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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

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,

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 spoofing⁴ 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

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 Association, *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: Commercial 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

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

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

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 Dorch (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 U.S. 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.

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

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

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

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

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.

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.miiis.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. Heilmeyer, 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

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

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

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

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.