J. Garstka, "Network-Centric Warfare: Its Origin and Future," *Proceedings* (January 1998), pp. 29–35.

[2] Peter Hays, "Current and Future Military Uses of Space," presentation at Outer Space and Global Security Workshop (Geneva: November 26, 2002); also see "Defense Watch," *Defense Daily* (August 19, 2002).

vulnerable to a wide range of threats. While satellite vulnerability is not a new phenomenon, it is now discussed in the context of asymmetric warfare. Within this context, non-state actors as well as states could resort to cyber warfare to disrupt information and transmission networks that rely heavily on satellites. Additionally, new states have acquired medium-range ballistic missiles and are seeking to acquire nuclear weapons. These capabilities could be employed in space as well as in terrestrial warfare.

While satellite vulnerability has remained fairly constant (albeit with the variations described above), the growth in U.S. dependency on satellites for the conduct of military operations and for global commerce has been quite dramatic. The Department of Defense regularly utilizes commercial satellite systems for 60 percent of its spaceborne communication. During crisis or conflict, the need for surge capacity can drive this percentage higher, approaching 80 percent during the Kosovo campaign.[3] In 1998, the failure of just one satellite—the Galaxy IV—disrupted 80 to 90 percent of 45 million pagers in the United States and blocked credit card authorization at some gas pumps.[4]

The coming debate over space weaponization will necessarily focus on two critical questions: How much would the weaponization of space help or hinder U.S. conventional military operations? And how much would it help or hinder global commerce, of which the United States is the principal beneficiary? In addition, the coming debate over space weaponization will take place in entirely different geopolitical and strategic contexts. Earlier debates were framed by the Cold War struggle between the United States and the Soviet Union, a contest in which both superpowers concluded that they had more to loose than to gain in a competition to weaponize space. The coming debate will take place at a time when the United States has no peer or near-peer competitors. In addition, U.S. military space initiatives will be viewed within the context of the Bush administration's decision to elevate preemptive strikes and preventive war from options to central features of U.S. military doctrine. Future U.S. initiatives to weaponize space will increasingly be viewed through this prism by the rest of the world.

The argument presented here is that terrestrial U.S. military dominance would be impaired, rather than enhanced, by American initiatives to weaponize space. While the United States clearly has the ability to outspend competitors, and to produce more advanced types of space weaponry, weaker adversaries will

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[3] Linda Haller and Melvin Sakazaki, *Commercial Space and United States National Security* (Washington, DC: Prepared for the Commission to Assess United States National Security Space Management and Organization, 2001), p. 79 and Peter Grier, "The Investment in Space," *Air Force Magazine* (February 2000), p. 50.

[4] General Accounting Office, *Critical Infrastructure Protection: Commercial Satellite Security Should Be More Fully Addressed* GAO-02-781 (Washington, DC: August 2002), p. 1.

have affordable, asymmetric means to counter U.S. initiatives in space, as well as on earth. The net result of an uneven competition to weaponize space would be that prudent U.S. defense planners could not count on protecting space assets, and that weaker adversaries could not count on the negation of U.S. advantages. Neither could be certain of the outcome of space warfare, but both adversaries would have to fear the worst. Because of the vulnerability of space assets to ASATs, both would need to assume a dangerous "hair-trigger" posture in space—unless the United States employed preemptive military means to prevent the launch or deployment of presumably hostile space assets belonging to other states.

The likely consequences of a dynamic, but uneven, space warfare competition are not hard to envision. Potential adversaries are likely to perceive American initiatives to weaponize space as adjuncts to a U.S. military doctrine of preemption and preventive war. Depending on the scope and nature of U.S. space warfare preparations, they could also add to Chinese and Russian concerns over the viability of their nuclear deterrents. U.S. initiatives to extend military dominance into space are therefore likely to raise tensions and impact negatively on U.S.-China and U.S.-Russia relations at a time when bilateral relations have some promising, but tenuous, elements. Cooperative relations with both countries will be needed to successfully combat proliferation, but Moscow and Beijing are unlikely to tender such cooperation if they perceive that U.S. strategic objectives include the negation of their deterrents. Under these circumstances, proliferation of weapons in space would be accompanied by terrestrial proliferation.

What compelling need is there to weaponize space when American military superiority is so extensive, and terrestrial developments to extend U.S. power projection capabilities are so promising? One argument is that portions of the earth's surface are not quickly reached by conventional U.S. power projection capabilities, and that space-based weapons could remedy this apparent shortcoming. Perceived gains by somewhat longer and quicker reach into the interior of, say, Russia, China, or Iran must be weighed against the resulting impairment of U.S. diplomacy, non-proliferation efforts, and alliance ties. Moreover, space warfare initiatives would threaten commercial networks on which advanced industrial societies have become increasingly dependent. They could also impair the continuation of an extraordinary phase of scientific exploration that fosters new insights about the origins and future of our planet, our solar system, and the mysteries that lie beyond.

Conversely, those who support U.S. initiatives to dominate space are obliged to explain how the benefits of their preferred course of action exceed downside risks. Those who are adamantly opposed to U.S. initiatives to dominate space are obliged to advance an alternative posture. The alternative to space dominance proposed here is space assurance. A space assurance posture requires the adoption of defensive measures to lessen or compensate for satellite vulnerability as well as a hedging strategy against troubling initiatives undertaken by others. Steps to reduce or compensate for satellite vulnerability will be discussed next.

REDUCING SATELLITE VULNERABILITY

How vulnerable are U.S. satellites today, how vulnerable are they becoming, and what realistically could be done to reduce vulnerability? Different types of satellite orbits have common vulnerabilities, although the closer satellites are to the earth's surface, the more vulnerable they are to varied means of attack. Constellations of satellites are less vulnerable to mission failure than singular satellites that perform vital missions. For example, a remote-sensing satellite might have a twin in orbit, but the loss of one to ASAT attack is not compensated by the survival of the other.

Although it is not quite so simple in practice, most satellites can be categorized as falling within one of three main altitude zones: low earth orbit (LEO), medium earth orbit (MEO), and geosynchronous orbit (GEO). The reason to begin with such a categorization scheme is that the vulnerabilities of satellites depend fairly strongly on their altitudes.[5]

Geosynchronous orbit is located at 22,300 miles or 35,888 kilometers above the surface of the earth (although in practice satellites may be located at slightly different altitudes, and follow figure-eights in their orbits rather than tracking the earth's rotational movement exactly). Low earth orbit is not so precisely defined.[6] A generous definition would include all satellites up to at least 2,000 kilometers altitude (partially on the grounds that existing intercontinental ballistic missiles could easily reach such altitudes if used as antisatellite weapons or in an "ASAT mode"). Medium earth orbits can be defined as those falling between LEO and GEO. As a practical matter, they are concentrated between 10,000 and 20,000 kilometers above the surface of the earth. Molniya

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[5] Primers on these technical matters include Ashton B. Carter, "Satellites and Antisatellites: The Limits of the Possible," *International Security* 10, no. 4 (Spring 1986), pp. 46–98; Paul B. Stares, *Space and National Security* (Washington, DC: Brookings Institution, 1987); Peter L. Hays, *United States Military Space Into the Twenty-First Century* (Maxwell AFB, AL: Air University Press, 2002); Bob Preston, Dana J. Johnson, Sean J.A. Edwards, Michael Miller, and Calvin Shipbaugh, *Space Weapons, Earth Wars* (Santa Monica, CA: RAND, 2002).

[6] Barry Watts, *The Military Uses of Space: A Diagnostic Assessment* (Washington, DC: Center for Strategic and Budgetary Assessments, 2001), p. 9.

orbits are highly elliptical, with low points at 800 kilometers in altitude and high points at 40,000 kilometers up.[7]

Most satellites today are in LEO or GEO orbits. Each of those zones accounts for about 45 percent of all non-Russian satellites, approximately 600 of which are in active use.[8] Another 5 percent are in MEO; most of the remainder are in elliptical orbits, and most of these are Russian-owned and operated. Of the 600 total satellites now in operation, nearly 350 are for non-military or general communications, 140 for military communications and imaging, 60 for navigation, and 50 for scientific or other commercial purposes.

U.S. military satellites are primarily situated in LEO or GEO orbits. The United States reportedly operates two weather satellites in polar LEO orbits, and perhaps half a dozen high-resolution imaging satellites in that zone as well. The United States also reportedly operates ocean reconnaissance satellites and geodesic or gravity-measurement satellites in low orbit. In GEO or near-GEO orbits, the Pentagon operates roughly five defense satellite communications system satellites, a similar number of defense support program satellites for early warning of ballistic-missile launch, three MILSTAR communication satellites, perhaps nine ultra-high frequency communication satellites, one polar military satellite, and a classified number of signals intelligence satellites. In MEO are found NAVSTAR/GPS satellites.[9]

A major space power or a nation possessing ocean-spanning missiles would have the means to disable or destroy large numbers of satellites. A larger grouping of states that possess medium- or intermediate-range ballistic missiles and states possessing small nuclear arsenals could also damage or destroy satellites in LEO. An even wider array of states could employ jammers to disrupt satellite operations in all orbits. And non-state actors as well as states could resort to cyber warfare to disrupt some satellite operations.

Satellites in GEO orbit could be attacked by another satellite placed in their vicinity, although this is not a simple matter. A satellite-killing mission to GEO orbit would first require propelling the ASAT vehicle beyond the earth's atmosphere and then powering the payload on a five-hour journey to reach GEO altitudes. Such ASATs could be "parked" in GEO orbits and readied for attack

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[7] For more on this topic, see Department of Defense, Joint Chiefs of Staff, "Orbital Characteristics," in *Joint Doctrine for Space Operations*, Joint Publication 3-14, Appendix F and James Oberg, Space Power Theory (Washington, DC: GPO, 1999), pp. 23–41.

[8] Watts, *The Military Use of Space*, p. 50.

[9] *Ibid.*; "2001 Space Almanac," *Air Force Magazine* (August 2001), available online at http://www.afa.org/magazine/space/0801alm.pdf; Aviation Week and Space Technology, *2003 Aerospace Source Book* (January 13, 2003).

as needed. ASATs could come in varying sizes and weights, with some predicting small packages that are difficult to detect when placed into orbit. Work on maneuvering "microsatellites" has been reported. Analysts also suspect that work is underway on hard-to-detect space mines. Larger maneuvering "space mines" are quite likely within the technical reach of a number of countries.[10]

If attacked by a space mine or by another form of kinetic energy ASAT, be it large or small, the satellite in question would likely be damaged severely, if not destroyed. It is extremely difficult and expensive to harden satellites against explosive charges or physical contact designed to negate satellite operations. Competition in this realm heavily favors the attacker, and any state capable of sending 1,000-kg payloads over intercontinental distances, requiring 7 km/second speeds during midcourse flight, or capable of putting relatively large satellite payloads into LEO or MEO, should be quite able to mass produce and launch ASATs.

Low- to medium-power lasers fired from the ground or from an aircraft at high altitude might be able to damage sensors on imaging or missile launch detection satellites. The amount of energy needed to destroy a light sensor, or infra-red sensor, at the wavelength to which it is most sensitive is much smaller than that needed to do structural damage to a satellites. If the U.S. airborne laser program proves to be militarily as well as cost-effective, it could have capabilities against some satellites in LEO but not beyond. One could envision a very large laser on earth or in space that might reach GEO, but none exist today.

While laser attacks on satellites in LEO could be envisioned, they are not simple to execute. To begin with, the target satellite would be over the horizon of a laser for only a few minutes, and the laser might not have sufficient power to heat the target to destruction in that limited time. In addition, fire control is complicated by the fact that the laser beam cannot be seen from the ground. The usual way to acquire a target is to "paint" a raster pattern in space around the presumed location of the target, just as a television picture tube sweeps an electron beam across the face to create an image. When the laser strikes the target, a reflection would be observed, permitting the raster size to be reduced. Eventually, the laser could zero-in on the satellite and destroy it. However, all this takes some time, laser fuel, and great precision.

A vulnerability assessment for MEO orbits would reach very similar conclusions. Given their orbital tracks, satellites in MEO orbits are in some

[10] See Tom Wilson, *Threats to United States Space Capabilities* (Washington, DC: Prepared for the Commission to Assess United States National Security Space Management and Organization, 2001), pp. 28–31.

ways harder to track than those in GEO. In addition, most satellites in MEO orbit operate in constellations, meaning that the loss of a single satellite or two might not result in mission failure. Thus, in some ways, satellites operating in MEO orbits are less vulnerable or susceptible to catastrophic loss than are GEO assets. However, their lesser distance from Earth than GEO satellites could also make them vulnerable to a greater panoply of missiles used to propel ASATs. Because satellites in MEO, including those in Molniya orbits, are closer to Earth than are satellites in geostationary orbits, they can be attacked with smaller interceptor rockets or with lasers of significantly lower power than those required to engage satellites in a 24-hour orbit.

Satellites in LEO orbits are vulnerable to attacks by booster rockets used for medium-, intermediate-, as well as intercontinental ballistic missiles.[11] Cruise-missile-sized ASAT vehicles launched from aircraft, along the lines of the U.S. Pegasus program of two decades ago, could also be capable of ASAT operations in LEO.[12] Rockets in the SCUD-C class (with ranges of 500 to 600 km) can reach altitudes of 200 to 300 km with their full high-explosive payload.[13] With minor modifications, their payload could be reduced, allowing them to reach somewhat higher altitudes. Such missiles could be used to place a debris cloud in the path of a low earth orbit satellite. Medium- and intermediate- range missiles might have the ability to maneuver in order to intercept a satellite with a hit-to-kill warhead. Finally, ICBMs can be fitted with an ASAT and adapted for orbital matching against target satellites.

The combination of a SCUD-C or a missile in the No Dong class (1,300 km) with even a crude nuclear weapon in the 20-50 kiloton yield range permits a completely different and highly effective method of attacking virtually all LEO satellites with a single shot. The nuclear warhead would create an electron belt at the desired altitude, and within a matter of weeks or less virtually all satellites passing through this belt would be degraded or negated by the electron exposure. It would be much more difficult to produce such an intense electron belt at higher altitudes than a few thousand kilometers.

Orbit-matching attacks on LEO satellites are not simple to execute, as was evidenced by the failure rate of the Soviet Union's co-orbital ASAT interceptor flight tests. In the rare case of the target passing directly over the ASAT launch

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[11] David Wright and Laura Grego, "Antisatellite Capabilities of Planned US Missile Defence Systems," *Disarmament Diplomacy* no. 68 (January 2003), available online at http://www.acronym.org.uk/dd/dd68/68op02.htm.

[12] The Pegasus booster was not a cruise missile, but rather a fairly simple combination of solid fuel rockets with a homing vehicle attached. However, this contraption was similar in size and shape to a cruise missile.

[13] See David Tanks, Principal Study Investigator, *Future Challenges to U.S. Space Systems* (Cambridge, MA: Institute for Foreign Policy Analysis, 1998), pp. 6, 8.

point, then the interceptor can simply be launched at a time just preceding the passage of the target. More likely, an orbit-matching ASAT weapon will need to maneuver to become aligned with the orbital plane of the target, during which time the intent of the maneuver and its initiator may become apparent. Effectiveness requires either highly mobile ASAT launchers that can move to the orbital track or an interceptor with the ability to change orbital planes in flight. The most fuel-expensive maneuver any satellite can make, however, is a significant change in orbit plane. For that reason, orbit-matching ASATs have historically used quite powerful space launch vehicles rather than ballistic missiles.

Midcourse ballistic missile defense interceptors able to reach altitudes of 1,000 to 2,000 km could also be used as ASATs against satellites in LEO.[14] Ballistic missiles carrying nuclear weapons could do considerable damage to satellites in LEO, as was demonstrated by the STARFISH nuclear test in 1962. This test of a 1.4-megaton warhead effectively killed or disabled every satellite in LEO over a seven-month timeframe.[15]

Much lower yield nuclear detonations in space would suffice to severely damage satellites in low earth orbit. A Defense Threat Reduction Agency study concluded that a single low-yield nuclear weapon detonated at high altitude (above 100 km) can negate a majority of LEO space assets in a few months. This study estimated that tens of billions of dollars in space assets would be destroyed in such a scenario. Recovery of services provided would require several years. Reconstitution might have to wait months until the radiation levels dropped to the point where satellite electronics could survive. The total cost to replace all lost civilian satellites could be as high as $100 billion.[16]

Very small nuclear weapons, perhaps with yields as low as 1-2 kilotons, such as were detonated in Project ARGUS in the late 1950s, could produce more discriminate effects, destroying a satellite at a distance of a few hundred meters while not producing enough radiation to reduce significantly the lifetimes of other LEO assets. Nor would a low-yield nuclear weapon create an electromagnetic pulse that could damage installations on the earth.

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[14] Wright and Grego, "Antisatellite Capabilities of Planned US Missile Defence Systems."

[15] See Stares, *Space and National Security,* pp. 74–75.

[16] Advanced Systems and Concepts Office, Defense Threat Reduction Agency, Department of Defense, *High Altitude Nuclear Detonations (HAND) Against Low Earth Orbit Satellites ("HALEOS")* (Defense Threat Reduction Agency, April 2001); Dennis Papadopolous , "Satellite Threat Due to High Altitude Nuclear Detonations," presentation for the Center for Nonproliferation Studies, Monterey Institute of International Studies (July 24, 2002); "High-Altitude Nuclear Explosions: Blind, Deaf And Dumb," *Jane's Defense Weekly* (October 23, 2002).

States as well as non-state actors that do not possess nuclear weapons and ballistic missiles could still disrupt satellite operations on the ground without resorting to space weaponry. Communications with ground stations could be vulnerable to disruptive techniques. These vulnerabilities are greatest for unprotected commercial systems, on which the U.S. military depends heavily for high-data-rate exchanges of information in modern war (approaching 1 billion bits per second in the Afghanistan conflict).[17] Military satellites could also be disrupted by hostile terrestrial acts. Satellite launch sites are few in number and could be subject to attack.

Threats and Countermeasures

Satellite protection can be developed against a number of electronic and directed energy threats, but protection against explosive devices or ramming is difficult to ensure. Because protection cannot be guaranteed, satellite hardening, agility, and redundancy could provide partial, but useful, insurance against these threats. A prompt ability to reconstitute or compensate for systems that have been attacked could also foil attacking plans. A cursory survey follows of the threats facing satellites and their possible remedies.

Jamming

Space systems face jamming threats both to the communications link from the ground to the satellite and from the satellite back to the ground, or to the uplink and the downlink, respectively.[18] In general, uplink jamming is more difficult because the jammer must be roughly as powerful as the ground-based emitter in order to overwhelm the signal received at the satellite's antenna. Jamming can be complicated by techniques such as spread-spectrum transmission. Downlink jammers, on the other hand, can frequently be much less powerful and still be effective because they are much closer to the receiver than the source of the signal (the satellite). Many U.S. receivers, such as GPS systems on precision munitions, use special directional receiving antennas that mitigate all but the most intense jamming.[19] The U.S. military will shy away from solely jam-resistant communication satellites because of the high costs involved. However, it is possible to envision an improved communication

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[17] Haller and Sakazaki, *Commercial Space and United States National Security*, p. 79; Grier, "The Investment in Space," p. 50; and GAO, *Critical Infrastructure Protection*, p. 1.

[18] Satellite-to-satellite communication can also be exposed to a "crosslink" jammer. However, it is the most complex and difficult approach and viewed as a low-probability threat. GAO, *Critical Infrastructure Protection,* p. 13–14.

[19] Wilson, *Threats to United States Space Capabilities,* pp. 37–39.

architecture that mixes jam-resistant systems with fiber optic capacity and more vulnerable commercial and military satellite transmissions bandwidth.[20] Beyond communications, the U.S. military has already included antijamming features in its upgrades to the GPS satellite constellation.[21] The Defense Advanced Research Projects Agency continues to work with pseudo-satellites ("pseudolites") on the land and in the air to boost the GPS signal and "burn" through the jamming.[22] "Filters" can be added to non-space components to allow them to better sort through the jamming noise and pick up the true signal.[23]

Hardening against electromagnetic pulse

Satellites can be hardened by factors of about ten against externally generated electronic pulses created by nuclear detonations. Satellite construction costs may grow by up to perhaps 10 percent as a result, but for military satellites in particular, the added costs are hardly onerous.[24] It is more difficult to harden equipment against system-generated electromagnetic pulse phenomena, which is likely to be a dubious financial proposition for commercial satellites. Hardening against electromagnetic pulse for satellites in MEO and GEO might be less of an imperative, since distances between satellites are greater at those altitudes. On-orbit spares or replacements on the ground can substitute for those satellites rendered inoperable.

Hardening against radiation

Satellites can be hardened somewhat against electrons and other radiation generated by nuclear explosions. This is an imperative for satellites in LEO, since radiation generated from nuclear bursts can be trapped in these orbits, destroying *all* non-hardened satellites over a period of weeks or months. The resulting radiation would slowly dissipate, requiring perhaps 18 months of waiting before non-hardened replacements would experience near-normal

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[20] Daniel Gonzales, *The Changing Role of the U.S. Military in Space* (Santa Barbara, CA: RAND, 1999), p. 20.

[21] Michael Dornheim, "GPS Improvements Set to Help Civil Users," *Aviation Week and Space Technology* (September 23, 2002), p. 56.

[22] Special Projects Office, Defense Advanced Research Projects Agency, "Global Positing Experiment (GPX)," Internet: http://www.darpa.mil/spo/SPO_handouts/GPX.pdf.

[23] "Raytheon gets GPS anti-jam contract for DAE program," *Aerospace Daily* (October 11, 2002), p. 6.

[24] Advanced Systems and Concepts Office, Defense Threat Reduction Agency, Department of Defense, *High Altitude Nuclear Detonations (HAND) Against Low Earth Orbit Satellites ("HALEOS")* (Defense Threat Reduction Agency, April 2001), slides 29–30.

lifespans.[25] Hardening against radiation would add perhaps 2-5 percent to total system cost.[26] It seems unlikely that the space industry would harden its satellites without significant prompting and subsidization from government entities.[27]

An additional effect from radiation in space is "transient radiation effects on electronics," or TREE. Ionizing radiation, particularly high-energy electrons, passing through electronic equipment can cause currents to flow where they should not, short-circuiting or burning out microcircuitry. TREE can also cause highly integrated chips to fail because the charge state of the microscopic transistors in those chips is changed by the passage of a charged particle. The smaller the chip, the more transistors packed into it, the greater is the probability of such an "upset" failure. While the upset might heal, it is possible that the equipment will be out of commission for some period. If the upset is so great as to require a reboot of the software, the time lost could become extremely significant.

Hardening against explosives

It is impossible to harden satellites against direct assaults by kinetic energy ASATs. The closing velocities and masses involved are simply too great for metals to withstand. Normal closing velocities in space are likely to be between 10 and 20 km/second. Hardening against explosives or ramming is therefore likely to be expensive as well as futile. Additionally, hardening would seriously reduce the life span of the satellite and significantly raise production and launch costs without providing suitable protection.

The more refined satellite sensors are, the more likely they are to be susceptible to crude forms of attack. Adding satellite maneuverability might well be more useful than hardening or armoring. While a 10-ton imaging satellite would have a hard time escaping from a highly maneuverable homing ASAT, some potential adversaries fielding much cruder ASATs might have difficulty dealing with maneuverable targets. The costs of adding thrusters and strengthening the satellite for higher structural loads are estimated to be between 10 and 20 percent of total system costs.[28] For certain high-value satellites and

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[25] *Ibid.*, particularly slides 12–16. Also Dennis Papadopolous, "Satellite Threat Due to High Altitude Nuclear Detonations," presentation for the Center for Nonproliferation Studies, Monterey Institute of International Studies (July 24, 2002).

[26] DTRA, *"HALEOS"*, slide 31 and Wilson, *Threats to United States Space Capabilities*, p. 43.

[27] DTRA, *"HALEOS"*, slide 32. Satellites in higher orbits are necessarily hardened against the greater levels of radiation they experience without the protection of the Van Allen belts.

[28] Wilson, *Threats to United States Space Capabilities,* p. 44.

particularly those in higher orbits that have more time for evasive maneuvers, this additional cost might be deemed worthwhile.

Self-protection

An alternative to maneuverability would be to provide important satellites with their own means of self-defense, such as explosive charges or small homing missiles to destroy ASATs before they can carry out attacks. To be effective, this self-protection measure would require shooting first, rather than waiting to find out whether an approaching object were an ASAT—unless, of course, warfare has already begun. The flight-testing and deployment of weapons in space designed to defend satellites from attack would be indistinguishable, for all practical as well as for space policy purposes, from the flight-testing and deployment in space of offensive weapons. Put another way, preemptive defense of satellites could also be employed as a preemptive offense. Moreover, the military utility of defending satellites by offensive means in space might be limited against sophisticated, maneuverable ASATs. The creation of space debris resulting from an active defense in space could also impair satellite operations.

Deception

Satellites, much like advanced combat aircraft, could be designed to be "stealthier." Reducing visibility to either radar or optical systems would complicate the tracking, and hence the targeting, of satellites.[29] Further, on-board decoys could be used to divert an attack. These decoys, which would mimic the radar and optical signatures of the satellite, are estimated to increase system cost by between 1 and 10 percent.[30]

Ground station protection

Destroying ground-based control facilities associated with satellite operations may be a more feasible option for future U.S. adversaries than initiating space warfare, particularly when large constellations of target satellites are supported by a small number of terrestrial facilities, as is the case with the GPS system. In such circumstances, the loss of a few ground stations could "result in a significant decrease in GPS performance worldwide."[31] The same

[29] The United States reportedly developed a satellite with stealth features that was apparently successful in alluding Soviet and U.S. civilian observers. See Jeffrey Richelson, *The Wizards of Langley: Inside the CIA's Directorate of Science and Technology* (Cambridge, MA: Westview Press, 2001), pp. 247–249.

[30] Wilson, *Threats to United States Space Capabilities*, p. 45

[31] *Ibid.*, p. 20.

argument applies to attacks on the ground segment of observation satellites, early warning satellites, and weather satellites. Clearly, there is benefit in diversifying and multiplying ground segment nodes, as is the case for some communication satellites in GEO. Cyber attacks against critical infrastructure, including satellite operations, must receive priority attention, as this threat appears more likely than the direct threat of physical destruction or sabotage. The Homeland Security Act's inclusion of satellites within the classification of critical infrastructure should accelerate risk reduction measures in this regard.[32]

Insurance Policies

One generic approach to reducing the vulnerabilities noted above would be to present an adversary with fewer high-value targets in space. A second generic approach would be to have back-ups, spares, or alternative means ready to replace or compensate for satellite losses. If potential adversaries know or presume that multiple attacks against satellites would be required to impair American military capabilities on the ground, and that U.S. space assets could be quickly reconstituted, they might well conclude that the initiation of space warfare would be both inadvisable and unsuccessful. However, as noted above, these measures would not be successful if an adversary detonates a nuclear weapon of sufficient yield anywhere above 100 km altitude.

Another form of satellite insurance is improved situational awareness of developments in space, particularly those of a potentially threatening nature. Improved situational awareness could provide early and repeated warnings of unwelcome developments warranting a U.S. response. Increased U.S. awareness could clarify to potentially hostile states that unwelcome steps will be detected promptly, thereby increasing the prospect of deterrence, at least in some cases. In addition, increased transparency of space activities and an improved U.S. ability to characterize developments in space could help convince some potential adversaries that they cannot carry out stealthy attacks on U.S. satellites with the expectation of plausible deniability. Better tracking of space debris can be used for collision avoidance. Improved monitoring techniques could also lay the groundwork for cooperative measures in space. Lastly, steps to improve situational awareness in space could increase the possibility that future U.S. decisions regarding space warfare initiatives could be made more on the basis of informed judgment than on surmise.

Situational awareness can be improved through unilateral measures and through cooperative arrangements with other nations or consortiums that have space launch capabilities. Cooperative threat reduction measures relating to

[32] Homeland Security Act, Sec. 201(d)(5); also see GAO, *Critical Infrastructure Protection*.

space are discussed in Chapter 4. Unilateral steps to increase U.S. awareness of the space operations of others, including nations that might at some future date wish to engage in space warfare, are discussed below.

There are a number of ways in which the United States could improve situational awareness in space. Improved capabilities in X-band radars currently being developed for missile tracking as part of a national missile defense system could also be tasked for space and debris monitoring. Additional X-band systems could be brought online to supplement the current, less accurate, C-band systems. The optical cameras that track objects in space, known as the Ground-Based Electro-Optical Deep Space Surveillance System, have undergone upgrades in recent years that, when complete, will allow the system to do an adequate job at monitoring those orbits. Information collected by these sensors has to be processed, filtered, organized, and stored. These data points are then used to build models of orbits using complicated algorithms. The algorithms being used, created when computer processors were significantly slower than today, could be updated to create a more accurate picture of the environment. Automation and filtering software needs to be used to "mine" the data and minimize the time required of human operators, a significant potential bottleneck in the cataloguing process. The United States currently has no space surveillance sensors in the southern hemisphere. Agreements with friendly countries to exchange information, or simply leasing land for space surveillance facilities, could help close some of these coverage gaps. Space-based sensors would also provide expanded understanding of the threat environment. There has been some discussion of using the Space-Based Infrared Sensors–High for space threat detection.

Additionally, few, if any, current satellites appear to carry the kind of long- and short-range detection systems needed to tell if the satellite is under attack, or even being closely approached by another object. Adding an on-board system for attack reporting would likely increase total system cost by between one and five percent and would probably require some kind of low-power 360-degree radar or proximity fuse system to detect the approach of another object.[33]

Vulnerability assessments need to become more of a factor in the design of future satellites and systems. One type of insurance policy against space warfare would be to opt for more systems with less, but adequate, capability instead of far fewer satellites with significantly greater capability. In some instances, advanced technology might permit the distribution of a single

[33] United States Air Force Scientific Advisory Board, *Space Surveillance, Asteroids and Comets, and Space Debris,* vol. 1 of *Space Surveillance* (United States Air Force Scientific Advisory Board, June 1997); "Changing Space Surveillance Needs," in Gonzales, *The Changing Role of the U.S. Military in Space,* pp. 45–54; and Wilson, *Threats to United States Space Capabilities,* p. 44.

satellite's function so that no single kill would be disabling. In other instances, back-up systems should be available in the event of the loss of satellites crucial for U.S. military operations. The U.S. military could move towards larger constellations of satellites, with greater overlap in coverage, that could withstand or compensate for gaps in coverage caused by the loss of a satellite. On-orbit spares or replacements on the ground could be used for rapid reconstitution. Replacements on the ground, however, would require U.S. investment in a rapid launch capability.[34]

Even if back-ups prove less capable or efficient than the satellites lost, they would address the risks attendant to single-point failures resulting in significant degradation of U.S. military capabilities. Of particular note in this regard are advances in unmanned aerial vehicles.[35] Looking toward the future, airborne assets, particularly for imaging and signals intelligence, but also for targeting, guidance, and communications, could be available to supplement, or, if need be, help compensate for satellites that are destroyed. Significant advances in remotely piloted vehicles could reinforce the conclusion by potential adversaries that the initiation of space warfare would produce ephemeral gains and punishing retaliation. Additional backup capabilities such as fiber optic land lines and undersea lines could prove helpful in some regions of the world to permit high-volume communications even if satellites are lost. Fiber optic capability could be leased at pre-set prices for use during crisis, analogous to the way that the Civil Reserve Air Fleet functions today.[36] U.S. naval combatants can be expected to retain the ability to communicate through line-of-sight and airborne techniques, so that battle groups have the ability to function as integrated entities even if their access to satellites is disrupted. Netted tactical data link systems provide relative navigation among net members. While not as accurate as GPS, netted systems, such as the Joint Tactical Information and Distribution System, mitigate the harm caused by jamming or more pernicious damage to the GPS system.[37]

Not all of these insurance policies will be realizable. Even after adopting as many of these measures as can prudently be afforded, satellites will remain vulnerable objects that usually follow predictable paths with limited maneuvering capability. The expense of sophisticated satellites reflects, in part,

[34] Currently, assuming all components are already at the launching facility, a launch requires between 40 to 150 days of preparation. Joint Chiefs of Staff, *Joint Doctrine for Space Operations*, p. I-4.

[35] In addition to long-endurance unmanned aerial vehicles, recent work has been done on using high-altitude blimps for certain intelligence, surveillance, and reconnaissance functions.

[36] Gonzales, *The Changing Role of the U.S. Military in Space*, p. 22.

[37] See Federation of American Scientists, "Joint Tactical Information and Distribution Systems," Internet: http://www.fas.org/man/dod-101/sys/land/jtids.htm.

their complex internal workings, and their unavoidably fragile external antennas and solar panels. There are no widely effective or comprehensive remedies to these threats, just as there is no assured escape from the dangers posed by weapons of mass destruction in this uncertain world. The best possible satellite defense mechanisms, like missile defenses, cannot possibly work perfectly. Defensive measures can make attacks on satellites more difficult, more expensive, more obvious, and less consequential, but they cannot ensure survivability under attack. Threats to satellites will continue to exist much as vulnerability to weapons of mass destruction and terrorism remains a fact of modern life, despite our best efforts to protect ourselves and to deter these threats.

This is not an invitation to despair or helplessness. While the dangers of proliferation are great, we still pursue a wide array of initiatives to reduce risk and to safeguard deadly materials. Similarly, insurance policies can be pursued to reduce the risks associated with satellite vulnerability. No single satellite must become so essential that its loss would result in catastrophe. Situational awareness, redundancy, and satellite reconstitution capabilities remain sound investments in national security.

In addition, the United States will continue to rely upon deterrence to protect its space assets. The United States maintains many military capabilities designed for other purposes that could be employed against an adversary's satellites in an emergency. These latent or residual capabilities reinforce deterrence and constitute yet another form of insurance against space warfare. In this context, deterrence does not require dedicated ASATs or flight tests and deployments of space weapons, since it is well understood that weapon systems designed for other purposes have the inherent capability to disrupt or destroy satellites. Indeed, these residual capabilities are growing, as the United States pursues advanced missile defenses and the airborne laser program that are designed for other missions but that could, if needed, be utilized against the satellites of a state that initiates space warfare. There are, in sum, numerous and growing ways for the United States to convey messages abroad that those who engage in space warfare against U.S. assets can expect to fail in their intended purpose and to reap significant penalties. The United States does not need to flight-test and deploy space weapons, whether offensive or "defensive" in nature, to underscore these messages.

DOWNSIDE RISKS OF WEAPONIZATION

The United States far outstrips potential competitors in military might, defense spending, military-related space activity, and the application of technology for national security. The United States will not give away these advantages, nor react with equanimity if a geopolitical challenger seeks to close these gaps. Indeed, President George W. Bush's first national security strategy posture statement asserted that, "Our forces will be strong enough to dissuade potential adversaries from pursuing a military build-up in hopes of surpassing, or equaling, the power of the United States."[38] The question at hand is whether the United States should also apply and extend dominant military capabilities to the weaponization of space.

Two divergent policy options are available to Washington. The United States can be the first to initiate the flight-testing and deployment of instruments of space warfare. Alternatively, the United States can seek to avoid these key thresholds, while hedging bets in the event that others do not follow the U.S. lead. The first option is consistent with a space dominance or space control posture. The second option is consistent with a space assurance posture.

The choice between space assurance and space dominance is fundamentally important since it will shape the contours of international security, global commerce, alliance ties, and relations between major powers. The United States cannot have it both ways: The pursuit of space dominance will come at the expense of space assurance. And space assurance is undermined by the pursuit of space dominance.

The choice to initiate weaponization would be based on the twin presumptions that other states will surely develop and proceed to deploy such capabilities, and that the United States has more to gain than to lose by competing to win in this domain. Under this course of action, deterrence of space warfare would be based on demonstrated capabilities and deployments. In contrast, a space assurance posture would rely upon a hedging strategy. The choice of a hedging strategy rather than weaponization presumes that other states will covertly develop, but not necessarily flight test and deploy, space warfare capabilities. This choice further presumes that the acknowledged ability of the United States to compete effectively in the weaponization of space, as well as a readiness to do so, would discourage other states from crossing key thresholds first. Deterrence, in other words, would continue to be served by inherent, rather than by demonstrated, capabilities. Another presumption behind a hedging strategy is that, if other nations flight-test and deploy space weaponry before the United States, Washington will not be placed at a dangerous or long-lasting disadvantage. Still another presumption behind the adoption of a hedging strategy is that, while the United States can compete quite successfully

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[38] *The National Security Strategy of the United States* (September 2002), p. 30, available online at http://www.whitehouse.gov/nsc/nss.pdf.

in the weaponization of space, on balance this posture would produce more complications than advantages, even for the strongest competitor.

Advocacy of a hedging strategy rests on the conclusion that the risks associated with the weaponization of space far exceed the benefits to the United States. Weaker adversaries may not wish to compete with Washington in the flight-testing and deployment of space weaponry, but neither are they likely to concede this high ground entirely. The technical challenges associated with developing space mines and other crude forms of space weaponry are not severe. Weaker states would therefore have the means to counter U.S. initiatives to weaponize space at low cost.

In space, as with terrestrial missile defenses, it is far more challenging to mount a successful defense than to penetrate a soft target. Because of their threatening nature and their vulnerability, weapons designed for space warfare, whether on the ground or in orbit, would become extremely high-value targets. To prevent a precarious and dangerous mix of satellites interspersed with ASATs, the United States would seek to prevent space mines and other attacking devices either from being launched or from being parked in orbit. Alternatively, if the United States does not prevent the deployment of foreign ASATs in space, it must be prepared to wage war by shooting first and asking questions later. Military operations in space would thus be placed on continual hair-trigger alert because successful dominance in space would not be possible without the capacity for preemptive strikes or preventive measures. Having first crossed key thresholds relating to the flight-testing and deployment of space weaponry, would the United States arrogate to itself the right during peace time to carry out preemptive strikes to prevent others from following suit? And having rejected arms control arrangements prohibiting the flight-testing and deployment of space weaponry, would the United States seek to impose or dictate these constraints solely on others, and by force of arms?

It is inconceivable that a quest by the United States to enforce dominion or appropriation of space in this manner could be politically sustainable or successful against varied means of retaliation. And even if a future government of the United States attempted to destroy threats to unimpeded U.S. satellite operations, how would U.S. satellites and the space shuttle cope with the debris resulting from space warfare? The technical challenges of launching successful preemptive or preventive attacks against deployed space mines would be daunting. Attacks against some space mines would doubtless trigger hostile responses, so preemptive or preventive attacks would need to be launched against as many targets as can be identified. Would warfare of this kind be confined to space? Would the United States also attack the space launch facilities and key communication nodes of the state or states that have orbited space mines? If not, would the United States shoot down space launch vehicles or aircraft that might be carrying space mines?

These questions, and others that flow logically from them, clarify the adverse military and diplomatic ramifications that would accompany U.S. initiatives to weaponize space. Considerable skepticism is warranted that preemption or preventive war strategies can be confined to space, since satellite warfare is so intimately related to military operations on Earth.

Attacks on satellites could severely damage prospects for escalation control and, in the worst case, could trigger the use of weapons of mass destruction against U.S. expeditionary forces, allies, or the U.S. homeland. Since space warfare would not be perceived as a trivial pursuit, those nations that could be gravely disadvantaged by the flight-testing and deployment of space weaponry are likely to consider equally grave countermeasures.

At a minimum, an attempt by the United States to seek space dominance through deployed war-fighting capabilities is likely to generate the launch of relatively cheap, low-tech, but lethal ASATs by weaker adversaries. An unequal competition to weaponize space could still place at risk satellites that are essential for U.S. military communications and early warning in deep crisis. The weaponization of space could thus result in increased U.S. casualties on the conventional battlefield.

U.S. initiatives to "seize" the high ground of space are likely to be countered by asymmetric and unconventional warfare strategies carried out by far weaker states—in space and to a greater extent on Earth. In addition, U.S. initiatives associated with space dominance would likely alienate longstanding allies, as well as China and Russia, whose assistance is required to effectively counter terrorism and proliferation, the two most pressing national security concerns of this decade. No U.S. ally has expressed support for space warfare initiatives. To the contrary, U.S. initiatives to weaponize space would likely corrode bilateral relations and coalition-building efforts. Instead, the initiation of preemptive or preventive warfare in space by the United States based on assertions of an imminent threat—or a threat that cannot be ameliorated in other ways—is likely to be met with deep and widespread skepticism abroad.

The international community has long been aware of latent threats to satellites residing in military capabilities designed for other purposes. Common knowledge of such military capabilities designed for other means has not generated additional instability in crisis or escalation in wartime. The flight-testing and deployment of dedicated space weaponry would add new instability in crisis and new impulses toward escalation. It would be folly to invite these consequences unless it is absolutely necessary to do so.

Space warfare, far more than terrestrial combat, does not lend itself to the formation of "coalitions of the willing." U.S. initiatives to weaponize space could therefore result in a lonely journey that leads to war without end and to war without friends. The burdens and risks placed upon the shoulders of U.S. expeditionary forces would be exceedingly great. In addition, the quest for space dominance would undoubtedly accentuate domestic political divisions on national security issues, which results in diminished U.S. security.

Given the strong likelihood of these severe penalties, what political imperatives or military requirements could possibly justify the initiation of flight-testing and deployment of space weaponry by the United States? The military rationales posed to justify space weaponry—such as the development of global, prompt, deep-strike capabilities against high-value targets that cannot be reached quickly enough by other conventional means—appear paltry when juxtaposed against these downside risks.

The only justifiable rationale for initiating the flight-testing and deployment of space weaponry by the United States is if another state crosses these thresholds first. Then, the United States would have ample grounds to respond in kind, or to take alternative steps to negate any presumed advantages accruing from such action. To be effective in deterring the flight-testing and deployment of space weaponry by others, the United States must be prepared to respond in kind. Otherwise, the threat of a rejoinder would be hollow, and deterrence of ill-advised initiatives by others would be weakened. A hedging strategy holds out the hope that the "prisoners' dilemma" that characterized U.S.-Soviet interactions on strategic offensive forces—in which competitors took steps that weakened their security because they felt even more insecure by not reacting—can be avoided in space.

The vastly uneven power equation now in place provides a potential escape from a reprise of the prisoner's dilemma. Since weaker states would not gain meaningful advantages by initiating weaponization of space, they would be well advised not to initiate space warfare. By doing so, they will not alter the fundamentals of U.S. military superiority, nor change the outcome of warfare with the United States. Besides, weaker states need not engage in asymmetric warfare in space when it is easier to do so on the ground. Conversely, the United States does not need to dominate space in order to dominate terrestrial warfare. Consequently, the prisoners' dilemma in space can be avoided during a period of profound asymmetries in national power, just as it was avoided during the Cold War.

Given the significant costs and risks associated with the weaponization of space, and the negligible military benefits this course of action would add to U.S. military superiority, there are no compelling reasons to bear these costs other than the initiation of flight-testing and deployment of space weaponry by other states. For as long as U.S. military primacy is unchallenged and growing, and as long as potential adversaries appear to be exercising restraint in flight-testing and deploying space warfare capabilities, U.S. respect for these thresholds constitutes the prudent course—particularly when the weaponization of space causes more complications than benefits for U.S. military operations.

The thresholds of flight-testing and deployment are considered central not because a single crossing of these thresholds will irretrievably lead to the weaponization of space, but because they lend themselves best to unilateral and cooperative monitoring arrangements. Flight-testing and deployment of ASAT capabilities occurred during the Cold War, but these were of a limited nature and did not signal irrevocable interest by the two nuclear superpowers in weaponizing space. The monitoring of flight-tests and deployments of space weaponry are not without challenges, as will be discussed below. Nonetheless, these monitoring challenges pale in comparison to those associated with the risks of weaponizing space.

Additional steps clearly need to be taken, both unilateral and cooperative in nature, to provide greater assurance that other states are not crossing key thresholds in space while the United States is exercising restraint. Unilateral steps to increase situational awareness in space are essential to monitor such activities and other potential threats to U.S. satellites. Cooperative measures to provide greater assurance that other states are also exercising restraint will be discussed in Chapter 4.

ELEMENTS OF A HEDGING STRATEGY

What are the essential elements of a hedging strategy? One central goal of a hedging strategy is to provide assurance that the United States is not surprised, and technologically outdistanced, by advances in ASAT capabilities that another country is able to achieve. Another central goal is to provide assurance to potential adversaries that, should they initiate the flight-testing and deployment of space warfare capabilities, they will prompt a most unwelcome reaction by the United States.

A hedging strategy therefore requires laboratory research and development on basic ASAT technologies. Military or civilian capabilities designed for other purposes but with inherent space warfare capabilities would remain operational and would occasionally be flight-tested. Such activities must be pursuant to the primary missions that these military or civilian programs were designed to execute and they must not be carried out against target satellites. One of the most difficult challenges would be to provide assurance, though unilateral monitoring capabilities and through cooperative measures, that flight tests of military or civilian systems designed for other purposes are not covertly being tested in an "ASAT mode."

What constitutes testing in an ASAT mode? By analogy with the Anti-Ballistic Missile Treaty's definition of "testing in an ABM mode," one could define "testing in an ASAT mode" to include all attempts to intercept or damage a satellite in space, or to target any object (ballistic target vehicle) in space with a velocity comparable to that of a satellite in a circular orbit at its altitude. The particulars of such a definition—and their application to different kinds of weapons—require detailed technical analysis. Since many different types of weapon systems could carry out such tests, the answer will vary from case to case.

Ballistic missile defense tests will require special attention. Realistic testing to improve intercept capabilities against theater ballistic missiles—missiles that have now proliferated to troubled regions where the United States has allies, friends, and forward-deployed forces—is essential. Midcourse intercepts are also being carried out to provide a ground-based, limited missile defense against ocean-spanning missiles. Some of these tests provide capabilities that, in the future, might be applied to satellite intercepts. Missile defense interceptors will add to the latent or residual ASAT capabilities that the United States and other states possess.

Some blurring of the line between missile defense and ASAT tests is inherent in on-going and projected flight-testing. One way to prevent such blurring is to cease all missile defense flight tests at altitudes that are suggestive of ASAT intercepts. This is neither a feasible nor a wise course of action, given the realities of missile proliferation and the imperative to field effective missile defenses. Rather than view missile defense flight-testing as removing the barriers to space weaponry, such activities can be considered another form of insurance against ASAT tests being initiated by others. Thus, on-going missile defense flight tests can constitute another component of a hedging strategy as long as tests are not undertaken against satellites or conducted in an ASAT mode. The use of satellite targets or "points of light" that substitute for satellite targets, needs to be foreclosed in missile defense testing either by executive branch policy or by congressional action.

A hedging strategy requires that the United States strictly abstain from flight-testing and deploying space weaponry. In Chapter 2, weaponization was defined as activities that involve the direct application of force either from space, within space, or, directed against objects in space from the earth's surface or atmosphere. Additionally, "space control" activities resulting in the denial of access to space or negation of an adversary's spacecraft constitute weaponization. Included in this definition of weaponization are dedicated

ASAT weapons, “defensive” weapons carried on satellites or other space objects that could be used for offensive purposes, and attacks against terrestrial-based targets carried out by military weapons systems operating in or from space. Excluded from this definition of space weaponization are military and civilian capabilities that could be used as ASATs but which have clearly been designed to carry out other missions, such as long-range ballistic missiles, advanced missile defenses, space launch vehicles, and the space shuttle. In a hedging strategy, these capabilities must not be tested in an ASAT mode. In addition, a hedging strategy would prohibit kill mechanisms for missile defenses that are flight-tested or deployed in space. Other basing modes for missile defenses would not be constrained as long as they are not flight-tested in an ASAT mode.

More specifically, essential elements of a hedging strategy might include the following:

Pursue indoor laboratory research and development

Basic technologies and concepts that could be applied to space warfare should be explored, as they are presumably being explored by other states and because the United States needs to be able to respond to unwelcome developments in space, should they occur. There will always be unanswered questions about the status of space warfare research and development by other states, since U.S. access to these facilities will be insufficient or denied outright. Nor would the United States necessarily be willing to provide complete indoor access. Because the United States will not be in a position to know for sure how close other states are to flight-testing ASAT capabilities, at least some U.S. ASAT concepts and development programs should be sufficiently advanced to be in a position to proceed quickly with flight-testing, should this need arise.

Seek transparency and cooperative measures for flight tests

Flight-testing, unlike laboratory research and development, lends itself to unilateral and cooperative monitoring arrangements. These measures could be applied to reinforce restraints on the flight-testing of space weaponry. The status of secret laboratory research and development programs will raise many unanswered questions. The initiator of space warfare laboratory programs will also have questions over the performance and effectiveness of techniques under development. Satisfactory answers to these questions usually require moving this work to the stage of flight-testing. Flight tests normally take place at test ranges that have the specialized accoutrements needed for launch, telemetry, and tracking. Tests that are of maximum use to design teams produce reams of data.

Cooperative measures might be pursued in conjunction with flight-testing to increase transparency about mission objectives in space. These principles and procedures, which are discussed further in Chapter 4, could provide states with the means to assure others that space weapons are not being flight-tested and that prudent hedges are not being deployed. States that wish to provide such reassurance could do so in many ways. They could agree only to launch space assets from declared or agreed test ranges. They could provide advance notification of all flight tests and space launches, along with their purpose, while making sufficient data available associated with space launches to confirm their stated purpose.

States could also adapt transparency measures painfully and meticulously negotiated in the strategic arms reduction talks (START) to provide reassurance that covert flight-testing and deployment of space weapons are not taking place under other guises. The first START accord explicitly permits close proximity to shrouded payloads on nuclear-tipped missiles, as well as the mandatory provision of telemetry to facilitate monitoring of the number of "stops" a multi-warhead-carrying missile in releasing its payload. A serious effort to investigate how these provisions might be adapted for space assurance is needed. The challenge for proponents of a space assurance posture would be to adapt these and other transparency measures in ways that do not compromise essential secrets associated with the operation of U.S. national technical means.

Avoid flight-testing in an "ASAT mode"

The residual capabilities of weapon systems designed for other purposes to serve as satellite killers could both strengthen and weaken a hedging strategy. Residual capabilities could reduce the imperative to test and deploy dedicated space warfare systems, thereby strengthening a restraint regime. But residual capabilities could also be flight-tested as satellite killers without advance warning, thereby weakening a restraint regime. One way to deal with residual space warfare capabilities while reducing downside risks would be to avoid the flight-testing of these "dual use" capabilities in an ASAT mode.

For example, the midcourse missile defense intercept programs now underway in the United States could easily have capabilities against low-altitude satellites, which move at roughly the same altitudes and speeds characteristic of ballistic missile warheads. Another missile defense concept, the airborne laser, is designed primarily for intercepting relatively short-range missiles in their boost phase. In principle, it, too, could be reoriented to attack satellites passing overhead, although the power and tracking requirements may be quite different. Even though satellites would not be located in the upper atmosphere, where the airborne laser is intended to operate, they are probably no more difficult to reach with its beam than a burning rocket within the upper atmosphere.[39]

These programs would add to the residual capabilities the United States and other countries already possess—capabilities that could be applied to space warfare. These programs, which include land- and sea-based ballistic missiles and space launch vehicles, will remain operational. Additional capabilities with latent potential for space warfare will be coming on-line, such as theater missile defenses. These programs should not be cancelled or curtailed simply because they have latent ASAT potential.

The advent of new missile defense programs with latent ASAT capabilities ought to provide further grounds for the United States to seek an ASAT restraint regime, since they reinforce the hedging posture advocated here. New U.S. missile defense programs that could be applied to space warfare are also likely to reinforce hedging strategies by other states. A space assurance posture therefore requires, at a minimum, common understandings of what constitutes flight-testing in an ASAT mode for different weapon systems now under development, field-testing, or deployment.

A more challenging, but potentially far more useful, approach would be to move beyond common understandings to arrive at detailed, common definitions of what constitutes testing in an ASAT mode for different types of weapon systems. Common definitions could be advanced in "Track II" forums, meetings between governmental experts, bilateral accords, and in formal, multilateral negotiations. Drawing distinctions between "normal" flight-testing and flight-testing in an ASAT mode will be easier for some weapon systems than for others. The airborne laser, for example, would clearly be engaged in missile defense if it is directed against rising missile bodies, and will clearly be directed against satellites if tests are conducted against such targets. Arriving at common understandings or definitions will be far more challenging in the case of midcourse missile defense intercepts.

Drawing distinctions in ambiguous cases—and having sufficient assurance to maintain a hedging strategy—would depend in part upon data collected by cooperative and unilateral means. It would be advisable for states that wish to affirm that tests have not been carried out in an ASAT mode to provide sufficient data during flight tests to affirm this, and to conduct tests in such a fashion as to clarify the alternative mission a state is striving to accomplish. Cooperative measures, combined with unilateral monitoring capabilities, could alleviate concerns and reaffirm a restraint regime.

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[39] David Fulghum, "Laser Offers Defense Against Satellites," *Aviation Week and Space Technology* (October 7, 1996), p. 27.

Perhaps the hardest and most ambiguous cases relate to the testing of ground-based lasers against objects in space. The distinction between defensive tests to measure the weaknesses of one's own satellites so that better protective measures can be instituted, and offensive-oriented tests that provide data useful for disabling another country's satellites, is very difficult to draw. A flat prohibition on testing lasers against a satellite belonging to someone else would be an essential element of space assurance. But what about testing to improve satellite protection? Testing to determine satellite vulnerability and to help devise defensive measures should not be prohibited. It should, however, be carried out in an indoor laboratory setting, rather than at outdoor test ranges.

For the foreseeable future, such problems weigh far more heavily on other nations than on the United States. With the demise of the Soviet Union, the United States far outstrips and out-funds other nations in space-related activity, including directed energy programs. New outdoor laser test ranges are difficult to conceal. The construction of such facilities takes a great deal of time and expense. Thus, the United States does not need to conduct open-air laser tests in an ASAT mode out of concern that a potential adversary might resort to similar tactics. As with other space warfare technologies in which the United States holds a clear lead, a workable restraint regime that involves lasers must therefore begin at home.

Emphasize research and development on non-destructive ASAT concepts

ASAT research and development programs will not serve as useful hedges if they entail explosive means to kill threatening objects in space, since the explosive effects could produce debris that hinders U.S. satellite operations. Thus, hedging efforts by the United States ought to focus on techniques that would have minimal destructive effects. However, even if the United States were to adopt this practice, other states might not. The question of debris mitigation and steps that might be taken to address this issue are discussed in Chapter 4.

Prohibit ASAT flight tests and deployments

A hedging strategy that seeks to reinforce restraint and provide assurance is not possible unless states fail to refrain from flight-testing and deploying space weapons. If states wish to uphold a restraint regime, they will agree to employ cooperative measures sufficient to allow confidence in mutual compliance. The difficulties involved in arriving at cooperative measures that balance the needs of transparency required for assurance against the needs of maintaining secrecy cannot be underestimated. However, harder monitoring challenges have been tackled in bilateral and multilateral negotiations. The challenges identified here could be satisfactorily addressed if key states are willing to accept the requirements of space assurance instead of the consequences of demonstrated space warfare capabilities. The requirements of space assurance include a higher level of transparency and cooperation than many states—including ardent opponents of space warfare—have previously been willing to accept.

Space warfare as a last resort

A final essential element of a space assurance and a hedging strategy is the clear recognition that space ought not to become a realm where preemptive strikes and preventive war become instruments of national policy. Space warfare should be an instrument of last resort. The means to execute first strikes from space ought to be avoided because, as discussed earlier, this quest could have severe political, diplomatic, economic, and military consequences for the United States. The flight-testing and deployment of space weaponry should be pursued with great reluctance, and only in the event that a hedging strategy fails.

Even in the event that the United States flight-tests and deploys space weaponry because of the ill-advised actions of other states, the explosive destruction of satellites must be viewed as an instrument of last resort. Debris in space represents a common enemy to all space-faring nations. Other means that are well within U.S. military capabilities to disrupt the military utility of an adversary's satellites are clearly preferable to the explosive destruction of objects in space, including the jamming of satellite communications and the destruction of ground stations. Superior U.S. war-fighting capabilities on the ground permit the United States the luxury of not having to turn space into a theater of actual warfare.

4

Assurance through Cooperative Measures

Cooperative measures can help provide assurance that space will remain a reliable transmission belt for global commerce and a realm of exploration for the benefit of all humanity. Cooperative measures can also reinforce current practices in space, which are highly advantageous to U.S. military operations. These measures are an essential component of a space assurance posture. Cooperative measures can help to enhance situational awareness in space, reduce satellite vulnerability, strengthen critically important thresholds against the flight-testing and deployment of space weaponry; and reinforce a hedging strategy against adverse developments in space. Cooperative measures lend credence to efforts to prevent threatening or destabilizing activities in space, as well as to declaratory statements of peaceful intent.

To achieve these goals, cooperative measures must provide sufficient transparency to alleviate concerns over worrisome activities, particularly that military capabilities designed for other purposes are not being tested in ways that are virtually indistinguishable from preparations for space warfare. If states are sufficiently concerned about the weaponization of space, they will agree to significant, intrusive, and broad-ranging cooperative measures.

The other key elements of a space assurance posture advocated in previous chapters—increased situational awareness, restraint from crossing key thresholds first, and adoption of a hedging strategy—can be undertaken unilaterally. The steps proposed in this chapter involve cooperative behavior, whether from consultation, negotiation, or from unilateral action. Cooperative behavior can be codified in bilateral or multilateral executive agreements. Cooperative behavior could also be codified in treaty form. Alternatively, cooperative behavior might result from quiet consultations that do not yield written accords of any kind.

Diverse aspects of cooperative behavior are explored below. Several different and interconnected forms of cooperation are now needed for the reinforcement of a meaningful space assurance regime. The specific form and mix of these cooperative measures can change over time, as political, military and technical developments occur. Getting the “right” mix at the outset is therefore less important than moving forward in those areas that can result in constructive near-term progress. It makes sense to accomplish what is politically feasible and useful first, while still pursuing other avenues of cooperation in space that are not yet ripe for accomplishment. The pursuit of cooperative measures that are unlikely in the short term—such as a multilateral treaty banning certain destabilizing activities in space—could still have utility, as this effort would demonstrate international sentiment in favor of space assurance and against the flight-testing and deployment of space weaponry.

The tasks ahead are formidable. They include reaffirming broad international agreement in favor of space assurance and against the concept of space dominance, as well as particularizing the modalities that best advance this core choice. If bipartisan agreement in Washington over the strategic concept that should govern U.S. space policy is not forthcoming, the clarification of this choice elsewhere—particularly among U.S. allies, friends, and major powers—has even greater value. The particular transparency measures required for space assurance—especially those needed to provide assurance that weapon systems designed for other purposes have not been flight-tested in an antisatellite (ASAT) mode—require deeper investigation. This inquiry lacked the time and technical expertise to provide specific answers to these questions. It is hoped that others will tackle this work program, which can shape the mix, content, and progression of cooperative measures to be implemented.

While the challenges in pulling together the cooperative measures required for space assurance are significant, they pale in comparison to the national security challenges that would result from the flight-testing and deployment of space weaponry. As discussed earlier, these pursuits would result in significant political, diplomatic, commercial, and national security costs.[1] In domestic U.S. politics, they would pit the military programs favored by some directly against the negotiating pursuits favored by others—a circumstance that usually produces an outcome disappointing to all. The avid pursuit of flight-testing and the deployment of space weaponry by the United States would also likely create deeper fissures in alliance ties and relations between major powers. Such initiatives would further complicate U.S. efforts to build "coalitions of the willing" to counter proliferation and terrorism. They are also likely to cause perturbations in global commerce.

The prospects of space warfare are low at present. By virtue of its leadership position in space commerce and military power, the United States now has unprecedented capacity to shape whether space becomes weaponized.

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[1] For other recent analyses that reach similar conclusions, see Bruce DeBlois, "Space Sanctuary: A Viable National Strategy," *Airpower Journal* 12, no. 4 (Winter 1998), pp. 41–57; David Zeigler, "Safe Heavens: Military Strategy and Space Sanctuary," in Bruce DeBlois (ed.), *Beyond the Paths of Heaven: The Emergence of Space Power Thought* (Maxwell AFB, AL: Air University Press, 1999), particularly pp. 223–233; and Karl P. Mueller, "Space Weapons and U.S. Security: The Dangers of Fortifying the High Frontier," (Paper presented at the 1998 Annual Meeting of the American Political Science Association, Boston, September 3–6, 1998).

As Philip E. Coyle and John B. Rhinelander have observed, "Not since the development of the atomic bomb has the United States had an equivalent opportunity and incentive to show leadership for restraint in the development of a new class of weapons, namely weapons in space."[2] If the United States exercises restraint in the flight-testing and deployment of space weaponry, while maintaining readiness to respond if others do so first, there is a reasonable chance that these thresholds will not be crossed. If, however, the United States takes the lead in flight-testing and deploying space weaponry, other states will surely follow suit. The salience of space warfare will remain low if such techniques are not tested or deployed. They can remain even lower if the United States adopts a prudent hedging strategy.

Given the extraordinary and growing differential in power that the United States enjoys in ground warfare, sea power, and air power, it is hard to propound compelling arguments for seeking to supplement these advantages by weaponizing space. The current U.S. lead in the military utilization of space has never been greater and is unchallenged.[3] If the United States pushes to extend its pronounced military dominance into space, others will view this through the prism of the Bush administration's national security strategy, which places emphasis on preventive war and preemption. Foreign leaders will not passively accept U.S. initiatives to implement a doctrine of space dominance. They will have ample, inexpensive means to take blocking action, as it is considerably easier to negate U.S. dominance in space than on the ground, at sea, and in the air. The introduction of space weaponry and ASAT testing are therefore likely to introduce grave complications for the terrestrial military advantages that the United States has worked so hard, and at such expense, to secure.

The fundamental decision by President Dwight D. Eisenhower at the beginning of the space age to emphasize peaceful uses and to resist the weaponization of space—priorities that subsequent U.S. presidents have either respected or sought to reinforce—has served U.S. and international interests well.[4] As James Clay Moltz has noted, these priorities have provided the backdrop for extraordinary civilian and commercial space achievements, including the moon landing, Skylab, the space shuttle, and the revolution in space communications that now undergirds daily commerce and the conduct of

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[2] "Drawing the Line: The Path to Controlling Weapons in Space," *Disarmament Diplomacy*, no. 66 (September 2002), p. 5.

[3] See Bruce M. DeBlois, "Space Sanctuary: A Viable National Strategy," p. 47.

[4] For a book-length survey on the foundations of U.S. space policy, see Walter A. McDougall, *…the Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985). For the origin of the Outer Space Treaty, see Raymond L. Garthoff, "Banning the Bomb in Outer Space," *International Security*, no. 5 (Winter 1980–81), pp. 25–40.

U.S. military operations.[5] Would these achievements have been attempted or been realized if space were considered just another battlefield of the Cold War? Would future achievements in space commerce and exploration be jeopardized by weaponizing space? These activities, as well as the military support function that space provides could be seriously jeopardized with the advent of space weaponry and ASAT testing. Much has been accomplished by not weaponizing space. Much more could be accomplished by maintaining the course set by President Eisenhower than by reversing it.

During the Cold War, the linkage between military space systems and nuclear deterrence conferred a high escalatory potential to ASAT use. As Kurt Gottfried and Richard Ned Lebow concluded in 1985, when the executive branch last sought to weaponize space, "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."[6]

The particulars of escalation have necessarily changed from the Cold War to asymmetric warfare, but the inherently escalatory nature of ASAT use remains inescapable. The flight-testing and deployment of space weaponry by any nation would likely generate responses in kind, as well as asymmetric responses. U.S. battle stations in space would become prime targets in the event of warfare and thus magnets for space mines or other countering devices that would cost a small fraction of the platforms to be defended.[7] Because the presumed advantage in space warfare goes to the side that strikes first, preemption or preventive war is likely to constitute the backbone of space warfare doctrine for the defender as well as the attacker. Consequently, the deployment of space weapons would be inherently provocative and destabilizing, not only because weaker as well as stronger states would associate such weaponry with preemptive strikes, but also because distinctions between offensive and defensive weapons in space would largely cease to have practical meaning.[8]

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[5] "Breaking the Deadlock on Space Arms Control," *Arms Control Today*, 32, no. 3 (April 2002), p. 5.

[6] "Antisatellite Weapons: Weighing the Risks," in "Weapons in Space, Vol. I: Concepts and Technologies, *Daedalus* 114, no. 2 (Spring 1985), p. 148.

[7] For earlier discussions of the space mine problem and non-offensive means of countering it, see Ashton B. Carter, "Satellites and Antisatellites," *International Security* 10, no. 4 (Spring 1986), pp. 84–87 and U.S. Congress, Office of Technology Assessment, *Antisatellite Weapons, Countermeasures and Arms Control* (Washington, DC: OTA, September 1985), pp. 64–66.

[8] Analysis on the escalatory potential of antisatellite warfare, both during and after the Cold War, is very sparse. See Paul B. Stares, "Nuclear Operations and Antisatellites," in Ashton Carter, John Steinbruner, and Charles Zraket, *Managing Nuclear Operations* (Washington, DC: Brookings Institution, 1987), pp. 679–703; Gottfried and Lebow, "Antisatellite Weapons: Weighing the Risks," pp. 154–163; Office of Technology Assessment, *Arms Control in Space: Workshop Proceedings* (Washington, DC: U.S. Congress, OTA, May 1984),

Space weapons are destabilizing for other reasons, as well. Space warfare is unlikely to be confined to space, since the platforms that would be primary targets for attack support terrestrial military operations. Civil societies have worked diligently to affirm laws of war to limit dangers to noncombatants. The dictates of international law that warfare be pursued in a discriminating and proportional fashion—guidelines that are reinforced by the "revolution in military affairs" pursued by the United States—are undercut by space warfare, since satellites subject to attack provide essential services to noncombatants as well as to armies, navies, and air forces. Their destruction is likely to make orbital swaths unusable for commercial and military purposes because, even if extreme care is taken by the stronger party to employ non-destructive techniques of satellite warfare, the weaker foe is unlikely to abide by such niceties. Moreover, the destruction of satellites by whatever means is likely to trigger vigorous, but less precise military actions by the armies, navies and air forces adversely affected.

Against these troubling prospects, the challenges associated with devising cooperative measures for space assurance do not appear so daunting or so severe. Besides, many of the essential building blocks for cooperation already exist, as will be noted below. The construction of a space assurance regime does not begin from scratch; the challenge ahead is to build upon and reinforce a foundation that has already been laid. Customary national and international behavior in space is peaceful. Space assurance was practiced inferentially as well as by specific treaty provisions by the United States and the Soviet Union, even during the roughest stretches of the Cold War. An era marked by terrorism and asymmetric warfare need not result in the weaponization of space—if Washington has the wisdom to reject the siren song of space dominance, and if other capitals exercise similar restraint.

BUILDING BLOCKS FOR SPACE ASSURANCE

Existing accords, regulations, and treaties provide the building blocks for a space assurance regime. These foundation stones have been laid in response to Cold War crises, in support of nuclear risk reduction and strategic arms control agreements, and to advance space exploration, global commerce, and communication. The 1963 Hotline agreement is not usually included in this mix, but this accord utilized two satellite circuits (and one wire telegraph circuit

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pp. 12–13; DeBlois, "Space Santuary," p. 52; Donald L. Hafner, "Verification of ASAT Arms Control," in Michael Krepon and Mary Umberger (eds.), *Verification and Compliance: A Problem-Solving Approach* (New York: St. Martin's Press, 1988), pp. 47–52; Theresa Hitchens, "US Space Policy: Time to Stop and Think," *Disarmament Diplomacy*, no. 67 (October–November 2002), p. 9; "The Sanctuary Doctrine: A Fallen Star," in David Lupton, *On Space Warfare: A Space Power Doctrine* (Maxwell AFB, AL: Air University Press, 1988), pp. 51–65.

as a backup) to maintain a constantly open channel between the U.S. and Soviet leaders. The successful implementation of the Hotline agreement required both superpowers to refrain from interfering with these satellite operations.

Another bilateral accord—the 1971 "Agreement on Measures to Reduce the Risk of Outbreak of Nuclear War"—required both parties "to notify each other immediately in the event of detection by missile warning systems of unidentified objects, or in the event of signs of interference with these systems or with related communications facilities, if such occurrences could create a risk of outbreak of nuclear war between the two countries." Another provision of this executive agreement required the parties to provide advance notification "of any planned missile launches if such launches will extend beyond its national territory in the direction of the other Party." This information was to be transmitted via the Hotline. By clear inference, satellites associated with the detection of missile launches, no less than the satellites required for Hotline communications, were recognized as central to nuclear risk reduction and escalation control during the Cold War.

These inferences were explicitly recognized in the 1972 Strategic Arms Limitation Talks (SALT) agreement and the Anti-Ballistic Missile (ABM) Treaty, which blessed the use of "national technical means" (NTM) of verification "for the purposes of providing assurance of compliance," obligated both countries not to interfere with NTM operated "in a manner consistent with generally recognized principles of international law," and not to use "deliberate concealment measures" which impeded verification. While the SALT I agreement has lapsed and the ABM Treaty is no longer operative after the Bush administration's withdrawal decision, treaty protections of NTM to monitor agreed treaty obligations are also embedded in the 1974 Threshold Test Ban Treaty, the 1976 Peaceful Nuclear Explosions Treaty, the 1987 Intermediate-Range Nuclear Forces Treaty, the 1991 Strategic Arms Reduction Treaty, and the 1992 Conventional Armed Forces in Europe (CFE) Treaty.

The accomplishments of superpower arms control during the Cold War were greatly facilitated by the ability of both the United States and the Soviet Union to monitor each other's military activities by objects in space and by other technical devices. Noninterference with these national technical means, and mutual acknowledgement of their centrality to strategic and crisis stability, paved the way for more relaxed national postures toward transparency. Growing tolerance for transparency, in turn, facilitated more meaningful limits and reductions on nuclear and conventional forces. These breakthroughs were predicated on intrusive, ground-based inspections, but purposeful on-site inspections remained intimately linked to observations from space. The NTM provisions of the 1972 SALT I accords were expanded in the 1979 SALT II

Treaty, specifically the obligation not to use deliberate concealment measures during testing practices associated with the Treaty's provisions. Another "common understanding" of SALT II was that "neither Party shall engage in deliberate denial of telemetric information, such as through the use of telemetry encryption, whenever such denial impedes verification of compliance" of Treaty provisions.[9] SALT II never entered into force, but these provisions were subsequently incorporated into the first Strategic Arms Reduction Treaty (START), concluded in 1991.

One of the prior conditions for successful reductions in strategic offensive arms was the acceptance by the Kremlin of intrusive, on-site inspections. This breakthrough occurred in 1986, when the Soviet Union agreed to on-site inspections in a multilateral accord promoting confidence-building measures in Europe. Subsequently, the 1987 Intermediate-Range Nuclear Forces (INF) Treaty significantly expanded the types and numbers of inspections, allowing close observation at operational missile sites, repair facilities, storage depots, training sites, and former missile production or assembly facilities.[10] The 1991 Strategic Arms Reduction Treaty extended these inspection provisions to include warhead monitoring. This Treaty also mandated the exchange of telemetry data from missile tests.[11]

The 1993 Chemical Weapons Convention (CWC) contains far-reaching provisions for "anywhere, any time" inspections of suspect sites. Many nations, including the United States, have vitiated these extraordinary measures through conditions attached to ratification or through watered-down implementation guidelines. Serious efforts to reinvigorate the CWC's implementation would not only serve global non-proliferation interests, but could also provide building blocks for a space assurance regime, since highly intrusive monitoring would be required to confirm that space launch payloads are not prohibited ASATs. These intrusive, cooperative-monitoring arrangements can additionally have enormous utility in controlling, reducing, and eliminating dangerous weapons and materials remaining after the Soviet Union dissolved. They could also have wide-ranging applications in other regions of the world plagued by tensions and

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[9] Article XV, first and second common understandings. See Theodore J. Ralston, "Verifying Limits on Antisatellite Weapons," in Nye and Schear (eds.), p. 140, endnote 2.

[10] For a detailed account of the inspection process, see Joseph P. Harahan, *On-Site Inspections Under the INF Treaty* (Washington, DC: GPO, 1993). Inspections are covered under Article XI of the treaty and dealt with in greater detail in the accompanying Protocol Regarding Inspections.

[11] Treaty's protections of "national technical means" of verification are found in Article IX, telemetry provisions in Article X, and inspection provisions in Article XI.

deadly arsenals.[12] The building blocks for cooperative, intrusive monitoring negotiated during the Cold War could also have considerable utility if suitably adapted for space assurance, as will be discussed below.

Multilateral treaty protections of space preceded U.S.-Soviet cooperative measures oriented toward communication in crisis and arms control monitoring. The 1963 Limited Test Ban Treaty (LTBT) provided the first formal differentiation between permitted terrestrial military activities and prohibited activities in the atmosphere and in outer space. The core obligation of the LTBT, which has entered into force in 94 nations, is that parties undertake "to prohibit, to prevent, and not to carry out any nuclear weapon test explosion, or any other nuclear explosion" in the atmosphere or in outer space.

The 1967 Outer Space Treaty provides the basic framework on international space law, including the following principles:

- The exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind;
- Outer space shall be free for exploration and use by all States;
- Outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means;
- States shall not place nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner;
- The Moon and other celestial bodies shall be used exclusively for peaceful purposes;
- Astronauts shall be regarded as the envoys of mankind;
- States shall be responsible for national space activities whether carried out by governmental or non-governmental entities;
- States shall be liable for damage caused by their space objects; and
- States shall avoid harmful contamination of space and celestial bodies.[13]

[12] For a book-length elaboration of this argument, see Michael Krepon, *Cooperative Threat Reduction, Missile Defense, and the Nuclear Future* (New York: Palgrave, 2003).

[13] These principles were largely drawn from prior deliberation in the United Nations General Assembly, particularly the General Assembly's Declaration of Legal Principles Governing the Activities of States in the

Explicit provisions barring the use of weapons of mass destruction for space warfare are central to the 1967 Outer Space Treaty, which has been ratified by 62 countries, including India, Iraq, Israel, Russia, the United States, and every country in the European Union. China and Iran have announced support for the Outer Space Treaty but have not yet deposited their instruments of ratification. Under the terms of this treaty, weapons of mass destruction are barred from outer space, as are "the establishment of military bases, installations and fortifications." The "testing of any type of weapons and the conduct of military maneuvers on celestial bodies" are also forbidden. The Outer Space Treaty establishes the principle that governments are responsible for space-related activities carried out within national borders and for assuring treaty compliance "whether such activities are carried on by government agencies or by non-governmental entities." When space activities are undertaken by international consortiums, responsibility for compliance "shall be bourne both by the international organization and by the States Parties to the Treaty participating in such organization."

The United Nations has played a central role in establishing treaty provisions and mechanisms to promote cooperative measures and "rules of the road" in space. An agreement on the rescue and return of astronauts and "the return of objects launched into outer space" was signed in 1968, adding content and specificity to the Outer Space Treaty. This multilateral treaty, as with its predecessor, was expressly negotiated "to promote international cooperation in the peaceful exploration and use of outer space." A Convention on International Liability for Damage Caused by Space Objects, signed in 1972, established the principle that the launching state "shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the Earth or to aircraft flight."

In 1975, the United Nations midwifed a Convention on Registrations of Objects Launched into Outer Space for the express purpose of establishing and maintaining a mandatory "central register of objects launched into outer space." The preambular language of this Convention includes statements of intent drawn from previous accords:

> *Desiring* also to provide for States Parties additional means and procedures to assist in the identification of space objects…
>
> *Believing* that a mandatory system of registering objects launched into outer space would, in particular, assist in their identification and would

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Exploration and Use of Outer Space, 1962 (XVIII). (The characterization of the Outer Space Treaty's general principles is drawn verbatim from www.oosa.unvienna.org/treat/ost/ost.html.)

> contribute to the application and development of international law governing the exploration and use of outer space…

This Convention obligates all States Parties to establish a national register of objects it has launched into space, and to furnish to the Secretary-General of the United Nations, "as soon as practicable," the following information from its registry: the name of the launching state or states, an appropriate designator of the space object or its registration number, the date and territory or location of launch, basic orbital parameters, including nodal period, inclination, apogee, perigee, and general function of the space object. The Convention further provides that participating states "may, from time to time, provide the Secretary-General of the United Nations with additional information concerning a space object carried on its registry," and that states "shall notify the Secretary-General of the United Nations, to the greatest extent feasible and as soon as practicable, of space objects concerning which it has previously transmitted information, and which have been but no longer are in earth orbit."

Executive agreements between the United States and the Soviet Union have also reinforced the centrality and utility of objects in space for nuclear risk reduction. By inference, the loss of these space objects by reason of attack or by other means could have grave consequences for the conduct of warfare and for escalation control. The successful functioning of nuclear risk reduction centers, established by the United States and Soviet Union in 1987, is dependent upon the integrity of direct satellite links that can transmit rapidly text and graphics. While the nuclear risk reduction centers are not intended to have a crisis management role—their principal function is to exchange information and notifications required under various arms control treaties and other confidence-building agreements—they can be used to transmit information in a crisis.[14]

Executive agreements that relate to cooperative measures associated with military-related activities on Earth, especially the avoidance of dangerous military activities, could also, by extension, provide useful building blocks for a space assurance regime. For example, the 1988 Ballistic Missile Launch Notification Agreement between the United States and the Soviet Union, provides for notification, no less than 24 hours in advance, of the planned date, launch area, and area of impact for any launch of an intercontinental ballistic

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[14] For more on the functioning of Nuclear Risk Reduction Centers, see Barry M. Blechman and Michael Krepon, *Nuclear Risk Reduction Centers* (Washington DC: Center for Strategic and International Studies, 1986); and *The U.S. NRRC: 1988–2002* (Washington, DC: Department of State, 2002). Additional analysis can be found in Richard K. Betts, "A Joint Nuclear Risk Reduction Center," in Barry Blechman (ed.), *Preventing Nuclear War: A Realistic Approach* (Bloomington: Indiana University Press, 1985), pp. 65–85 and "A Nuclear Risk Reduction System: The Interim Report of the Nunn-Warner Working Group on Nuclear Risk Reduction," in Blechman (ed.), *Preventing Nuclear War*, appendix A, pp. 167–71.

missile (ICBM) or a submarine-launched ballistic missile (SLBM). This Agreement also provides that these notifications be provided through the nuclear risk reduction centers.[15] The specific time line for notification in this accord is far superior to the Registration Convention's requirement to do so "as soon as practicable." Notifications regarding ICBM and SLBM launches could, in principle, extend to flight tests of other systems that have residual space warfare capabilities. In addition, the notification window could be lengthened to assist other states in readying monitoring devices, thereby increasing assurance that the tests are not for space warfare purposes.

The growing degradation of the Russian early warning capability (symbolized by a false alarm caused by a Norwegian rocket in 1995 that was initially interpreted by Russian authorities as a U.S. missile attack), as well as concerns of "Y2K" glitches in early warning systems, prompted joint U.S.-Russian efforts to increase assurance related to missile launches.[16] In June 2000, U.S. and Russian officials signed a Memorandum of Agreement on the Establishment of a Joint Center for the Exchange of Data. This agreement is designed to implement exchanges of information on launches of ballistic missiles as well as space launch vehicles detected by the warning systems of the parties. It also calls for "efficient resolution of possible ambiguous situations related to information from the warning systems of the Parties." The Memorandum further called for the preparation and maintenance of a unified database for a multilateral regime for the exchange of notifications of launches of ballistic missiles and space launch vehicles.[17]

In December 2000, U.S. and Russian officials signed another Memorandum of Understanding on Notifications of Missile Launches whose purpose was to lay the groundwork for establishing a "pre- and post-launch notification system." Paragraph two of the memorandum has particular relevance. Under the terms of this agreement, each party is obligated to provide pre-launch and post-launch notifications for launches of ballistic missiles that meet certain range or altitude criteria and, with rare exceptions, pre-launch and post-launch notifications for launches of space launch vehicles.[18]

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[15] See http://www.state.gov/t/ac/trty/4714.htm.

[16] For more on this instrument of nuclear risk reduction, see John Steinbruner, *The Significance of Joint Missile Surveillance* (Committee on International Security Studies Occasional Papers, American Academy of Arts and Sciences, July 2001), p. 5. Available online at http://www.amacad.org/publications/missile.pdf.

[17] Article 2, JDEC Memorandum of Agreement, http://www.state.gov/t/ac/trty/4799.htm. The multilateral database was designed to prevent a repeat of the close call caused by Norwegian rocket launch whereby Norwegian officials notified Russia, but the information was not passed on to the proper individuals.

[18] See http://www.state.gov/t/ac/trty/4954.htm

This accord has yet to be implemented, owing in part to bureaucratic obstacles on the Russian side.[19] Its relevance as a building block for a space assurance regime is considerable. Particularizing the parameters of ICBM and SLBM launches has utility for distinguishing between routine flight tests and flight tests that are carried out in an ASAT mode. Extending prior notification provisions to space launches would also help direct monitoring assets toward these activities. Other transparency measures borrowed from previously negotiated treaties, if applied to space launches, could provide further help in distinguishing between routine and troubling payloads.

The International Code of Conduct against Ballistic Missile Proliferation, finalized in November 2002, enumerated a number of voluntary, multilateral confidence-building measures. Subscribing states "resolve" to provide information on the number and class of launches in the previous year, and also to provide launch sites (including test ranges). Additionally, they are encouraged to consider allowing international observers at these sites. Pre-notification of launches is also encouraged, which "should include such information as the generic class of Ballistic Missile or Space Launch Vehicle, the planned notification launch window, the launch area and the planned direction." Such notifications would be sent to a coordinating country, a position that would rotate amongst subscribing states, that would act as a clearinghouse for such information. The Code of Conduct also asks subscribing states to "resolve" to "ratify, accede to or otherwise abide by" the 1967 Outer Space Treaty, the 1972 Liability Convention and the 1975 Registration Convention. Despite its voluntary nature, China, India, Iran, Iraq, North Korea, Pakistan, and Syria have expressed reservations with joining the Code of Conduct. Consequently, this initiative has been characterized as being "high on quantity—a respectable total of nearly 100 states attending the launch—but low on quality—the Code's measures are limited in the extreme, and several countries of greatest proliferation concern have failed to subscribe even to these steps."[20]

Another bilateral accord of particular relevance to the establishment of a space assurance regime is the 1989 Prevention of Dangerous Military Activities Agreement (PDMA). The PDMA focused on four specific categories of "dangerous military activity," including "interfering with command and control

[19] See Peter Baker, "Nuclear 'Milestone' Divides US, Russia; Failure to Construct Joint Warning Center Suggests Bigger Problems on Missile Defense," *The Washington Post* (June 13, 2001).

[20] Mark Smith, "Stuck on the Launch Pad? The Ballistic Missile Code of Conduct Opens for Business," *Disarmament Diplomacy,* no. 68 (December 2002–January 2003), available online at http://www.acronym.org.uk/dd/dd68/68op01.htm; also see "Code of Conduct Aims to Stop Ballistic Missile Proliferation," *Arms Control Today* (January–February 2003), pp. 19, 32.

networks in a manner which could cause harm to personnel or damage to equipment of the armed forces of the other Party," as well as the use of lasers "in such a manner that its radiation could cause harm to personnel or damage to equipment of the armed forces of the other Party." It established procedures to deal with border or boundary incursions, including the provision of designating "special caution areas."

The objective of the PDMA was to prevent dangerous activities "of personnel and equipment" of the armed forces of one side "when operating in proximity to the personnel and equipment of the other party during peacetime." The PDMA defined a laser as "any source of intense, coherent, highly directional electromagnetic radiation in the visible, infrared, or ultraviolet regions that is based on the stimulated radiation of electrons, atoms or molecules." The PDMA also regulated troop movements and maneuvers in areas of high tension; and it prohibited interference with communications, command, and control networks during peacetime.[21]

The general concept behind the PDMA—the avoidance of inherently dangerous military activities with clear escalatory potential, as well as the establishment of procedures to "expedite measures to terminate" interference—has direct applicability to space assurance, where dangerous practices could also have serious escalatory potential. Ongoing military-related practices in space, including the provision of weather information, geodesy, satellite imagery, and communication services, are not inherently dangerous, since they have been carried out for decades without prompting warfare or escalation. New kinds of military activity in space, particularly those relating to the flight-testing and deployment of space weaponry, or the flight-testing of weaponry designed for other purposes in an ASAT mode, are inherently dangerous for the reasons previously enumerated. An agreed code of conduct by space-faring nations to avoid dangerous military activities in space could therefore have considerable value. One such provision, as in the PDMA, could specify prohibited activities regarding the use of lasers.

Another U.S.-Soviet executive agreement affirmed rules of the road for professional naval conduct on the high seas. The 1972 Incidents at Sea

[21] The text of the agreement can be found in *International Legal Materials* 28, no. 2 (1989), pp. 877–895. Contemporary press accounts can be found in Bob Woodward and R. Jeffrey Smith, "U.S.-Soviet Pact to Curb Incidents," *Washington Post* (June 7, 1989) and Michael R. Gordon, "Accord on Risk of Accidental U.S.-Soviet Conflict," *New York Times* (June 8, 1989). Also see Kurt Campbell, "The Soldiers' Summit," *Foreign Policy*, no. 75 (Summer 1989), pp. 76–91 and 91, and Scott Sagan, "Reducing the Risks: A New Agenda for Military-to-Military Talks," *Arms Control Today* 21, No. 6 (July–August 1991), pp. 16–21.

Agreement[22] was prompted by a series of highly dangerous military maneuvers between the two superpower navies and naval aircraft. Of particular concern was the escalatory potential of major surface combatants that would "bump" on the high seas or at sensitive maritime passages as well as threatening maneuvers by naval aircraft.

The "IncSea" Agreement, on which many other bilateral agreements between foreign navies have been based, established rules of the road at sea. Specifically, the agreement provides for:

- Steps to avoid collision;
- Not interfering in the formations of the other party;
- Avoiding maneuvers in areas of heavy sea traffic;
- Requiring surveillance ships to maintain a safe distance from the object of investigation so as to avoid embarrassing or endangering the ships under surveillance;
- Using accepted international signals when ships maneuver near one another;
- Not simulating attacks at, launching objects toward, or illuminating the bridges of the other party's ships;
- Informing vessels when submarines are exercising near them; and
- Requiring aircraft commanders to use the greatest caution and prudence in approaching aircraft and ships of the other party and not permitting simulated attacks against aircraft or ships, performing aerobatics over ships, or dropping hazardous objects near them.[23]

Even more than the PDMA, the IncSea Agreement could serve as a model for bilateral or multilateral agreements to prevent dangerous military activities in space.

The treaties, conventions, and executive agreements negotiated over four decades have many useful provisions, but their implementation has occasionally been spotty and their prohibitions on space weaponry are narrowly confined to

[22] It is formally known as the Agreement Between The Government of the United States of America and the Government of the Union of Soviet Socialist Republics on the Prevention of Incidents on and over the High Seas.

[23] This characterization of the "IncSea" Agreement is drawn verbatim from the U.S. Government's summary of the accord, which can be found at http://dosfan.lib.uic.edu/acda/treaties/sea1.htm. For more on this accord, see David Winkler, *Cold War at Sea: High-Seas Confrontation between the United States and the Soviet Union* (Annapolis, MD: Naval Institute Press, 2000); Sean Lynn-Jones, "The Incidents at Sea Agreement," in Alexander George, Philip Farley, and Alexander Dallin (eds.), *U.S.-Soviet Security Cooperation: Achievements, Failures, Lessons* (New York: Oxford University Press, 1988), pp. 482–509; and Jan Prawitz, "A Multilateral Regime for Prevention of Incidents at Sea," in Richard Fieldhouse (ed.) *Security at Sea* (New York: Oxford University Press, 1990), pp. 220–225.

weapons of mass destruction. As such, they leave many openings for those who wish to explore, flight test, and deploy conventional means of space weaponry. These avenues were widened when the Bush administration withdrew from the ABM Treaty in 2002, an accord that previously extended prohibitions on space weaponry to space-based interceptors, directed energy weapons, and other futuristic war-fighting concepts in space.

This brief and partial compilation of treaty provisions, executive agreements, and United Nations General Assembly resolutions clarify clear and broad-ranging international commitment to "the common interest of all mankind in the progress of the exploration and use of outer space for peaceful purposes" (to use the Outer Space Treaty's preambular language). The intentions and purposes of the Outer Space Treaty, the UN's Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, from which the Outer Space Treaty was drawn,[24] as well as subsequent international conventions relating to space, are all oriented toward peaceful uses. Thus, while international law permits activities that are not expressly prohibited by treaties, customary practice has been protective of space as an arena free from conflict. Space warfare by any means could be construed as incompatible with the fundamental objects and purposes of treaties, conventions, and executive agreements that are protective of space.

Indeed, two eminent students of international law and practitioners of treaty drafting, George Bunn and John B. Rhinelander, have argued that the "one overall rule" of the Outer Space Treaty—that space shall be preserved for peaceful purposes for all countries—could well be considered as an overriding principle. If an overwhelming majority of the States Parties to the Outer Space Treaty construes this principle as prohibiting ASATs, such an interpretation would be "permissible," and could be given formal standing through UN channels or other means.[25] These ideas will be given further consideration below.

COOPERATIVE THREAT REDUCTION INITIATIVES

The dangers associated with nuclear weapons and other weapons of mass destruction have been deemed by the United States and almost every other nation in the world to be so severe as to warrant arms control initiatives, formal treaty prohibitions, executive agreements, intrusive monitoring procedures, and

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[24] Adopted on December 13, 1963 as resolution 1962 (XVIII).

[25] "Outer Space Treaty May Ban Strike Weapons," *Arms Control Today* 32, No. 5 (June 2002), available online at http://www.armscontrol.org/act/2002_06/letterjune02.asp. Also see Coyle and Rhinelander, "Drawing the Line," p. 6.

other cooperative measures to reduce such dangers. The purposes of these varied arrangements have included, *inter alia*, to affix and affirm international norms against the possession and use of weapons of mass destruction, thereby stigmatizing transgressions; to retard development and possession of prohibited weapons; to facilitate early warning of prohibited activities; and to foster a concerted international response against malefactors.

The flight-testing and deployment of space weaponry has been inextricably linked to the dangers associated with weapons of mass destruction. The initial prohibitions on space weaponry, after all, were expressly tied to weapons of mass destruction. During the Cold War, space warfare was widely considered a harbinger of nuclear warfare, given the connectivity of satellites most likely to be attacked with the command, control, and targeting of nuclear forces. This linkage has not disappeared with the dissolution of the Soviet Union and the advent of extreme forms of asymmetric warfare and terrorism. States possessing nuclear weapons that might become adversaries to the United States could view U.S. initiatives to weaponize space as an attempt to negate their deterrents. Space-to-ground warfare initiatives to further extend U.S. military advantages could therefore prompt compensatory steps by weaker states, including the accelerated pursuit of unconventional weapons.

Unlike the use of nuclear, chemical, and biological weapons in combat, the destruction of satellites in warfare has not yet transpired. The initial prosecution of space warfare would thus be an historic act. Its ramifications would only become apparent over time, but there is reason to believe that those consequences would be more severe than, say, previous uses of chemical weapons on the battlefield. Prior use of chemical weapons has contributed to military stalemates in World War I and in the war between Iran and Iraq during the 1980s. Space weaponry, unlike chemical weapons, is more likely to produce fears or expectations of military breakthroughs. The use of space weaponry therefore has a high escalatory potential.

Much intellectual, political, and diplomatic effort has been expended in attempts to reduce threats associated with weapons of mass destruction. These efforts have included, but have not been limited to, arms control and non-proliferation treaties. Because space warfare is likely to be so consequential, and because of its linkages to weapons of mass destruction, commensurate intellectual, political, and diplomatic efforts are also needed to devise cooperative threat reduction measures in this realm.

The terminology of “cooperative threat reduction” is used here, rather than “arms control,” for several reasons. To begin with, these efforts could well include arms control treaties, but the overall enterprise would be of wider scope. Just as the current building blocks of a space assurance regime involve treaty provisions, executive agreements, UN resolutions, and informal practices, a similar mix could be envisioned for space assurance in the future. Reliance solely or primarily on arms control treaties is likely to be problematic, for political and other reasons described below. Moreover, even if successfully negotiated, arms control treaties associated with space warfare are likely to be insufficient, given the latent space warfare capabilities that resides in war-fighting instruments designed for other purposes. Thus, while treaty provisions could well add to the current mix of restraints on space warfare, a more broad-gauged approach of cooperative threat reduction measures is proposed here.

President Jimmy Carter's attempt to negotiate limits on space warfare with the Soviet Union were bedeviled by problems of scope, definition, and monitoring.[26] As noted in Chapter 2, devising a sufficiently useful definition of space weaponry would not be an insuperable problem, if the United States and its negotiating partners wished to do so. Even so, problems of scope and verification of agreed constraints would remain. The problem of scope reflects the conundrum that ASAT capabilities residing in civilian and military programs, such as long-range missiles carrying nuclear weapons, would continue to be present even if "dedicated" ASATs were banned. The monitoring problem relates to the difficulty of gaining sufficient assurance that ASATs banned by agreement are not secretly retained.

This monitoring problem is far from simple, but it is not nearly as severe as was the case during the Carter administration. Subsequently, Washington and Moscow succeeded in negotiating and implementing highly intrusive monitoring arrangements, including many types of on-site inspections, and the "anywhere, any time" challenge inspection provisions of the Chemical Weapons Convention. Treaty provisions could be suitably adapted, and additional strengthening measures could be added, to serve negotiated constraints on space warfare.

The problem relating to the scope of an agreement would remain vexing. Now, as during the Carter administration, designing arms control approaches that capture all residual space warfare capabilities is neither practical nor desirable. At the same time, a narrow-banded approach that focuses solely on dedicated space weapons will be insufficient if restraint in deploying dedicated

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[26] Accounts of the Carter administration's difficulties in negotiating a ban on ASATs can be found in John Wertheimer, "The Antisatellite Negotiations," in Albert Carnesale and Richard N. Haass (eds.), *Superpower Arms Control: Setting the Record Strait* (Cambridge, MA: Ballinger Publishers, 1987); Donald L. Hafner, "Verification of ASAT Arms Control," pp. 45–73; "Antisatellite (ASAT) Arms Control," Committee on International Security and Arms Control, *Nuclear Arms Control, Background and Issues* (Washington, DC: National Academy Press, 1985), pp. 159–187; and Paul B. Stares, *The Militarization of Space: U.S. Policy, 1945–1984* (Ithaca, NY: Cornell University Press, 1985), pp. 180–200.

ASATs or other instruments of space warfare is accompanied by the avid pursuit of such capabilities under other guises. Cooperative measures to reduce the threat of space warfare must therefore be broadly cast.

TREATIES

One value of adding to treaty-based prohibitions on space warfare lies in the strengthening of international norms that define unacceptable behavior in space. Treaty regimes, when combined with military capabilities to deny gains or to punish violators, have more of a salutary deterrent effect than either in isolation. Deterrence is further enhanced when treaties contain intrusive monitoring provisions and complementary transparency measures. When deterrence by means of treaty constraints and supplementary military capabilities fails, treaty signatories are on much firmer ground in taking compensatory military steps than in the absence of treaty constraints.

Another rationale for strengthening treaty instruments is that the flight-testing and deployment of space weaponry would have multiple, adverse impacts on proliferation and arms control. The initiation of flight-testing and deployment of space weaponry would make remedies, whether in the form of treaty constraints or the development of customary practices of cooperative threat reduction, either extremely difficult or far less meaningful. The demonstrated pursuit of space warfare capabilities by the United States would also adversely affect existing arms control, non-proliferation, and disarmament accords. While the continued absence of ASAT testing does not insure success in countering proliferation, the active pursuit of ASATs would surely worsen bilateral U.S. relations with both Russia and China, two states whose assistance is required for help in the most troubling proliferation cases. It is reasonable to expect that the proliferation of ASATs would be accompanied by the proliferation of weapons of mass destruction.

In democratic polities, treaties are supported by domestic constituencies that expect proper adherence. "Creative" or loose interpretations of treaty obligations can generate political resistance. Extrication from treaty commitments is difficult, but not impossible. Formalized treaty constraints, which require the consent of two-thirds of the U.S. Senate, reflect bipartisan support, and can help to serve as a buffer against volatile mood swings in domestic politics. Formal treaty prohibitions on space warfare could also provide assurance that is necessary for global, space-dependent commerce.

Proponents of space warfare capabilities are usually dismissive of arms control remedies. They seek to maximize military flexibility and to minimize treaty constraints. Treaty critics are also highly sensitive to the monitoring problems associated with assuring compliance with agreed obligations. They point out that some states of concern might opt out of treaty regimes; others might join, but secretly violate treaty obligations.

For those most skeptical of the value of arms control, such concerns are not "fixable" by adjustments in treaty language. When key administration figures hold this view, seeking "common ground" by loosening treaty constraints to facilitate military options could prove to be a fruitless exercise.[27] The Bush administration is highly skeptical of the value of existing multilateral arms control accords, and has yet to propose new initiatives in this area. Consequently, at present there is insufficient bipartisan support in Washington for broadening treaty constraints against space warfare. The administration of President Bill Clinton did not pursue this agenda during its two terms, and the administration of President George W. Bush actively opposes it.

Nonetheless there is considerable utility in devoting intellectual effort to the question of how existing treaty constraints against space warfare might be strengthened. One reason for doing so rests on the core presumption that expanded treaty prohibitions on space warfare, backed up by intrusive verification and military might, are in the national security interests of the United States. While some will continue to reflexively oppose treaties, the value of broadening existing treaty prohibitions against space warfare could become more apparent in the future. It makes sense to lay the groundwork now for possible negotiation at a later date. Preparatory work for eventual negotiations could also clarify the need and the particulars of less formal measures that could reinforce barriers against the flight-testing and deployment of space weaponry, and could be more easily implemented in the near term. In addition, preparatory efforts to construct treaty constraints could serve as a useful reminder of public and international sentiment against space weaponization.

The objectives and purposes of formalizing added constraints against space warfare would flow from the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space adopted by the United Nations General Assembly in 1963 and the preambular language of the 1967 Outer Space Treaty, which has been ratified by the United States and nearly 100 other countries. These principles, which are regularly affirmed by the UN General Assembly, might be broadened to reflect how central satellites have become to the international community for global commerce, economic development, and public safety. A December 2000 UN General Assembly resolution affirming the importance of the Outer Space Treaty, calling for reinforcing measures, including verification, and calling on all countries to

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[27] For ideas on how domestic U.S. divisions might be bridged, see James Clay Moltz, "Breaking the Deadlock on Space Arms Control," *Arms Control Today* 32, no. 3, April 2002, pp. 3–9, and "Reining in the space cowboys," *Bulletin of the Atomic Scientists* 59, no.1 (January–February 2003), pp. 61–66.

refrain from acts contrary to the peaceful uses of space, passed by a vote of 163-0, with the United States, Israel, and Micronesia abstaining from voting.[28]

Existing building blocks for a space assurance regime would be largely negated if nations resume the flight-testing and deployment of space weaponry not specifically barred by the Outer Space Treaty. During the Cold War, occasional flight-testing of space weaponry and quite limited (in number and duration) deployments of dedicated ASATs did not generate a chain reaction of unwelcome developments for reasons elaborated elsewhere. The likelihood of negative developments associated with the flight-testing and deployment of space weaponry are greater now than during the Cold War, partly because daily commercial transactions now depend on satellites, and partly because the stabilizing context of superpower rivalry has been replaced by the instabilities associated with asymmetric warfare and horrific acts of terrorism.

Supporters of a space dominance posture argue that, precisely because potential adversaries are so disadvantaged in terrestrial confrontations with the United States, they will engage in flight-testing and deployment of space weaponry. In this view, the first use of space weaponry by a far weaker foe could have significant adverse impacts for the United States. Moreover, because the first use of space weaponry could have such deleterious impacts, weaker adversaries will not follow the U.S. example of restraint. The Rumsfeld Commission report on space reflects this perspective, as does James Oberg, who argues that a successful strike on space assets could inflict a “disproportionate loss in war-making capability” upon an opponent. In Oberg’s view, “The strategic military gain, system vulnerability, and detachment from an earthbound public’s concerns, will combine to render space a target much too tempting to pass over.”[29] Everett C. Dolman places the stakes even higher: “Who controls Low-Earth Orbit controls Near-Earth space. Who controls Near-Earth space dominates Terra. Who dominates Terra determines the destiny of humankind.”[30]

Consequently, those who seek space domination will strenuously oppose broadening treaty restrictions against space warfare. For three decades, the ABM Treaty and its corollary agreements stood as a bulwark against the weaponization of space, as it prohibited the flight-testing and deployment of space-based interceptors based on existing or futuristic technologies. Now that

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[28] For more on the UN role, past, and perhaps future, see Rebecca Johnson, “Multilateral Approaches to Preventing the Weaponization of Space,” *Disarmament Diplomacy,* no. 56 (April 2001), available online at http://www.acronym.org.uk/dd/dd56/56rej.htm.

[29] James Oberg, *Space Power Theory* (Washington, DC: GPO, 1999), pp. 153, 155.

[30] This thesis provides the basis of *Astropolitik: Classic Geopolitics in the Space Age* (London: Frank Cass, 2002).

this bulwark has been removed, proponents of a U.S. space dominance posture would be loathe to accept new impediments to their goal. Space, in this view, provides the means for quick, lethal strikes in regions that are currently remote to U.S. power projection. Space provides a medium in which opposing weapons of mass destruction could be neutralized, where information warfare could be waged, and where U.S. military dominance could be extended for the indefinite future.[31]

These analyses are not persuasive. As discussed elsewhere, the United States has profound terrestrial vulnerabilities that are easier to exploit than U.S. vulnerabilities in space. Moreover, if the United States adopts prudent insurance policies against space attacks, they will not affect the outcome of the battle.

Two countries most often suspected of covertly preparing to initiate flight-testing and deployment of space weaponry—China and Russia—are vocal supporters of treaty-based initiatives to "prevent an arms race in space." These efforts may be based on the well-founded view that the United States could compete effectively in the weaponization of space, a competition that would be detrimental to all space-faring nations without diminishing terrestrial U.S. military dominance. Typically, two Russian commentators have called for measures to prevent the weaponization of space while concluding that, "The states with substantial space capabilities will have significant strategic advantages. This will force other states to develop and deploy (without controls) such military systems. A chain reaction will occur."[32]

Chinese government spokespersons and analysts echo the Russian critique:

> Like many other countries, China is of the view that introducing weapons into space will not contribute to the goals of ensuring space security or reducing space vulnerability. Rather, it will lead to an arms race in space, which will then be turned into another battleground, thus endangering our dependence upon space… [T]he space powers themselves are likely to become the biggest victims.[33]

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[31] For articulate expositions of this view, see Steven Lambakis, *On the Edge of Earth, The Future of American Space Power* (Lexington: The University Press of Kentucky, 2001); Dohlman, *Astropolitik*; and Simon P. Worden and Martin E.B. France, "Towards an Evolving Deterrence Strategy: Space and Information Dominance," *Comparative Strategy* 20, No. 5 (October–December 2001), pp. 453–466.

[32] Vasily Lata and Vladimir Maltsev, "Military Activities in Space and International Legal Regulations," *Yaderny Kontrol* 7, no.4 (Fall 2002), p. 11.

[33] Cheng Jingye, "Treaties as an Approach to Reducing Space Vulnerabilities," in James Clay Moltz (ed.), *Future Security in Space Commercial, Military, and Arms Control Trade-Offs,* Occasional Paper No. 10 (Monterey, CA: Center for Nonproliferation Studies, Monterey Institute for International Studies, July 2002), p. 48.

On June 27, 2002, Russia and China jointly submitted a proposal to ban space weapons to the Conference on Disarmament. The basic obligations of their proposed ban included:

- Not to place in orbit around the Earth any objects carrying any kinds of weapons, not to install such weapons on celestial bodies, or not to station such weapons in outer space in any other manner.

- Not to resort to the threat or use of force against outer space objects.

- Not to assist or encourage other States, groups of States, international organizations to participate in activities prohibited by this Treaty.

In support of this proposal, the governments of Russia and China suggest the adoption of confidence-building measures, including information exchanges on space policy, space launch sites, and the "property and parameters" of objects being launched.[34]

There is nothing unusual or particularly duplicitous in nations pursuing military capabilities that their governments ostensibly seek to control or eliminate. The U.S.-Soviet negotiating history, for example, was replete with examples of such behavior by both countries. One must assume that, alongside their proposal to ban ASATs, Russia, China, and other governments are working on such devices behind closed doors, as is the United States. Indeed, one would expect nations to hedge their bets against the advent of space weaponry, precisely the course of action advocated here for the United States.

If the stated Chinese and Russian interest in negotiating prohibitions on space warfare is genuine, both countries should be prepared to accept transparency measures sufficient to provide assurance that covert flight-testing and deployment of space weaponry are not being undertaken. And if Chinese and Russian advocacy of treaty prohibitions is merely a cover for preparations for a "Space Pearl Harbor,"[35] this bluff should be called by demanding acceptance of transparency measures sufficient to provide confidence in compliance or early warning of prospective noncompliance. If Russia and China are as concerned about an arms race in space as their public statements

[34] "Working Paper on PAROS presented by the Delegations of China, the Russian Federation, Viet Nam, Indonesia, Belarus, Zimbabwe and Syrian Arab Republic," Permanent Mission of the People's Republic of China to the United Nations Office in Geneva and Other International Organizations in Switzerland (June 27, 2002), available online at http://www.china-un.ch/eng/30622.html.

[35] This terminology is borrowed from the Rumsfeld Space Commission report.

suggest, they will accept the application and adaptation of intrusive measures negotiated for other purposes to a space assurance regime.

Monitoring and intrusive measures are needed for flight-testing and deployment because these two thresholds are most amenable to observation and to cooperative measures to increase transparency. The monitoring provisions and transparency measures chosen would, of necessity, have to strike a balance between the need to protect vital national security secrets and the need to detect indications of non-compliance. Clearly, this dividing line will vary depending upon the type of weapon to be controlled. Biological weapons, for example, require indoor monitoring because they can be moved readily and because a small amount of bio-weapons can cause a large loss of human life.

The best stage in space weaponry development to strike this balance and to apply treaty monitoring and cooperative measures is when the dictates of weapon testing mandate a move from indoors to outdoors. Proper testing requires specialized equipment and controls. The most convenient place to carry out such testing is at oft-used test ranges. Previous patterns of testing provide a baseline of information upon which new tests can be evaluated. They can also offer useful insights as to what kinds of transparency measures would be most useful in characterizing the activity being observed. Cooperative monitoring measures at test ranges and space launch facilities would need to be supplemented by national technical means.

Meaningful space assurance requires that all states refrain from flight-testing, deployment, or use of weapon systems designed to damage, disable, or destroy objects in or from space. Meaningful space assurance also requires that all states refrain from testing in an ASAT mode multi-purpose weapon systems primarily designed for other purposes.[36] Restraint regimes of this sort could be codified in formal treaty texts or, as discussed below, by a less formal "code of conduct" for space assurance—a set of rules of the road that states might agree to in bilateral executive agreements or in multilateral accords.[37]

Restraint regimes of the kind proposed here are likely to fail if they are partial rather than comprehensive. Several analytical attempts have been made to distinguish between permitted and prohibited ASAT tests to accommodate

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[36] Johnson uses different formulas to reach a similar conclusion, calling for a ban on the deployment of all kinds of weapons in space, and bans on the testing, deployment, and use of ASATs. "Multilateral Approaches."

[37] Many others have pointed to the utility of "rules of the road" for space. See, for example, Paul B. Stares, *Space and National Security* (Washington, D.C.: The Brookings Institution, 1987) p. 169–172; Stares, "Nuclear Operations and Antisatellites," pp. 702–703; OTA, *Arms Control in Space*, pp. 12–13, 20–21; OTA, *Antisatellite Weapons, Countermeasures and Arms Control*, pp. 116–119, 136–138, and Hafner, "Verification of ASAT Arms Control," pp. 61–63; and Michael May, "Safeguarding Our Military Space Systems," *Laboratory Reviews* (January–February 1987), reprinted in *Science* (April 18, 1986), pp. 336–340.

other prospective U.S. military objectives.[38] However, the "partial" weaponization of space is unlikely to provide assurance or stability. Partial ASAT flight-test bans could readily be negated by permitted ASAT testing, or by testing in an ASAT mode. If the strategic arms competition is any guide, partial bans will channel resources and effort to permitted, but unhelpful, activities. It is hard to reconcile a space assurance regime with any ASAT testing, or any testing in an ASAT mode.

The military activities in space that should be flatly prohibited have not been carried out by Moscow since June 18, 1982. There have been no reports of Chinese ASAT tests or testing in an ASAT mode. Consequently, the ambitious objectives sought here would not require changes in military activities over the past two decades—a considerable plus in any negotiation. They would, however, require that Moscow accept even more openness regarding military practices established over the past two decades,[39] and that Beijing adopt a sea change in attitude toward transparency.

While one may be sympathetic to the argument that a "permissive" interpretation of the Outer Space Treaty would prohibit all space warfare activities, this approach is fraught with difficulties. Treaty foes have also taken the route of unilaterally endorsing "permissive" interpretations to serve their policy preferences, most notably with regard to the Anti-Ballistic Missile Treaty. In this particular instance, permissive interpretations were strenuously rejected by treaty defenders.[40] Space assurance cannot rest on a double standard that holds that permissive treaty interpretations are incorrect when they facilitate military initiatives, but are correct when they strengthen treaty regimes. Permissive, unilateral interpretations are therefore not the preferred means of expanding treaty prohibitions. Instead, it would be preferable to secure multilateral endorsement of an extension of the Outer Space Treaty's prohibition against weapons of mass destruction in space to prohibit the deployment of all forms of space weaponry. This endorsement could be expressed most authoritatively both through the U.N. General Assembly and through the

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[38] See Carter, "Satellites and Antisatellites," pp. 94–98; Hafner, "Verification of ASAT Arms Control," pp. 52–55; and Moltz, "Breaking the Deadlock," p. 8.

[39] The 1991 START accord, which remains in effect until 2006,and which can be renewed in successive five-year intervals by the consent of the Parties, contains ten different kinds of on-site inspections, but it does not mandate inspections at space launch facilities. See Peter L. Hays, *United States Military Space*, p. 165, footnote 194.

[40] These battles have been recounted in numerous books, most notably by Strobe Talbott, *The Master of the Game: Paul Nitze and the Nuclear Peace* (New York: Alfred A. Knopf, 1988) and Raymond L. Garthoff, *The Great Transition: American-Soviet Relations and the End of the Cold War* (Washington, DC: The Brookings Institution, 1994).

Conference on Disarmament in Geneva, the forum for negotiating multilateral accords of this kind.

The central preparatory tasks associated with endeavors to expand treaty protections against space warfare include, first, the construction of a widely acceptable, common sense, and comprehensive definition of what constitutes space weaponry, and what actions should be prohibited. Second, the construction of useful and verifiable definitions of what constitutes "testing in an ASAT mode" for different types of weapon systems and non-military platforms. Third, the conceptualization of a mix of monitoring arrangements and transparency measures sufficient to verify that prohibited activities are not being carried out. Fourth, the conceptualization of how information gathered by varied means could be disseminated in a sufficiently inclusive way among States Parties.

This is a substantial and challenging work program. As noted previously, a suitable definition of space weaponry should be achievable, but this must garner considerable international support—both with respect to what is included and what must be excluded. This analysis affirms the widely held view that existing satellites that support military-related activities do not constitute the weaponization of space. If, alternatively, China raises old objections that satellites utilized for military communications and targeting be included in a working definition of space weaponry, international agreement to expand treaty protections against weaponization are doomed to failure.

Constructing useful definitions of what constitutes testing in an ASAT mode will require technical studies that are beyond the scope of this monograph. The importance of such tasks can readily be understood, however. The U.S. space shuttle, for example, was obviously not designed for space warfare, given its limited number, high cost, human crew, and vulnerability to attack. However, the space shuttle was specifically designed to retrieve satellites in need of repair or replacement. Thus, distinguishing and codifying permitted and prohibited activities would be needed for space transportation systems. Such distinctions would also be needed for military weapon systems that were designed for other purposes but which could also be utilized for space warfare.

The argument presented here is that the inherent potential of missile defenses and strategic offensive forces to destroy satellites does not constitute an insuperable problem for a space assurance regime. Instead, these and other capabilities constitute useful hedges against unwelcome surprises or non-compliance with treaty prohibitions, as well as persuasive reasons why the flight-testing and deployment of dedicated space weaponry are unnecessary. Nonetheless, the flight-testing and deployment of multi-purpose weapon systems can only be harmonized with constraints against space warfare if the testing of these weapon systems is not carried out in ways that mimic antisatellite warfare.

The challenge of distinguishing between testing in an ASAT mode and testing for other military purposes will vary from one weapon system to the next. When such tests are completely or mostly indistinguishable from space warfare—such as the testing of ground-based lasers to determine the tolerance levels of one's own satellites against illumination by another state—a strong presumption exists against testing outdoors. In the case of lasers, it would be far preferable to conduct testing indoors so that necessary measurements can be taken to improve the defenses of U.S. satellites. The advent of advanced missile defenses and perhaps the airborne laser will pose additional challenges in distinguishing between testing in an ASAT mode and testing for other military purposes.

Where might the preparatory work associated with broadening and reinforcing treaty prohibitions against space weaponry take place, and what drafting mechanism might best be used? Many useful ideas have been suggested. The Conference on Disarmament (CD) in Geneva has a mandate to conduct multilateral negotiations of this kind, but the CD has evolved into a very large forum consisting of 66 countries. (At the time when the Outer Space Treaty was negotiated, negotiations in Geneva were conducted among eighteen nations.) More importantly, the CD's work agenda and end products require consensus. In recent years, preliminary discussions—let alone negotiations—on space warfare have been tied up in wrangling between the United States, which wants to move forward on a production ban for fissile material for nuclear weapons but does not wish to negotiate on space weaponry, and China, which seeks to link negotiations on a fissile material production ban with talks on space. The Clinton administration was also unenthusiastic about talks in the CD on the peaceful uses of outer space. The last such discussions were convened in 1994. Considerable diplomatic effort will be needed to conclude a multilateral convention in the CD on space warfare—if the United States and every other state refrain from exercising veto power.

The United Nations has played more of a role than the CD in erecting the foundation for what could become a space assurance regime. The UN General Assembly periodically convenes meetings of a Committee on the Peaceful Uses of Outer Space. The UN General Assembly regularly passes resolutions that serve to clarify international sentiment against the weaponization of space. These resolutions, however, are non-binding on UN members, and the Committee on the Peaceful Uses of Outer Space has no mandate to negotiate. Even if it had, this committee, which is roughly the same size as the CD, could also make for an unwieldy negotiating forum.

Another possible venue for space negotiations could be established by a single state or a grouping of states that wish to take the lead in doing so. The model here would be the Government of Canada's role in promoting an international convention banning the use of landmines. The "Ottawa process" was given a significant boost by the technical inputs and energy provided by non-governmental organizations that convened alongside governmental experts. The advantage of this approach is that a coalition of the willing would not be constrained by the formalities of diplomatic procedure.[41] The disadvantage is that some key states could be absent from the drafting process and would feel no compulsion to join the Convention.

All of these approaches are unsatisfying in one respect or another. Inclusive approaches require the consent of reluctant states, while self-selected initiatives may not bring recalcitrant parties in. The consensus rule can badly weaken multilateral accords without providing assurance that all states of concern will agree, even to watered-down restraints. But there may be even less assurance that key states will join conventions in which they played no drafting role.

Given the CD's consensus rule and the Bush administration's strong antipathies toward multilateral accords that could constrain U.S. military options, the likelihood of formal agreements in this forum to broaden the Outer Space Treaty's prohibitions against space warfare are poor for the near term. At the same time, many studies need to be undertaken before negotiations can bear fruit. This work agenda cannot be further delayed on the grounds that there is still no formal negotiating mandate to deal with space matters in the CD.

It is therefore essential that experts convene to address thorny technical issues that stand in the way of a verifiable ban on the flight-testing, deployment, and use of ASATs, as well as bans on testing in an ASAT mode. Useful interactions as well as added energy and expertise could result if coalitions of the willing included government and non-governmental experts. The venue for such meetings should depend on where the relevant expertise exists or can get to with a minimum of inconvenience and expense. The selection of the proper venue—Geneva, Vienna, New York, or elsewhere—should be based on where this work program, driven by talented, dedicated people, can be most expeditiously carried out. It is now imperative for a core group of states and non-governmental organizations to begin preparations for the convening of a coalition of the willing, and to draft a preliminary work program. Clearly, one subject of discussion would be whether the scope of the Outer Space Treaty ought to be broadened or whether a separate, supplementary convention should

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[41] This option is advocated by Johnson in "Multilateral Approaches."

be constructed.[42] A list of technical studies that could benefit from working group deliberations is also needed.

Since verification arrangements and transparency measures will be necessary to increase assurance in compliance and to provide early warning of possible non-compliance, these subjects of investigation must be tackled without further delay. Arrangements for the sharing of information to affirm commitments among states parties also require technical and political assessment. As these measures are central to space assurance, they would be required whether or not new treaty prohibitions are implemented. Thus, preparatory studies can have as much utility for a code of conduct and rules of the road for space assurance as for formal treaty prohibitions. Less formal arrangements for space assurance that might be pursued while waiting for formal treaty provisions to take effect are considered next.

RULES OF THE ROAD FOR SPACE ASSURANCE

If dangerous military practices are deemed important enough to be codified for activities on land and at sea, and dangerous enough to seek their prevention, then it makes good sense to emulate these established practices for military activities in space. Rules of the road have been found acceptable by many armies and navies; what has been found useful for tanks, surface combatants, and the terrestrial use of lasers would surely be useful for spacecraft, as well.

There are many reasons to negotiate rules of the road for space assurance. These agreements could foster space-dependent commerce and help protect costly investments. They could assist in the prevention of accidents in space and the loss of spacecraft or human lives. By generating the exchange of information and transparency, they could provide early warning of troubling developments when a nation withholds promised data or acts contrary to information provided. Rules of the road for space assurance could set or affirm international norms of responsible behavior. They could help encourage all space-faring nations to follow such norms and they can help isolate states that play by dangerously different rules. They could alleviate some security concerns and provide stepping-stones for treaty prohibitions, while serving as interim measures if work on treaties continues to be blocked. By creating a more stable environment in space, they could help dampen threat perceptions and undercut the rationale for weaponizing space.

The upside potential of codifying rules of the road for space assurance is significant. What are the downside risks? One could argue, as was often done

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[42] Coyle and Rhinelander advocate a supplementary convention, concerned that the Bush administration might withdraw from the Outer Space Treaty if it were opened for amendment. ("Drawing the Line," p. 6.)

during treaty negotiations during the Cold War, that a code of conduct that affirms rules of the road could provide a false sense of security, lulling a nation to let down its guard. There was little evidence to support this argument during superpower negotiations, which were accompanied by vigorous military programs to provide bargaining leverage or to compensate for perceived or emerging weaknesses. The American public wasn't lulled into a false sense of security by negotiations and treaties. Instead, it was alarmed when superpower negotiations broke down and when dangerous military practices filled this void.

Another possible argument against constructing rules of the road for space assurance is that such efforts might substitute for or displace treaty negotiations on preventing the weaponization of space. To the contrary, work to codify rules of the road could precede stalled treaty negotiations, facilitate them, or proceed in tandem. Much of the analysis required to construct rules of the road for responsible space conduct also has applicability for treaty negotiations. Progress on one track need not stall, and could accelerate, progress on another. The reverse of this argument could therefore gain more traction, as treaty foes, concerned over a "slippery slope" of ASAT arms control, dig in their heels and oppose rules of the road for space assurance. As the Rumsfeld Commission on space cautioned, "The US must be cautious of agreements intended for one purpose that, when added to a larger web of treaties or regulations, may have the unintended consequences of restricting future activities."[43]

Yet another set of arguments might focus on difficulties in monitoring rules of the road that, if unverifiable, could be more easily broken. During the ASAT talks in the Carter administration, the U.S. Joint Chiefs of Staff opposed an agreement on non-interference with satellites and non-use of ASATs, combined with rules of the road, based on verification concerns, as well as the worry that the Congress would then cut funding for satellite survivability and "hedging" research on ASATs.[44] Then, as now, there are no guarantees against cheating or sudden, unwelcome surprises. Thus, skeptics could argue that rules of the road are slim reeds that are easily broken in a crisis. In this view, it is far better to rely upon U.S. military dominance in space.

There are no simple answers to concerns over verification. Monitoring challenges must be tackled, first analytically, and then by devising interconnected monitoring arrangements, some of which might entail production of improved NTM. While the monitoring of rules of the road need not be as stringent as for treaty obligations, it still must be sufficient to provide assurance

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[43] *Report of the Commission to Assess United States National Security Space Management and Organization* (Washington, DC: January 11, 2001), pp. 17–18.

[44] Stares, *The Militarization of Space,* p. 199.

of compliance and early warning of misbehavior. Some monitoring tasks for rules of the road may, indeed, prove to be extremely difficult to operationalize.

While verification is important, national security is even more important. Critiques based on monitoring shortfalls often imply that weapon programs provide more security than restraint. This may well be true in some cases, but not in space. U.S. national security is enhanced by rules of responsible behavior in space and damaged by ambitions to dominate this realm. Moreover, the presence of weaponry in space is inherently more dangerous to U.S. military, commercial, and scientific interests than its absence. Unwelcome surprises are more likely by weaponizing space than by exercising restraint that is backed up by effective monitoring and prudent hedges.

There are many strong arguments for the codification of rules of the road for responsible behavior in space, and only a few, weak arguments against this course of action. The codification of such rules, as with formal treaty obligations, requires improved U.S. situational awareness of activities in space. Improved monitoring capabilities would help U.S. officials to determine whether rules of the road are being adhered to, when troubling developments occur, the nature of evolving threats, and thus the nature of appropriate responses.

The infrastructure for situational awareness in space does not have to be fully established prior to negotiating and implementing cooperative measures for space assurance. Just as the Limited Test Ban Treaty was negotiated and ratified prior to the launch of the first Vela Hotel satellites, progress can be made alongside improved monitoring capacity. At the same time, it is essential to begin to consider ways in which information can be shared with states that endorse space assurance without compromising NTM.

Rules of the road for space will have much more traction when it is possible to monitor activities of interest, both unilaterally and collaboratively. The attainment of perfect monitoring capabilities will elude us, whether for reasons of cost, politics, or technology. There may also be some transparency measures that the United States is unwilling to accept. This is not the time or place to rehash prior arms control debates over "adequate" or "effective" verification. Part of the work program ahead relates to the application of improved situational awareness to rules of the road that are necessary for space assurance, and what kinds of steps would be needed to respond to troubling developments of varying degrees of severity.

Key Elements of a Code of Conduct

Laser Testing

One key element of a multilateral code of conduct for space assurance must deal with laser testing. Working by analogy, the lasing provisions in the PDMA, which prohibits "using a laser in such a manner that its radiation could cause harm to personnel or damage to equipment of the armed forces of the other Party," would need to be applied to objects in space. The IncSea agreement contains a complementary provision "not use searchlights or other powerful illumination devices to illuminate the navigation bridges of passing ships of the other Party."[45] If the use of lasers or other powerful forms of illumination is dangerous against soldiers and navigation bridges in peacetime, they are also dangerous against satellites.

As with proposals to partially limit ASAT flight-testing, limited outdoor bans on the lasing of satellites—such as a ban on lasing satellites belonging to another country, while permitting laser testing against one's own satellites—would erode, rather than build space assurance. This reasoning is based on the inescapable conclusion that the testing of lasers outdoors against one's own satellites to determine their vulnerability and to facilitate the design of defensive measures is indistinguishable from testing that is useful to dazzle, disrupt, or destroy satellite functioning.

In order to monitor this key element of a code of conduct for responsible space-faring nations, ground-based laser facilities would need to be defined and designated. Laser tests at ground-based facilities, as well as the purpose of such testing, would need to be communicated in advance. Similar provisions would be needed for laser testing from airborne platforms, or from sea-based platforms. An agreed definition of laser tests in an ASAT mode would be required for all platforms. Supplementary cooperative measures might also be required.

As discussed in Chapter 3, a ban on indoor lasing activities is neither practical nor wise. The monitoring of such a ban would be problematic with respect to the acceptance of intrusive transparency measures. Indoor laser tests could also provide useful information to improve defensive measures of satellite protection. While indoor laser testing could provide information applicable to offensive purpose, it is not feasible to prohibit such activities. The latent capabilities residing in lasers, as with other residual ASAT capabilities, can therefore provide insurance against the unwise decision by another state to initiate the flight-testing and deployment of space weaponry. And as with other

[45] For the connection between the two provisions, see Winkler, *Cold War at Sea*, p. 165.

U.S. insurance policies, the existence of lasers need not undermine a space assurance regime, as long as they are not tested outdoors in an ASAT mode.

Collisions, Dangerous Maneuvering, Simulated Attacks

IncSea agreements contain provisions against collisions, dangerous maneuvering, unsafe distancing, and simulated attacks. Comparable rules of the road are needed for the avoidance of dangerous practices in space. Proper adaptation for each of these provisions requires technical assessments and feasibility studies that should be undertaken as soon as possible by governmental and non-governmental coalitions of the willing.

Independent studies carried out during the Cold War investigated several generic approaches to reinforce rules of the road for safe conduct and for the avoidance of dangerous military activities in space. One approach focuses on "keep out zones." Acceptance of this concept would require common agreement that such zones constitute a legitimate regulation of space to protect satellites rather than an "appropriation" of space that is prohibited under the terms of the Outer Space Treaty. One analyst has described the function of keep out zones as giving "a satellite under attack time to react…or, very importantly, informing its owners that it is undergoing deliberate attack."[46] The removal of ambiguity and the clarification of motive constitute two useful aspects of keep out zones. These objectives could be reinforced by the provision of prior notification for space launches and orbital characteristics, as noted below. Keep out zones could be unique to different orbits.[47] A parallel precedent for "regulating" space already exists to minimize radio interference from satellite operations in geosynchronous orbit.

When U.S. concerns were focused on the Soviet "co-orbital" ASAT, one independent analyst proposed orbital plane limitations. Since the Soviet co-orbital ASAT started its attack by "going into an orbit within one degree or so of its target's orbital plane,… an appropriate 'rule of the road' might be to prohibit any launch by one side into an initial orbit within, for example, two degrees of the orbital inclination and right ascension of any of the other side's satellites."[49] Another generic approach to help prevent collisions, interference, dangerous maneuvering, and simulated attacks might involve rules of the road relating to "safe passage" in space. If keep out zones or other forms of orbital plane

[46] Ashton B. Carter, "Satellites and Antisatellites," p. 86.

[47] *Ibid.*

[48] The text of the Constitution is available online at http://www.itu.int/aboutitu/basic-texts/constitution.html.

[49] Hafner, "Verification of ASAT Arms Control," p. 62.

limitations are not feasible in some or all cases, technical assessments would be required to determine if other aspects of space flight, such as closing velocities, might be subject to constraints. Coalitions of the willing are needed to re-examine and update earlier proposals for the safe passage of satellites through space. The possible connection between keep-out zones and the liability convention is also worth exploring.[50]

Notification and Registration

Additional steps are warranted to broaden and otherwise improve notification of space launches and registration of space objects. Rudimentary registration provisions exist in the 1975 UN Registration Convention, but these are more hortatory than mandatory. The current UN registration regime will remain woefully inadequate as long as meaningful information is not provided in a timely fashion. Expanded notification, to include prior notifications of space launches as well as their purposes, payloads, type of launch vehicle, azimuth, geographic launch cite, and expected orbital plane, would be consistent with a space assurance regime.

A more robust system could be modeled on the 2000 Pre- and Post-Launch Notification System agreement and the Joint Data Exchange Center agreement between the United States and Russia signed in 1998. The joint center database could be expanded to serve as a multilateral clearinghouse for notifications of ballistic missile and space vehicle launches. Studies on how these memoranda of understanding might be utilized for a wider conception of space assurance would be useful. Further analysis is also required on whether greater transparency regarding notifications would impair data collection by national technical means, or whether such information is already quite evident from observable orbital characteristics. How much notification is required for space assurance and how much information must be protected for intelligence-gathering purposes constitutes a key question requiring further assessment, particularly with respect to changes in orbital characteristics.[51]

Prior notifications of the number and purpose of satellites launched could be double-checked by national technical means. Limits on the number of space launches within an agreed period of time might also serve as a useful confidence-building measure, since multiple launches would be required to

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[50] Theresa Hitchens, "Some Ideas on Space Security," paper prepared for the Outer Space and Global Security Seminar, November 26–27, 2002, sponsored by the United Nations Institute for Disarmament Research, the Simons Centre for Peace and Disarmament Studies, Project Ploughshares Canada, and the Simon Foundation, available online at http://www.cdi.org/space-security/ideas.cfm.

[51] The acceptability of advance notification has come a long way since the Outer Space Treaty. See Garthoff, "Banning the Bomb in Outer Space," p. 29.

disable satellite constellations by conventional means. Voluntary constraints on the number of space launches within a set period of time could be lifted under emergency conditions. Cooperative measures could be employed to increase transparency, lend credence to declarations, and facilitate data sharing. One avenue that may be worth exploring in this regard is including space launches in the provision to transmit telemetry associated with missile launches contained in the 1991 Strategic Arms Reduction Treaty. This provision, which, like the START I Treaty, remains in effect until the treaty lapses in 2006, unless otherwise extended, calls for the exchange of tapes containing all "telemetric information" within 65 days after the launch.

Interference

The International Telecommunications Union (ITU) Convention, formalized in 1994, regulates space activity by assigning orbital slots for satellites in geosynchronous orbit and by apportioning the radio spectrum for communications satellites. Article 45 requires that,

> All stations, whatever their purpose, must be established and operated in such a manner as not to cause harmful interference to the radio services or communications of other Members or of recognized operating agencies, or of other duly authorized operating agencies which carry on a radio service, and which operate in accordance with the provisions of the Radio Regulations.

The ITU Constitution further states that members accept the necessity to take "all practicable steps to prevent the operation of electrical apparatus and installations of all kinds from causing harmful interference to the radio services or communications" covered under this compact. However, articles 34 through 36 permit actions to "cut off" transmissions if they "appear dangerous to the security of the state."[52] Dedicated ASAT capabilities are costly to develop and test, compared to more prosaic means of disrupting satellite operations by jamming, spoofing, or hacking into computer networks linked to space systems. The United States and other nations have devised countermeasures to reduce the vulnerability of satellites to such means of interference.

Rules of road against jamming, spoofing, and hacking activities directed against satellites can be useful in peacetime, but will not be respected during combat. Because interference capabilities will continue to exist, and will be continually upgraded, countermeasures are required. Improved countermeasures are integral to space assurance. U.S. capabilities to counter jamming, spoofing,

[52] The text of the Constitution is available online at http://www.itu.int/aboutitu/basic-texts/constitution.html.

and hacking will be second-to-none in this regard. However, jamming, spoofing, and hacking capabilities extend well beyond space-faring nations. Sometimes the initiator of activities harmful to U.S. satellites could logically be inferred from the political environment, such as the existence of a crisis or a regional conflict. However, the ability of the United States to identify the initiator of activities harmful to satellites might not be readily achievable in all cases. If the initiator were not a space-faring nation, U.S. ASAT capabilities would be irrelevant. If the perpetrator is a space-faring nation, the United States has comparable or better means to respond in kind to interference, or to respond by other means.[53]

Orbital debris and space traffic management

Orbital debris mitigation and space traffic management require multilateral solutions. Earth is surrounded by litter—perhaps 9,000 objects larger than ten centimeters in diameter, and an estimated 100,000 pieces of orbital debris larger than a marble. As Joel Primack has written,

> [S]pace does not clear after an explosion near our planet. The fragments continue circling the Earth, their orbits crossing those of other objects. Paint chips, lost bolts, pieces of exploded rockets—all have already become tiny satellites, traveling at about 27,000 kilometers per hour, 10 times faster than a high-powered rifle bullet. A marble traveling at such speed would hit with the energy of a one-ton safe dropped from a three-story building. Anything it strikes will be destroyed and only increase the debris.[54]

The weaponization of space is an environmental as well as a national security issue. The environmental degradation of space created by space-faring nations constitutes a danger to space exploration, the space shuttle, and other peaceful uses of space. Space litter also poses difficulties for the military uses of space.

Indeed, the U.S. government—under the auspices of NASA—has been working hard for many years to decrease the creation of debris as well as to foster an international agreement designed to mitigate debris created from space launches. Without new measures, the population of debris (including inoperable satellites) larger than ten centimeters could grow appreciably. Current National

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[53] For discussions of these threats see Jelen, "Space System Vulnerabilities and Countermeasures," pp. 100–107; and Tom Wilson, *Threats to United States Space Capabilities* (Washington, DC: Prepared for the Commission to Assess United States National Security Space Management and Organization, 2001), pp. 37–39.

[54] Joel Primack, "Pelted by paint, downed by debris," *Bulletin of the Atomic Scientists* 58, no. 5 (September–October 2002), p. 24.

Space Policy, dating from 1996, makes minimizing debris a domestic imperative:

> The United States will seek to minimize the creation of space debris. NASA, the Intelligence Community, and the DoD, in cooperation with the private sector, will develop design guidelines for future government procurements of spacecraft, launch vehicles and services. The design and operation of space tests, experiments and systems, will minimize or reduce accumulation of space debris consistent with mission requirements and cost effectiveness.[55]

The policy goes on to note that,

> It is in the interest of the U.S. Government to ensure that space debris minimization practices are applied by other space-faring nations and international organizations. The U.S. Government will take a leadership role in international fora to adopt policies and practices aimed at debris minimization and will cooperate internationally in the exchange of information on debris research and the identification of debris mitigation options.[56]

Subsequently, NASA in 2000 promulgated final U.S. Government Orbital Debris Mitigation Standard Practices that apply to all space launches. NASA's efforts have also served as a basis for international efforts to develop similar voluntary guidelines, under the Interagency Space Debris Coordination Committee (IADC). The IADC, established in 1993, includes the space agencies from China, France, Germany, India, Italy, Japan, Russia, Ukraine, the United Kingdom, the United States and the European Space Agency. The UN Committee on the Peaceful Uses of Outer Space hopes to reach a consensus on debris mitigation guidelines between 2003 and 2004, with implementation to begin in 2005.

The weaponization of space, particularly with respect to the flight-testing of antisatellite weapons, would greatly compound existing concerns over safe passage. In the event of a resumption of ASAT tests, the Pentagon would attempt to mitigate space debris, as it does with respect to missile defense tests,

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[55] PDD-NSC-45/NSTC-8. The White House National Science and Technology Council Fact Sheet: National Space Policy (September 19, 1996), Section 7, Paragraph a. U.S. policy since 1996 has been to minimize debris creation. See National Science and Technology Council, The White House, "Fact Sheet, National Space Policy" (Washington, DC: September 19, 1996), available online at http://www.ostp.gov/NSTC/html/fs/fs-5.html. Implementing this policy could be problematic for ASAT flight tests. See "Possible Funding Boost In FY '04 Budget Could Lead To KE-ASAT Flight Test," *Defense Daily* (December 17, 2002).

[56] The White House National Science and Technology Council Fact Sheet, Paragraph b.

but the effectiveness of such efforts is questionable. Moreover, other states that test ASATs may not be as conscientious about debris creation.

The actual use of ASATs would compound these dangers exponentially. Space warfare would not only constitute a threat to targeted satellites, it would also create debris fields that would threaten satellites operating in low earth orbit, including NTM, space transportation systems such as the U.S. space shuttle, and the International Space Station. The damage resulting from warfare that includes ASAT use could be more long lasting in space than on Earth.

Traffic management and debris mitigation efforts are essential components of space assurance. Certainly, the UN-led efforts to craft voluntary debris mitigation guidelines are welcome and should be encouraged. At the same time, it would also be prudent to seek to codify such guidelines by strengthening the Convention for International Liability for Damage Caused by Space Objects. Industry groups advocate the establishment of operating standards for debris mitigation through the International Organization for Standardization.[57]

Space assurance requires much-improved tracking of objects in space. Currently, NASA is keeping tabs on around 10,000 objects with a diameter larger than 10 centimeters. However, debris smaller than that is difficult to find, and can be just as dangerous, as it can disable a satellite and create concerns about the safety of the space shuttle. Furthermore, while smaller objects are routinely monitored in LEO, the catalogue of space objects in GEO primarily covers objects bigger than 1 meter in diameter (such as non-working satellites).[58]

Space tracking, or space situational awareness, can also serve as a confidence-building measure. Better data sharing among the United States government, the European Space Agency, and the Russian Space Agency would be helpful, as would the development of improved space tracking capabilities.

Consultative and Implementation Arrangements

A code of conduct embodying rules of the road for responsible space activities will not be self-enforcing. Nor would it have the status of a formal treaty. Mechanisms must be devised to encourage proper implementation, and appropriate penalties need to be considered for misbehavior.

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[57] *International Space Cooperation: Addressing Challenges of the New Millenium*, Report of the 6th International Space Cooperation Workshop, sponsored by the American Institute of Aeronautics and Astronautics, the UN Office of Outer Space Affairs, the Confederation of European Aerospace Societies, and the International Academy of Astronautics (March 2001), Recommendation 14, p. 13.

[58] *Ibid.*, p. 10–11.

Fortunately, work on possible elements of such a code has been done by a number of research and industry groups. For example, the March 2001 international industry workshop recommended that rules governing physical location of satellites, especially those on orbit maneuvering, be developed including: “right of way rules” for satellites passing near others in a manner that might cause interference; “zoning rules;” “communication rules,” such as requiring that owners of a satellite in geosynchronous orbit passing by another satellite warn the latter’s owners; and improved collision warning.[59]

The IncSea agreement, strategic arms control treaties, and other accords created consultative bodies to address concerns over implementation. The effectiveness of these bodies is a function of the willingness of the parties to comply with the letter and the spirit of the agreements reached, as well as the degree to which implementation can be “depoliticized.” In the case of the IncSea agreement, depoliticization was facilitated by equating proper implementation with professional naval conduct. It helped that implementation reviews were confined to naval channels.[60] In contrast, implementation of the ABM Treaty and the accompanying strategic arms accords became highly politicized.[61]

Unlike the IncSea agreement and the strategic arms accords, proper implementation of a code of conduct in space would be a multilateral, rather than a bilateral responsibility. The standards set for proper implementation of the CWC and the Biological Weapons Convention (BWC) suggest the need for strong oversight so that obligations set for space will be faithfully implemented. Poor compliance with the CWC and BWC is not in plain view. In contrast, behavior associated with a code of conduct in space can be subject to observation, as well as to cooperative measures to increase transparency. While direct observation provides more of a basis to expect proper behavior, such compliance could be reinforced if appropriate penalties could be devised in the event of questionable practices. Supporters of a code of conduct are obliged to address this question.

SUMMING UP

The United States faces a fundamental choice in the years ahead. That choice is between space assurance or space dominance. Washington cannot

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[59] *Ibid.*, p. 9–12 and William Ailor, “Space Traffic Control: Data Access Defines the Future,” (American Institute of Aeronautics and Astronautics, 2002).

[60] Winkler, *Cold War at Sea*, pp. 173–174.

[61] See Sidney N. Graybeal and Michael Krepon, “Making Better Use of the Standing Consultative Commission," *International Security* 10, No. 2 (Fall 1985), pp. 183–199.

achieve both, since the quest for space dominance will generate countermeasures and insecurity. Space assurance is achievable. Its realization requires wisdom and restraint. The rewards of this choice include the continued benefits to the United States of the twin revolutions of space-based commerce and military affairs, unfettered advances in space exploration, and a harmony in space that has eluded us on Earth.

The quest for space dominance would jeopardize all this, and far more. Space dominance cannot be realized because others have the means to block U.S. ambitions using basic, low-cost technologies. If space becomes a haven for all manner of weaponry, hair-trigger postures that plagued policy makers during the Cold War will be elevated to the heavens.

The weaponization of space will complicate rather than enhance U.S. military capabilities. It is likely to impair global commerce, weaken U.S. alliances, and foster proliferation. Without question, the United States has more to lose than to gain by space warfare.

The weaponization of space was avoided during the Cold War, even though both superpowers jockeyed for military advantage on virtually every other front. Weaponization is inevitable if the United States leads the way. It is not inevitable if the United States continues along the path of space assurance. By previously choosing to advance the peaceful uses of space rather than to weaponize this realm, the United States has reaped extraordinary rewards. By initiating the weaponization of space, the United States would jeopardize these rewards, as well as generate severe environmental hazards for space exploration and satellites in low earth orbit.

Among the extraordinary powers that the United States now enjoys is the power to shape the agenda for the use of space in the twenty-first century. If Washington seeks to extend its military dominance by flight-testing and deploying space weaponry, other capitals would surely follow suit. They would not do so in as sophisticated or as expensive a manner, but they will compete as best they can. If, on the other hand, the United States refrains from embarking on a course to weaponize space, there are no guarantees that others will exercise similar restraint. Potential adversaries will, however, have less incentive to do so, since Washington can compete effectively in space warfare, even if it does not benefit from it. Neither would weaker states, since the use of ASATs would complicate, but not alter, U.S. terrestrial military dominance. Weak states are more likely to carry out sneak attacks against the United States in our cities, our ports, and wherever the American flag is flown abroad, than to engage in space warfare.

Proponents of testing and deploying space warfare capabilities have not satisfactorily explained why extending U.S. war-fighting dominance into space is necessary, or how the benefits of their preferred course of action exceed the risks of unintended escalation, diplomatic isolation, environmental spoilage, and commercial losses that are likely to result. Nor have they explained how they would foil the low-cost, low-tech countermeasures to U.S. space warfare initiatives likely to be pursued by weaker states. A hedging strategy against space warfare initiatives by potential adversaries makes good sense. A strategy to initiate the flight-testing and deployment of space weaponry makes little sense.

During the Cold War, the United States and the Soviet Union maintained nuclear forces on hair trigger alert, ready to be fired within minutes of an order to launch. One of the likely consequences of seeking a space dominance posture would be to elevate this hair trigger posture into space. Space weapons would beget space mines; ASATs would beget more ASATs. The side that shoots first in space would cross a critical threshold in the history of combat, but it would not alter the dynamics of asymmetric warfare. If the United States carries out preemptive strikes in space, it would still expect retaliation in unconventional ways. And if the weaker party carries out a surprise attack in space, it would still expect a devastating response. Nonetheless, both potential adversaries would perceive more value in shooting first than in asking questions later.

This "no win" outcome can be prevented by reinforcing and not crossing the two key thresholds of flight-testing and deploying space weaponry. The taboo against damaging satellites in warfare which has withstood the Cold War needs to be extended. The avoidance of flight tests and deployments of space weaponry is amenable to verification and cooperative monitoring if the United States, China, Russia, and other space-faring nations are willing to accept transparency measures that serve to prevent the weaponization of space.

There are two general approaches to reinforce the peaceful uses of space. One general approach relies on formal, treaty obligations. There are several pathways that could be followed under this approach, including a broadening of the Outer Space Treaty's prohibitions against the use of weapons of mass destruction in space, or the negotiation of a separate convention governing other types of weapons in or from outer space. The second approach involves the enumeration of a code of conduct for safe, responsible, national behavior in space. These rules of the road would not have the formal status of treaties, but they could help prevent dangerous military practices in space. Similar practices have already been endorsed by the United States and other countries for dangerous military activities on the ground, in the air, and at sea.

These general approaches are not in competition with one another. Indeed, they are mutually reinforcing. Both require monitoring and cooperative measures to confirm compliance or to clarify instances of troubling behavior.

Both approaches need to be backed up by superior U.S. intelligence and power projection capabilities. Both require new standards of cooperation and transparency among space-faring nations.

The potential for space warfare has long existed in the form of long-range missiles carrying nuclear weapons, as well as additional weapon systems designed for other missions. These latent or residual capabilities reinforce, rather than negate, a space assurance posture. These capabilities constitute insurance policies against space warfare initiatives by potential adversaries. They do not impair space assurance as long as residual capabilities are not tested in ways that mimic space warfare.

Considerable analytical work is required to particularize a space assurance posture. One crucial task is to determine guidelines for multi-purpose weapon systems so that they are not tested in an ASAT mode. Monitoring arrangements and cooperative measures to provide such assurance need to be devised. A coalition of the willing, consisting of governmental and non-governmental experts, is needed to begin systematic efforts that can contribute both to a code of conduct and to an international convention designed to strengthen existing norms against the weaponization of space.

Four decades ago, Hedley Bull reminded us that “marginal increases in security may be pursued at exorbitant economical or moral cost.”[62] The impulse to secure an added measure of terrestrial dominance by weaponizing space needs to be stifled, not just on economic and moral grounds, but also because it would impair U.S. military operations, space exploration and commerce, non-proliferation efforts, and alliance relations. The quest for a marginal addendum to U.S. military superiority by weaponizing space would constitute egregious over-reaching. There is much to do here on Earth to deal with the challenges of terrorism and proliferation. New impulses are needed for cooperative threat reduction, alliance cohesion, and economic security. Efforts expended to flight test and deploy space weaponry constitute an unwise distraction from the grave challenges we now face.

[62] *The Control of the Arms Race* (New York, NY: Frederick A Praeger, 1961), p. 25.

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