United States Military Space:
Into the Twenty-First Century

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FOREWORD

We are pleased to publish this forty-second volume in the *Occasional Paper* series of the United States Air Force Institute for National Security Studies (INSS). Lieutenant Colonel Pete Hays, a former Director of INSS, presents two very timely, rigorously researched and documented, and important papers on United States military space. We present them together as representing a range of related issues and imperatives for military space policy and development.

The first paper, "What is Spacepower and Does It Constitute a Revolution in Military Affairs?," examines the concept of "spacepower" as it is emerging within the United States military and business sectors to establish the basis for military space roles and implications. It also posits military-commercial sector linkages as the best near-term roadmap for future development. As commercial activities expand the importance of United States space, and as technological advances enable military missions, Hays sees expanded military roles, including space weaponization, on the horizon. He concludes that military space has already had significant impact on the "American way of war." That trend will only continue as the promise of a true space-led revolution in military affairs awaits eventual space weaponization.

Given an increasingly important United States commercial and military presence in space, the second paper, "Space-Related Arms Control and Regulation to 2015: Precedents and Prospects," presents a detailed analysis of existing regulation and controls that constrain and shape military space use and development. It also presents a comprehensive examination of current and future issues that will define likely arenas of international efforts to further control military space. The United States must be very aware of the possible consequences for our overall commercial and military space efforts in addressing these issues. Finally, the paper suggests areas where some current regulatory emphasis could benefit the United States, indicating areas for current policy emphasis. Together, the two papers provide a timely and important examination of the current state and the likely future of United States military space, and they raise concerns that must be understood and factored into United States policy planning and space development.

About the Institute

INSS is primarily sponsored by the National Security Policy Division, Nuclear and Counterproliferation Directorate, Headquarters US Air Force (HQ USAF/XONP) and the Dean of the Faculty, USAF Academy. Our other sponsors currently include the Air Staff's Intelligence, Surveillance, and

Reconnaissance Directorate (XOI) and the Air Force's 39th and 23rd Information Operations Squadrons; the Secretary of Defense's Office of Net Assessment (OSD/NA); the Defense Threat Reduction Agency; the Army Environmental Policy Institute; and the Air Force Long-Range Plans Directorate (XPXP). The research leading to the papers in this volume was sponsored by OSD/NA, DTRA, and XONP. The mission of the Institute is "to promote national security research for the Department of Defense within the military academic community, and to support the Air Force national security education program." Its research focuses on the areas of greatest interest to our organizational sponsors: arms control, proliferation, aerospace planning and policy, information operations, and regional and emerging issues in national security.

INSS coordinates and focuses outside thinking in various disciplines and across the military services to develop new ideas for defense policy making. To that end, the Institute develops topics, selects researchers from within the military academic community, and administers sponsored research. It also hosts conferences and workshops and facilitates the dissemination of information to a wide range of private and government organizations. INSS provides valuable, cost-effective research to meet the needs of our sponsors. We appreciate your continued interest in INSS and our research products.

About this Publication

This Occasional Paper represents a test publication in cooperation between INSS and the Air University (AU) Press. We hope to solidify long-term cooperation between INSS and the AU Press as it continues to serve USAF-wide interests.

JAMES M. SMITH
Director

WHAT IS SPACEPOWER AND DOES IT CONSTITUTE A REVOLUTION IN MILITARY AFFAIRS?

EXECUTIVE SUMMARY

This paper attempts to answer the first question in its title by examining ways to describe and categorize space activities. It examines the second question by using analogies between previous revolutions in military affairs and spacepower. The paper describes three ways to describe spacepower: 1) space activity sectors (civil, commercial, intelligence, and defense); 2) military space mission areas (space support, force enhancement, space control, and force application); and 3) Lupton's four military space doctrines (sanctuary, survivability, control, and high-ground). It also discusses different ways to view space: as an economic center of gravity and a global utility, in terms of seapower and airpower analogies, as a frontier, and in terms of religious implications and the Overview Effect. The paper uses the revolution in military affairs (RMA) definition developed by the Center for Strategic and Budgetary Assessments and argues that spacepower will not represent a true RMA until space is weaponized. For the near-term, the links between spacepower and the commercial space sector should be studied most carefully because these linkages will point to how the military can best use commercial space assets and also highlight the areas where it will require dedicated military systems. Although space is not an economic center of gravity today, it may emerge as one in the coming decades. It is less clear, however, that traditional "flag follows trade" arguments will lead to an increased military space presence or provide the best way to protect space assets. Looking beyond just economic considerations, there appear to be a growing number of strategic factors that are creating pressure for increased militarization and probably weaponization of space. To date, military space developments have been very important, but they have been more evolutionary than revolutionary. As current political and technological challenges are surmounted, however, it is likely that space—like every other environment humankind has opened—will become weaponized and will emerge as a true RMA.

SPACE-RELATED ARMS CONTROL AND REGULATION TO 2015: PRECEDENTS AND PROSPECTS

EXECUTIVE SUMMARY

This essay discusses the five most important precedents in space-related arms control and regulation in considerable detail: the reconnaissance satellite overflight regime, the communications satellite regulatory regime, the Outer Space Treaty regime, the Anti-Ballistic Missile Treaty regime and space-based defenses, and anti-satellite (ASAT) developments and ASAT arms control. It also outlines the space-related parts of START I and II, the most recent arms control treaties. Finally, the essay discusses five space-related areas that contain significant conflict today and are likely to remain contentious into the future: space weaponization; high-altitude nuclear detonations; high-resolution commercial remote sensing; global utilities; and spectrum crowding, orbital debris, and space traffic control. From the precedents in space arms control three major themes stand out: space is seldom a stand-alone policy consideration, the truisms that "arms are always controlled in a democracy" and "arms control works best when it's needed least," and the large number of extreme difficulties for space-related arms control. When examining the contentious areas for space arms control through 2015, the essay finds that there are at least four entrenched camps within the United States—space hawks, inevitable weaponizers, militarization realists, and space doves—and this is likely to make it very difficult for the United States to advance major arms control initiatives on space weaponization for the foreseeable future. Likewise, the United States either faces daunting political and technical challenges or would simply be wise to take a measured approach to arms control or regulation for a number of related issues such as high-resolution commercial remote sensing, global utilities, spectrum crowding, and space traffic control. Opportunities for arms control and regulation in these areas should be studied very carefully, balanced evenly in relation to their costs and benefits for the four space sectors, and weighed against both their opportunity costs and likely unintended consequences. One near-term opportunity for space-related arms control and regulation may be the proposed "spaceworthiness license"—a way to create incentives for the commercial sector to harden satellites against nuclear effects and to minimize orbital debris.

WHAT IS SPACEPOWER AND DOES IT CONSTITUTE A REVOLUTION IN MILITARY AFFAIRS?

A confluence of trends and recent developments has elevated national security space issues close to the top of the American defense policy agenda. During 2000, national security space issues were carefully examined in three of the most important congressionally mandated studies ever convened on this subject: The National Reconnaissance Office (NRO) Commission, the National Imagery and Mapping Agency (NIMA) Commission, and the Commission to Assess National Security Space Management and Organization (Space Commission).[1] These studies—along with the arrival of the George W. Bush Administration; the installation of Donald H. Rumsfeld as Secretary of Defense; and ongoing sweeping changes in senior military leadership positions including General Richard B. Myers as the new Chairman of the Joint Chiefs of Staff, General John P. Jumper as the new Chief of Staff of the Air Force, and General Lance W. Lord in the new four-star billet as commander of Air Force Space Command—create an outstanding opportunity to examine current national security space issues and to place them into a broader context. Accordingly, this paper attempts to outline answers to two fundamental questions concerning the relationship between space and national security: 1) what is spacepower? and 2) does spacepower constitute a revolution in military affairs?

WHAT IS SPACEPOWER?

"Spacepower" is literally a cosmic concept that is complex, indeterminate, and intangible. It is pregnant with a range of possibilities but it means so many different things to different people and groups that the concept is fraught with ambiguity. Confusion swirls on the semantic level because there is no commonly accepted definition or accepted wording for this concept.[2] There is not even agreement on basic issues such as where the atmosphere ends and space begins.[3] Yet, despite these weaknesses in the conceptual foundation for spacepower, a strong and widespread recognition of the growing importance of space to national security has developed. Indeed, this is a central theme in much of the recent literature such as the Space Commission Report, Barry D. Watts' *The Military Use of Space*, Steven Lambakis' *On the Edge of Earth*, Everett C. Dolman's *Astropolitik* and Robert Preston's *Space Weapons: Earth Wars*.[4] In addition, spacepower has figured very prominently in several of the most recent Title X wargames conducted by the U.S. Army and Air Force.[5]

This paper highlights the emerging consensus on space's growing importance but takes a wide-ranging perspective on the attributes that comprise spacepower, sees the elements of spacepower as interrelated and multidimensional, and emphasizes that the determinants of space's strategic utility go beyond just international military competition. It first looks at ways to categorize spacepower such as space activity sectors, military space mission areas, and David Lupton's four military space doctrines. Then, it examines a broad range of factors that shape our perceptions of space. Throughout, it argues that economic factors now shape spacepower in fundamental ways, primarily due to rapid growth in commercial space activities and the inherently dual-use nature of many space systems.

Ways to Categorize Spacepower

Space Activity Sectors. The attributes of spacepower are often described using four sectors of space activity: civil, commercial, military, and intelligence.[6] The Space Commission Report provides an outstanding, current, and comprehensive overview of the types of activities that are contained in each sector and how they contribute to national security:

> *Civil Space Sector*. The civil space sector is approaching a long-standing goal of a permanent manned presence in space with the deployment of astronauts to the International Space Station. The U.S. has shouldered the largest share of development and funding for this effort. Because it is an international program, however, its benefits for scientific research, experimentation and commercial processes will be widely shared. The number of countries able to participate in manned space flight has grown substantially. In addition to the U.S. and the USSR (now the Russian Federation), 21 other countries have sent astronauts into orbit in U.S. and Russian spacecraft. The People's Republic of China has announced its intention to become the third nation to place human beings in orbit and return them safely to earth. Other research and experiments in the civil sector have many applications to human activity. For example, civil space missions to understand the effects of the sun on the earth, other planets and the space between them, such as those conducted by the Solar Terrestrial Probe missions, will help in the development of more advanced means to predict weather on earth.
>
> *Commercial Space Sector*. Unlike the earlier space era, in which governments drove activity in space, in this new era certain space applications, such as communications, are being driven by the

commercial sector. An international space industry has developed, with revenues exceeding $80 billion in 2000. Industry forecasts project revenues will more than triple in the next decade. Whereas satellite system manufacturing once defined the market, the growth of the space industry today, and its hallmark in the future, will be space-based services. The space industry is marked by stiff competition among commercial firms to secure orbital locations for satellites and to secure the use of radio frequencies to exploit a global market for goods and services provided by those satellites. International consortia are pursuing many space enterprises, so ascertaining the national identity of a firm is increasingly complex. The calculations of financial investors in the industry and consumer buying habits are dominated by time to market, cost and price, quantity and quality. It is a volatile market.

Nevertheless, as a result of the competition in goods and services, new applications for space-based systems continue to be developed, the use of those products is increasing and their market value is growing. Space-based technology is revolutionizing major aspects of commercial and social activity and will continue to do so as the capacity and capabilities of satellites increase through emerging technologies. Space enters homes, businesses, schools, hospitals and government offices through its applications for transportation, health, the environment, telecommunications, education, commerce, agriculture and energy.

Space-based technologies and services permit people to communicate, companies to do business, civic groups to serve the public and scientists to conduct research. Much like highways and airways, water lines and electric grids, services supplied from space are already an important part of the U.S. and global infrastructures. The most telling feature of the new space age is that the commercial revolution in space has eliminated the exclusive control of space once enjoyed by national defense, intelligence and government agencies. For only a few thousand dollars, a customer today can purchase a photograph of an area on earth equal in quality to those formerly available only to the superpowers during the Cold War. Commercial providers can complement the photographic images with data that identify the location and type of foliage in an area and provide evidence of recent activity there. They can produce radar-generated maps with terrain elevations, transmit this information around the globe and combine all of it into formats most useful to the customer. This service is of increasing value to farmers and ranchers, fisherman and miners, city planners and scientists.

Defense Space Sector. Space-related capabilities help national leaders to implement American foreign policy and, when necessary, to use military power in ways never before possible. Today, information gathered from and transmitted through space is an integral component of American military strategy and operations. Space-based capabilities enable military forces to be warned of missile attacks, to communicate instantaneously, to obtain near real-time information that can be transmitted rapidly from satellite to attack platform, to navigate to a conflict area while avoiding hostile defenses along the way, and to identify and strike targets from air, land or sea with precise and devastating effect. This permits U.S. leaders to manage even distant crises with fewer forces because those forces can respond quickly and operate effectively over longer ranges. Because of space capabilities, the U.S. is better able to sustain and extend deterrence to its allies and friends in our highly complex international environment. Space is not simply a place from which information is acquired and transmitted or through which objects pass. It is a medium much the same as air, land or sea. In the coming period, the U.S. will conduct operations to, from, in and through space in support of its national interests both on earth and in space. As with national capabilities in the air, on land and at sea, the U.S. must have the capabilities to defend its space assets against hostile acts and to negate the hostile use of space against U.S. interests.

Intelligence Space Sector. Intelligence collected from space remains essential to the mission of the Intelligence Community, as it has been since the early 1960s. Then the need to gain access to a hostile, denied area, the USSR, drove the development of space-based intelligence collection. The need for access to denied areas persists. In addition, the U.S. Intelligence Community is required to collect information on a wide variety of subjects in support of U.S. global security policy. The Intelligence Community and the Department of Defense deploy satellites to provide global communications capabilities; verify treaties through "national technical means"; conduct photoreconnaissance; collect mapping, charting, geodetic, scientific and environmental data; and gather information on natural or man-made disasters. The U.S. also collects signals intelligence and measurement and signature intelligence from space. This intelligence is essential to the formulation of foreign and defense policies, the capacity of the President to manage crises and conflicts, the conduct of military operations and the development of military capabilities to assure the attainment of U.S. objectives.[7]

Military Space Mission Areas. Another important typology for describing spacepower was first adopted by the U.S. military in the 1980s and still provides a foundational and consistent framework to categorize the military missions that contribute to spacepower.[8] Under this typology, **space support** is a very broad category that contains all activities that enable military space mission accomplishment. Space support includes the development and acquisition of all military space hardware and software; all the infrastructure required to launch, track, and command military space systems; and all the personnel and the education and training systems required to sustain military space activities. **Force enhancement** is the primary emphasis of today's military space forces. This mission refers to all military space activities that help to increase the warfighting effectiveness of terrestrial forces and is sometimes referred to as "space support to the warfighter." Force enhancement is further divided into the following areas: geodesy, weather, communications, navigation, early warning and attack

Table 1: Force Enhancement Mission Areas, Primary Orbits, and Associated Space Systems[9]

Geodesy	Meteorology	Communications	Navigation	Early Warning and Attack Assessment	Surveillance and Reconnaissance
Low-Earth Orbit (LEO)	Polar LEO	Geostationary Orbit (GSO)	Semi-synchronous Orbit	GSO and LEO	Polar LEO and GSO
Landsat	Defense Meteorological Support Program (DMSP), National Polar-Orbiting Operational Environmental Satellite System (NPOESS)	Defense Satellite Communications System (DSCS) II, DSCS III, Ultra-High Frequency Follow-on (UFO), Milstar, Global Broadcast System (GBS), Advanced Extremely High Frequency (AEHF), Wideband Gapfiller Satellite (WGS)	Global Positioning System (GPS)	Defense Support Program (DSP), GPS, Space-Based Infra-Red System (SBIRS) High and Low	Keyhole (KH) Series, Signals Intelligence (SIGINT) Satellites, Future Imagery Architecture (FIA), Integrated Overhead SIGINT Architecture (IOSA)

assessment, and surveillance and reconnaissance. Table 1 lists current and near-term space systems most closely associated with each of these six mission areas. There is widespread consensus on the elements that constitute these two military space mission areas and general agreement that the United States should perform these types of missions from space.

By contrast, there is much less consensus on the types of functions that would be required for space control and force application or on the need for the U.S. military to perform such missions. **Space control**, refers to "the ability to assure access to space, freedom of operations within the space medium, and an ability to deny others the use of space, if required."[10] The use of anti-satellite (ASAT) weapons is one commonly discussed space control mission, but a wide range of missions—including conventional or unconventional attacks on terrestrial telemetry, tracking, and controlling (TT&C) facilities—would also fall into the space control area. The final category, **Force application** is usually defined as the use of military force to, from, or within space where the primary objective is to affect the course of terrestrial conflict directly. Space-based ballistic missile defense (BMD) is often discussed as the most important near-term force application mission. Most military space activities fit into one of these four categories and, of course, most of today's military space activities are in the first two categories: space support and force enhancement.

Lupton's Four Military Space Doctrines. The four military space doctrines developed by David Lupton in *On Space Warfare* provide an important and comprehensive way to analyze the strategic rationale behind military space activities (they are summarized in Table 2 below).[11] The **sanctuary** doctrine builds on President Dwight Eisenhower's concepts of "open skies" and "space for peaceful purposes" by emphasizing that space systems are ideal for monitoring military activity, providing early warning to reduce the likelihood of surprise attack, and serving as National Technical Means of Verification (NTMV) to enable and enforce strategic arms control. The basic tenet of the sanctuary doctrine is that space surveillance systems make nuclear wars less likely. Sanctuary doctrine is closely linked to deterrence theory and the assumption that no meaningful defense against nuclear attack by ballistic missiles is possible. Sanctuary doctrine advocates believe that overflight and remote sensing enhance stability and that space must be kept a weapons-free zone to protect the critical contributions of space surveillance systems to global security. **Survivability**, Lupton's second space doctrine, emphasizes broad utility for military space systems, not only at the strategic level emphasized in the sanctuary doctrine, but also at the tactical level of space support to the warfighter that has emerged as the most important force enhancement mission since the end of the Cold War.

Table 2: Attributes of Military Space Doctrines

	Primary Value and Functions of Military Space Forces	**Space System Characteristics and Employment Strategies**	**Conflict Missions of Space Forces**	**Appropriate Military Organization for Operations and Advocacy**
Sanctuary	• Enhance Strategic Stability • Facilitate Arms Control	• Limited Numbers • Fragile Systems • Vulnerable Orbits • Optimized for NTMV mission	• Limited	NRO
Survivability	Above functions plus: • Force Enhancement	• Redundancy • Hardening • On-Orbit Spares • Crosslinks • Maneuver • Less Vulnerable Orbits • Stealth • Reconstitution Capability • Defense • Convoy	• Force Enhancement • Degrade Gracefully	Major Command or Unified Command
Control	• Control Space • Significant Force Enhancement		• Control Space • Significant Force Enhancement • Surveillance, Offensive, and Defensive Counterspace	Unified Command or Space Force
High Ground	Above functions plus: • Decisive Impact on Terrestrial Conflict • BMD		Above functions plus: • Decisive Space-to-Space and Space-to-Earth Force Application • BMD	Space Force

The survivability doctrine also differs from the sanctuary doctrine because it highlights space system vulnerabilities and questions whether space can be maintained as a sanctuary due to ongoing technological improvements in systems such as ASAT weapons. Lupton's **control** doctrine is analogous to military thinking about sea or air control and asserts the need for control of space in order to apply spacepower most effectively. Thus, the control doctrine sees space as similar to other military environments and argues that both commercial activities and military requirements dictate the need for space surveillance, as well as offensive and defensive counterspace capabilities. Lupton's final doctrine, **high ground**, argues that space is the dominant theater of military operations and is capable of affecting terrestrial conflict in decisive ways. As a primary example of such capability, the high-ground doctrine points to the potential of space-based BMD to overturn the dominance of offensive strategic nuclear forces.

Factors that Shape Our Perceptions of Spacepower

A number of less tangible factors, including some that are not directly related to national security, may also help to shape our perceptions of spacepower in more subtle yet important ways. Due to the rapid growth of the commercial space sector during the last decade, economic considerations such as whether space has become an economic center of gravity and its role as a global utility are now key factors in shaping our perceptions about spacepower. As discussed below, other major factors that shape our perception of spacepower include seapower and airpower analogies, the frontier analogy, and the overview effect.

Space as an Economic Center of Gravity and a Global Utility. The most important set of factors that shape our perceptions of spacepower relate to the growing commercial importance of space, claims that it constitutes an economic center of gravity (COG), and its emergence as a global utility. Perceptions on the importance of these factors vary considerably but they nonetheless became a central theme in United States Space Command's (USSPACECOM) public discourse during the latter half of the 1990s. This emphasis was most pronounced during the tenure of General Howell M. Estes as Commander-in-Chief of USSPACECOM (CINCSPACE); continued during the tour of General Richard B. Myers; but, interestingly, has not been repeated thus far by General Ralph E. Eberhart, the current CINCSPACE. The increased use of the term COG to describe the commercial space sector coincided with rapid actual growth in commercial space activities in this period but it was predicated even more directly on projections of exponential growth. Forecasts during 1997 and 1998 called for growth at a "blistering rate of 20 percent a year" to support a "gold rush in space."[12]

> 550 satellites today are in Earth orbit, performing numerous critical defense and civil functions. Nearly half of them belong to the US, and half of those are commercial. US space investment now exceeds $100 billion, and the stakes are about to go higher.

> Expectations are that the US and the world's other spacefaring nations, over the next five years, will pump another $500 billion into space. They will launch at least 1,000, and possibly 1,500, new satellites. Most will be commercial systems. Many will have military significance.
>
> "We'll see commercial use of space go out of sight," said USAF's Chief of Staff, Gen. Michael E. Ryan.[13]

General Estes developed and articulated one of the most powerful visions for space of any CINCSPACE to date. Early in his tenure (August 1996-August 1998) he began emphasizing the emergence of space as an economic COG at virtually every opportunity. In one of his earliest and most sweeping speeches, delivered at the United States Space Foundation's annual symposium in April 1997, he introduced several major themes he would reiterate in speeches and in reports during the remainder of his term:

> Today, more than ever, it is important that all Americans understand that our investment in space is rapidly growing and soon will be of such magnitude that it will be considered a vital interest—on par with how we value oil today. . . .
>
> Now while it might seem appropriate that I should be more concerned with military space, I must tell you that it is not the future of military space that is critical to the United States—it is the continued commercial development of space that will provide continued strength critical for our great country in the decades ahead. Military space, while important, will follow.
>
> Commercial space, as I said earlier, will become an economic center of gravity, in my opinion, in the future and as such will be a great source of strength for the United States and other nations in the world. As such, this strength will also become a weakness, a vulnerability. And it's here that the U.S. military will play an important role, for we will be expected to protect this new source of economic strength.[14]

Space as an economic COG was also an important theme in the *Long Range Plan*, the most important report USSPACECOM released during General Estes' tenure:

> Space capabilities are becoming absolutely essential for military operations, national commerce, and everyday life. In fact, space is emerging as a military and economic center of gravity for our information-dependent forces, businesses, and society. Life on earth is becoming inextricably linked to space. . . .
>
> Although the notion of space as a sanctuary appears seductive to many, our increasing reliance on space systems, and information derived from space, creates a center of gravity potential adversaries clearly understand. Protection takes on a new dimension as non-DoD systems (commercial and third-party) become even more integrated into plans for using joint forces.[15]

General Estes linked his vision of a growing commercial space sector as a burgeoning economic COG directly to the assumption that this growth would prompt calls for an increased military role in protecting "this new source of economic strength." The logic of this "flag follows trade" argument is clear and has historical precedents but to date it has not yet prompted any significant calls for better protection.[16] If anything, the general attitude of the commercial space industry has thus far minimized threats to their systems and denied the need for better military protection.[17] It is currently unclear that military means are the best way to protect commercial satellites or that the military will be called upon to build a more robust space infrastructure based on perceived threats to commercial systems.

Despite the industry's tepid response, the Air Force continued to emphasize the flag follows trade route to a greater military space presence. General Estes was an influential member of the Air Force's General Officer "Board of Directors" that agreed following a CORONA meeting in November 1996 to issue *Global Engagement*—a sweeping new vision statement for the Air Force. This statement corresponded closely with his perception of the importance of space to the nation and asserted that the Air Force is "now transitioning from an *air* force into an *air and space* force on an evolutionary path to a *space and air* force."[18] In a related bureaucratic move, General Estes also attempted to have space designated as an "area of responsibility" (AOR) similar to the AORs assigned to regional commands by the Unified Command Plan (UCP). As a result, CINCSPACE was designated as the single focal point for all military space operations, but the 1998 UCP stopped short of his recommendation to make space a dedicated AOR.[19] After retiring, General Estes became even more outspoken in his assessments, "declaring that anyone who does not believe that space is emerging as 'an economic center of gravity for our country . . . [is] not paying attention' to what is going on. 'It is a fact—lots and lots of money [is] going to space worldwide and lots of investment in this country.'"[20]

General Richard B. Myers, General Estes' successor as CINCSPACE, was confirmed as Chairman of the Joint Chiefs of Staff in 2001. He served as CINCSPACE from July 1998 until February 2000 when he became Vice Chairman of the Joint Chiefs of Staff. General Myers generally reiterated General Estes' emphasis on space as an economic COG but added three important changes: first, that space was already a COG; second, that space was a *military* and economic COG; and third, that United States reliance on commercial space had created vulnerabilities easily exploited by potential adversaries. One of his first pronouncements along these lines came in Los Angeles at the Air Force Association Space Symposium in November 1998: "space has become a military and economic center of gravity. So much of the world's standard of living, so much of its commercial wealth depends on space."[21] Later in his tenure, General Myers put more emphasis on how U.S. reliance on commercial space was creating new vulnerabilities: "Clearly, our reliance on commercial space has created a new center of gravity that can easily be exploited by our adversaries."[22] Just before leaving his CINCSPACE tour, General Myers summarized his position and emphasized the importance of space control in an editorial for *Aviation Week & Space Technology*:

> Space is a military and economic center of gravity. We can't afford to take it for granted. Only through a robust space control and modernization vision can we thwart military or terrorist attacks, and manage the space "gold rush," while continuing to reap tremendous benefit, both in economic and national security terms.[23]

The current CINCSPACE, General Ralph E. Eberhart, assumed his position in February 2000. In his speeches and reports thus far he has usually avoided using the term COG to describe the economic and military importance of space and, in general, he has not placed as much emphasis on the growth and importance of the commercial space sector as did his predecessors. General Eberhart's approach reflects the recent slowdown in commercial space, gave some support to the Air Force's emphasis on the aerospace concept and aerospace integration in its June 2000 vision statement, *Global Vigilance, Reach & Power*, and is in line with the major recommendations in the Space Commission report.[24] The Air Force's 2000 vision statement attempted to move the Service "Back to the Future" by returning to "aerospace" (a concept originally articulated by Chief of Staff Thomas D. White in the 1950s) and abandoning the separate "air and space" construct that was introduced in June 1992 and emphasized in the November 1996 *Global Engagement* vision.[25] Instead, General Eberhart has stressed personnel issues such as retention problems; the command's efforts to come to grips with its newest missions, computer network defense (CND) and computer network attack (CNA); and, especially, the need for space control.[26] He also recommended the formation of a Space Tactical School to "develop space warfare concepts" and has created the "Space Aggressor Squadron, whose job it is to play against the Air Force and other services in wargames such as Red Flag and to heighten both military and civilian awareness of the threat[.]"[27] One of the best illustrations of these subtle changes in emphasis came in General Eberhart's November 2000 interview in *Aviation Week & Space Technology*:

> Integration has been exactly the right thing to concentrate on these last 5-10 years, as we tried to harness the national systems post-[Operation] Desert Storm. . . . The fact that we heard so much about [the need for integration] after Desert Storm, and didn't after Kosovo, tells me that we're on the right track. Now, we need to make sure we can protect the capabilities that resulted from that integration. . . . I don't think we would be good stewards of space if we only thought about 'integration.' We also need to be spending resources and intellectual capital on space control and space superiority. . . . The importance of space control and space superiority will continue to grow as our economy become more reliant on space. . . . If we only look at space in terms of 'integration,' in my view, we'll fall into the same trap we fell into with the airplane. . . . We [initially] thought of it in terms of intelligence, surveillance, reconnaissance, communication and weather [support]. If we only think of space in these ways, [it's just] a 'higher hill' as opposed to a center-of-gravity. We [also] have to be able to surveil, protect and negate under this space control mission.[28]

But is commercial space truly an economic COG for the United States? More than most, commercial space is a volatile industry that been through several boom and bust cycles and has often delivered less than promised. It is also highly complex because it is closely tied not only to economic cycles but also to many other factors such as technological developments, international politics, and domestic regulation. USSPACECOM's assertions during 1997-99 that space is an economic COG were made based on projections drawn from the commercial space sector's strongest ever growth cycle. The "gold rush" mentality of firms seeking competitive niches in the communications spectrum or in specific markets reinforced perceptions that commercial space would remain in a cycle of continuing upward acceleration. The resulting projections too often relied on best-case scenarios rather than more somber economic analysis and they also suffered from the lack of an objective and timely overall market survey. Analysts currently have far better insight into these issues due to the slower actual development of the markets over of time and the Futron Corporation's new annual *Satellite Industry Guide* helps to address the later problem.[29] Futron's guide, based on their proprietary database and published in partnership with the Satellite Industry Association and George Washington University's Space Policy Institute, uses a "consistent and reliable set of industry metrics based on primary research data" to provide a comprehensive survey of where the industry has been and where it is heading.[30]

Space activities clearly enhance and enable many economic activities; space should undoubtedly be considered a strategic sector of the global information infrastructure and the world economy. Using the Futron data to analyze the current status and trends of the commercial space sector, however, one overarching conclusion immediately jumps out: as of the end of 2000, commercial space activity simply did not develop in the directions and magnitude projected as recently as two years ago. Despite the significant growth of the commercial space sector in the second half of the 1990s, the trajectory of actual developments fell significantly short of the projected vector ($500 billion investment and 1000-1500 launches by 2003) that had been touted in forecasts as late as the end of 1998.

Where does the commercial space sector fall within the big picture context of the overall U.S. economy? Aerospace corporations form an important part of the economy but in pure dollar terms they—like any other single industry—are simply not a dominant sector or an economic COG in terms of overall value, revenues, or market capitalization. The main reason for this is the huge size of the U.S. gross domestic product (GNP). The Commerce Department estimated the 2000 U.S. GDP at $9.873 trillion, a value that dwarfs the value of any individual sector.[31] Anyone watching the financial markets during the past several years knows that revenues and market valuations are highly volatile; but, while growing, space-only revenues and valuations have never yet been that big a part of the U.S. economy at any time or under any classification scheme. Consider revenues: the 2001 *Fortune Magazine* list of the top 500 U.S. corporations by revenue does show a scattering of aerospace companies among the top 100 firms—Boeing at number 15, Motorola at 34, United Technologies at 64, Lockheed Martin at 69, Honeywell at 71, and the AMR Corporation at 98.[32] But this listing reflects *all* revenues for these firms rather than their space-only revenues. When the space-only revenues are examined the picture becomes quite different. According to the Space Commission Report, *global* commercial space activities generated a total of $80 billion in revenues in 2000, and while this is clearly a lot of money in absolute terms, it represents only 8.9 percent of the revenues of just the top five U.S. corporations (Exxon Mobil, Wal-Mart, General Motors, Ford Motor, and General Electric) from the *Fortune* 500 list for 2001.[33]

Should we consider commercial space "on par with how we value oil today"? Space is not there yet in dollar terms: the total revenues of energy corporations from the *Fortune* 500 list for 2001 was more than three times the value of the revenues from aerospace corporations.[34] But how about the market valuation of space corporations? At the end of 1999 the combined market valuation for *all* major U.S. aerospace firms (Boeing, Honeywell, United Technologies, General Dynamics, Textron, Lockheed Martin, Raytheon, TRW, Northrop Grumman, and Litton Industries) amounted to approximately $150 billion but was still less than the market valuation of Home Depot Corporation.[35] The intent of all these comparisons is not to depreciate the importance of commercial space activities; rather, they are designed to show that commercial space activities do not yet constitute a COG for the economies of the United States or the world. The comparisons also help to illuminate the true strategic utility of commercial space activities and highlight that these activities should be thought about and valued in a variety of ways other than just in terms of economics.

Despite the relatively small size of commercial space in comparison with the whole U.S. economy, it is nonetheless a vibrant sector that had grown very rapidly prior to the current recession and is still creating novel commercial activities. A few statistics and trends illustrate the overall state of the commercial space sector. During the period from 1996 through 2000, for example, global commercial space revenues rose 85 percent, going from $44.8 billion to $83 billion; and total employment rose 46 percent, from 173,400 to 253,600.[36] Likewise, from 1996 to 1998 the total number of satellites launched each year (both commercial and non-commercial) rocketed up 80 percent from 86 to 155.[37] In retrospect, however, 1998 represents a spike in launch numbers that was clearly caused by a major push to populate big non-geostationary orbit (big NGSO) constellations such as Iridium and Globalstar with relatively small networked comsats. It is unclear whether this pattern will be repeated due to the cloudy prospects for future big NGSO systems and the larger number of satellites that may be carried per launch on future systems. Total launches declined 42 percent to 90 total in 1999 and declined roughly another 15 percent in 2000.[38] Another overall trend may be more significant and enduring: the late 1990s marked the first time commercial space activities and investment approached or actually exceeded government activity in areas such as number of launches, satellite manufacturing revenue, and launch revenue.[39] With government space expenditures projected to remain relatively constant, even modest growth in commercial space activities will widen the gap and continue the transformation of the commercial space sector from the smallest sector into the largest.

Futron defines **satellite services** as the use of satellites to deliver telephony, television, radio, data communication, remote sensing data, and government services. These services are the largest single component of commercial space, saw revenue growth of 134 percent between 1996 and 2000, and accounted for $37 billion or 44.5 percent of total commercial space revenues in 2000.[40] In the past, telephony was the dominant satellite service but now the "major driver of satellite services revenue is services that are provided directly to end-user customers (for example, [direct-to-home] DTH television services)."[41] The growth in direct to end-user services such as DTH television is extremely important to commercial space but this growth should not be allowed to mask two important considerations: 1) satellite telephony now accounts for only 3-5 percent of the $1 trillion global telephony market; and 2) the growth in other end-user services served to offset the concurrent precipitous decline in satellite telephony caused by the growing dominance of fiber optics for most telecommunications services. Simply put, satellites' once dominant position in global transoceanic telephony has already been lost to fiber; fiber's share of this market grew from only two percent in 1988 to over 80 percent in 2000.[42] Moreover, because new fiber technologies such as optical switching and dense wavelength division multiplexing (DWDM) are slated to be in widespread use by 2002 and are designed to double (at least) the capacity of each fiber strand, even next generation wireless broadband such as Hughes' Spaceway system may continue to have a very hard time competing with fiber for any fixed, point-to-point telecommunication service.[43] The satcom versus fiber tradeoff is just one of the many complex issues that will shape the future of wireless broadband and the role of space systems within these markets. At present, however, it is not clear that large-scale "Internet-in-the-sky" systems such as Teledesic can be developed cheaply, quickly, and flexibly enough to compete effectively with terrestrial alternatives for most applications.

Satellite manufacturing is the second largest component of the commercial space sector. This area grew by 47.5 percent between 1996 and 2000 and accounted for $18.3 billion or 22 percent of total commercial space revenue in 2000.[44] As within the rest of the aerospace industry, there has been a great deal of consolidation and restructuring within the satellite manufacturing business. Five firms now dominate the global satellite manufacturing market: Boeing Satellite Systems (formed in October 2000 when Boeing acquired the Hughes Electronic satellite manufacturing businesses), Space Systems/Loral, Lockheed Martin, Astrium (formed by the 1999 merger of Matra Marconi Space and DaimlerChrysler Aerospace), and Alcatel. Increasing competition both within the industry and between satcom and fiber has required firms to adapt rapidly to changing market forces. Improved manufacturing processes and standardization techniques for GEO comsats have reduced the amount of time from contract award to launch from 58 months in 1991 to 29 months in 1998.[45] In an even more radical departure for the industry, most NGSO satellites are now put together using assembly line techniques within a matter of a few days. The market for both GEO and NGSO satellites is also quite cyclical; for example, 40 GSO comsats were ordered in 2000 versus only 15 ordered in 1999.[46] But is unclear that satellite builders can sustain their recent rates of growth even with the restructuring in the industry and new manufacturing techniques.

United States satellite builders face a particularly difficult challenge because they must overcome significant hurdles to obtain export licenses and now face newly consolidated but experienced and subsidized European competition that is made more attractive by a weak Euro. Indeed, satellite manufacturing representatives and many independent analysts now argue that the United States Government (USG) overreacted to the inappropriate space technology transfers detailed in the Cox Report.[47] They believe that when the government returned export license approval authority to the State Department from the Commerce Department in March 1999 it did not make common-sense distinctions between exports to allies and to others. Further, they charge that these changes created large administrative burdens and regulatory time delays that have undermined sales in this strategic sector but that do not necessarily enhance national security or keep critical technologies out of the wrong hands.[48]

Launch and **ground equipment manufacturing** form the last two segments of the commercial space sector; in 2000 they comprised $9.6

billion (11.5 percent) and $17.7 billion (21.3 percent), respectively, of the world's total commercial space revenues.[49] Between 1996 and 2000, launch revenues grew by 39 percent and ground equipment manufacturing revenues grew by over 82 percent.[50] Launch is undoubtedly the most competitive component of commercial space due to a wide variety of launch vehicle suppliers, many of which are state sponsored or otherwise subsidized by the five states that offer commercial launch services (United States, Europe, China, Ukraine, and Russia). The August 1994 U.S. Space Transportation Policy formally divided effort on new launch vehicles between the NASA and DOD, with the former responsible for developing new reusable launch vehicles (RLVs) and the latter responsible for new expendable launch vehicles (ELVs).[51] The X-33, X-34 and the evolved expendable launch vehicle (EELV) are the programs that flowed directly out of this policy.[52] Under the Space Lift Initiative (SLI) announced by the Bush Administration in March 2001, funding for the X-33 and X-34 programs was ended before any flight tests were conducted and, despite some discussions, DOD has not stepped in the save the X-33 program.[53] In the United States there are also currently no less than seven commercial RLV companies in the conceptual development phase but it is very unlikely that there will be enough demand to keep all of these efforts alive.[54] Other significant factors shaping the near-term prospects of the commercial launch industry include: the continuing string of failures in launch or in achieving the correct orbit, the expiration of launch quotas for Ukrainian and Russian launch vehicles, investments by launch providers in NGSO systems, launch range standardization and modernization plans, and the successful emergence of Sea Launch—the first commercial sea-mobile launch platform. The ground equipment manufacturing component of commercial space activities is characterized by rapid growth (especially in direct to end-user services), significant consolidations within larger companies, and the entry of a large number of smaller companies. The most important merger was between AlliedSignal and Honeywell in December 1999 and this was followed-up in October 2000 when General Electric agreed to acquire Honeywell in a tax-free merger valued at $43 billion.[55] The U.S. Department of Justice gave conditional approval for this acquisition in May 2001 but in July the European Union rejected the deal on anti-trust grounds, making it the first proposed merger of U.S. corporations blocked solely by European regulators.[56]

A final set of issues related to these commercial space considerations is the role of spacepower in providing global utilities. Like their terrestrial counterparts, space-based global utilities provide basic services or public data. Examples of space-based global utilities include weather data and Global Positioning System (GPS) positioning and timing signals. Current

U.S. policy calls for these services to be provided as a public good without direct user fees.[57] The importance of these space-based global utilities is growing and they often constitute an imbedded or enabling technology within other systems. GPS timing signals, for example, can be used to synchronize the compressed digitized packages of data within communications networks that use protocols such as Code Division Multiple Access (CDMA) and Time Division Multiple Access (TDMA). Overall, these space-based global utilities form an important part of the global infrastructure for public services and commercial intercourse. However, there are a number of questions concerning the types of threats these systems face and how these might best be mitigated. Some analysts, primarily in the U.S. military, believe that threats to these systems call for increased space control efforts in order to provide protection.[58] Other analysts note that commercial satellite operators are not clamoring for military protection, wonder if similar threats warrant the development of military space control capabilities, and question whether the development of such capabilities would, in fact, protect space-based global utilities.

Seapower and Airpower Analogies. Another direct and obvious set of factors shaping our perceptions of spacepower are the oft-invoked analogies between spacepower and seapower or airpower. There is, of course, a rich literature on seapower and airpower theory. Seminal theorists who developed important perspectives on military operations in these two mediums include: Alfred Thayer Mahan, Julian Corbett, Giulio Douhet, William "Billy" Mitchell, and John Warden.[59] Some of the key concepts that these theorists developed or applied to the air and sea mediums are command of the sea, command of the air, sea lines of communication, common routes, choke points, harbor access, concentration and dispersal, and parallel attack. Several of these concepts have been appropriated directly into various strands of embryonic space theory; others have been modified slightly then applied. For example, Mahan and Corbett's ideas about lines of communications, common routes, and choke points have been applied quite directly onto the space medium. Seapower and airpower concepts that have been modified to help provide starting points for thinking about spacepower include harbor access and access to space, and command of the sea or air and space control.[60] But, of course, to date no comprehensive spacepower theory has yet emerged that is worthy of claiming a place alongside the seminal seapower and airpower theories listed above.[61]

There are also many fundamental questions concerning the basic attributes of the space medium and how appropriate it is to analogize directly from seapower or airpower theory when attempting to build spacepower theory. Few concepts from seapower theory translate directly into airpower theory—why should we expect either seapower or airpower theory to apply directly for the distinct medium of space? Questions concerning the attributes of space and the proper way to build space doctrine are also at the heart of the disagreements between the Air Force and rest of the Department of Defense (DOD) over whether air and space should be treated as a seamless operational medium (defined as aerospace by the Air Force) or regarded as distinct air and space mediums (as seen by the rest of DOD).[62]

> many of the problems with the aerospace concept and the development of space-power theory and doctrine have already been thoughtfully addressed in this [*Aerospace Power*] journal over the years. Dennis Drew, Charles Friedenstein, and Kenneth Myers and John Tockston published three of the best analyses during the 1980s.[63] These interrelated articles build on Drew's doctrine-tree model—the idea that doctrine should grow out of the soil of history, develop a sturdy trunk of fundamental doctrine, branch out into doctrine for specific environments, and only then attempt to sprout the organizational doctrine analogous to "leaves." This approach provides a comprehensive way to examine the aerospace concept and the Air Force's first official space doctrine, Air Force Manual (AFM) 1-6, *Military Space Doctrine,* released in 1982.[64] Friedenstein finds that "there is no doctrinal foundation for the term *aerospace*" (emphasis in original) and critiques the Air Force for attempting to produce "leaves on a nonexistent branch" because it had not developed environmental doctrine before issuing the organizational doctrine in AFM 1-6.[65] Myers and Tockston strongly critiqued the Air Force's tendency to "force-fit" space doctrine into the mold of air doctrine and argued that the three major characteristics of space forces are in fact emplacement, pervasiveness, and timeliness.[66]

Thus, despite several efforts to appropriate or adapt key concepts from seapower and airpower theory, we are currently still adrift without a comprehensive spacepower theory to guide us and would be wise to cast our nets more widely and beyond traditional national security considerations.

Spacepower and the Frontier Analogy. The image of a frontier to be tamed evokes powerful images, particularly for Americans, and it is therefore not surprising that it has become one of the most popular ways to describe space. Frederick Jackson Turner first advanced his frontier thesis in 1893 as a way to describe and explain what he perceived to be distinctive characteristics of American history and American political thought.[67] For Turner, numerous American cultural traits could all be attributed to the influence of the frontier—"that coarseness and strength combined with acuteness and acquisitiveness; that practical inventive turn of mind, quick to find expedients; that masterful grasp of material things... that restless, nervous energy; that dominant individualism."[68] In short, he argued that the frontier represented "the line of most rapid Americanization."[69] A very short list of important specific references to space as a frontier would include the beginning of Captain James Tiberius Kirk's opening monologue on the original *Star Trek* series; the title of Space Studies Institute founder Gerard K. O'Neill's 1977 book, *The High Frontier,* the report of the 1986 National Commission of Space, *Pioneering the Space Frontier*; and Senator Bob Smith's (R-NH) numerous references to space as the "permanent frontier."[70] As with most other concepts associated with spacepower, there is much more agreement on describing space as a frontier than on the national security implications of this association. The U.S. military obviously played a very important role in opening the frontier. It took on exploration missions such as Lewis and Clark's Expedition, surveys for railroad routes by the Topographical Engineers, construction of navigable waterways by the Corps of Engineers, and protection for pioneers. Clearly, the military helped to explore, survey, and pacify the American frontier—are these activities analogous to what will be conducted in space and is the military the proper organization to carry them out?

Spaceflight, the Overview Effect, and Religious Implications for Spacepower. A final set of perspectives on spacepower may shape our views in the most subtle and pervasive ways. At their core, these perspectives link space to humankind's purpose and destiny. Humankind has pondered its relationship with the cosmos for millennia and perceptions about space form foundational components of many religious beliefs. In the modern era, the visions of spaceflight produced by Jules Verne and H. G. Wells helped to lay the foundation for the new genre of science fiction and were echoed in the quasi-religious zeal of spaceflight pioneers such as Konstantin Tsiolkovsky and Wernher von Braun as they laid the conceptual framework for spaceflight and began to create some of the tools needed to "leave the cradle." Later science fiction authors such as Arthur C. Clarke, Robert Heinlein, and Isaac Asimov combined with the increasing popularity of this genre for television and films has pervaded the human psyche with the boundless possibilities of space and rendered our actual achievements in space mundane by comparison. Yet, as humans entered space, many people and groups believed that the rationale and importance of spaceflight took on increased significance. Mainstream views on spaceflight cover a broad range. Individuals such as Gerard K. O'Neill build on Turner's frontier thesis and emphasize exploration as a cathartic and defining human characteristic. Carl Sagan is a primary spokesman for those who view spaceflight in scientific and ecological terms and see it as essential to the survival of the human species. Visions about spaceflight undoubtedly culminate in what Frank White labels "the overview effect"—nothing less than space opening the door to the next phase of human evolution.[71]

Likewise, the links between space and religious beliefs are still very important in the modern era. The first Soviet cosmonauts, for example, went to great pains to emphasize that they had not seen God during their travel through in the heavens and this prompted Western retorts questioning whether they were pure of heart. The reading of the first ten verses from *Genesis* by the crew of Apollo 8 as they became the first humans to view an Earthrise from Lunar orbit on Christmas Eve 1968 evoked strong religious feelings. As McDougall tells us, humankind has never "been able to separate our thinking about technology from teleology or eschatology."[72] The very framework of his book warns that technocracy in general and spaceflight in particular cannot serve as humankind's Guarantor of Destiny; instead, his instinct tells us

> that our science and technology, feeble as they are in controlling Nature, are so acute in studying it that they will soon reveal their limits. It is then that man must confess the mortality of his works, without turning on them or himself with contumely. It is then that the orthodox message is a sure guide: God made us, is disappointed in us, but loves us anyway, by which we are redeemed. Technology is our subcreation. We made it, we will be disappointed in it, but we must love it anyway, or it cannot be redeemed.[73]

The message for analysts attempting to understand spacepower is simple: the medium is the message. To a greater degree than any other physical domain, space is shaped in fundamental ways by our very broad-ranging perceptions about it. Any comprehensive analysis of the strategic utility of spacepower must attempt to take these factors into consideration.

DOES SPACEPOWER CONSTITUTE A REVOLUTION IN MILITARY AFFAIRS?

As with virtually everything else associated with spacepower, there is a wide range of opinion on this question. In order to address this question, we must first engage the issue of revolutions in military affairs (RMAs) more generally. During the 1990s, discussion of RMAs became a cottage industry within strategic studies and defense policy analysis. Unfortunately, to this analyst at least, it is unclear whether this whole endeavor has generated more light than heat. Nonetheless, in order to continue we need some working definition of RMA and some sense of what constituted past RMA.

This paper adopts the definition of RMA advanced by Dr. Andrew Krepinevich and his Center for Strategic and Budgetary Assessments (CSBA). They define an RMA as a major discontinuity in military affairs.

> They are brought about by changes in militarily relevant technologies, concepts of operation, methods of organization, and/or resources available, and are often associated with broader political, social, economic, and scientific revolutions. These periods of discontinuous change have historically advantaged the strategic/operational offense, and have provided a powerful impetus for change in the international system. They occur relatively abruptly—most typically over two-to-three decades. They render obsolete or subordinate existing means for conducting war.[74]

CSBA makes the case that there have been "at least a dozen cases of revolutionary change in the conduct of war: Chariot, Iron Age Infantry, Macedonian, Stirrup, Artillery/Gunpowder, Napoleonic, Railroad, Rifle, Telegraph, Dreadnought/Submarine, Air Superiority/Armored Warfare, Naval Air Power, and Nuclear Weapons."[75] Brief descriptions of the six most recent RMAs help to further clarify the concept:

> *The Napoleonic Revolution.* During the last decade of the eighteenth century, a social and political revolution in France transformed war. The advent of universal conscription—the *levée en masse*—dramatically expanded the size of armies and increased their reconstitutability. Equally important, the new conscript armies—composed of literate citizen soldiers—had a fundamentally different relationship to the societies from which they were drawn. All-weather roads and a new

form of military organization—the corps—transformed logistics, and mass column assaults and mobile artillery transformed tactics.

The Railroad, Rifle, and Telegraph Revolution. The commercial development of the railroad and telegraph and the military development of the breech-loading rifle between 1840 and 1870 revolutionized war on land. The railroad revolutionized logistics, the rifle transformed tactics, and the telegraph fundamentally changed strategic command and control. With the advent of the railroad and telegraph, time, i.e., speed of mobilization, became a critical measure of military effectiveness. The large-scale movements of armies made possible by the new industrial infrastructure also gave birth to a new level of war—the operational level. By often giving statesmen a better sense of the overall military situation than that possessed by senior commanders in the field, the telegraph also transformed civil-military relations.

The Dreadnought/Submarine Revolution. The advent of steam propulsion and metal construction in naval shipbuilding ushered in a period of near constant technological change during the last decades of the nineteenth century. The completion in 1906 of the H.M.S. Dreadnought—the world's first all-big gun, turbine-driven battleship—provided existential evidence of another revolution in military affairs. With its uniform main armament—ten 12-inch guns—Dreadnought could outshoot any older warship. A principal impetus of the Dreadnought Revolution—the submarine—proved to be equally revolutionary. As a result of the increasing threat that these new weapons posed to battlefleets, the long-standing naval strategy of close blockades of enemy ports had to be abandoned. Even more important, the "hierarchy of power" in naval warfare, which had been established with the advent of the capital ship more than three centuries earlier, had been severely undermined.

Armored Warfare/Air Superiority. The stunning victory of German forces over the French, British, Dutch, and Belgian armies in May-June 1940, marked another departure in land warfare. From then on, the unit of account in measuring any army's strength would no longer be the number of soldiers it had under arms. While the development of armored warfare depended upon the maturation of the dominant technology—the tank—technology itself was not sufficient to effect the revolution. Several other developments—in supporting technologies (e.g., tank radios), organization (combined arms formations and supporting air arms), operational concepts (deep penetrations on narrow fronts and air superiority), and climate of command (mission-oriented tactics, or *auftragstaktik*)—were essential components of the transformation launched by the blitzkrieg.

Naval Air Power. World War II also saw a transformation of war at sea. With the advent of naval air power, fleets that formerly could not engage their enemy unless they were in visual range could now hurl blows at one another from distances of hundreds of miles. Moreover, whereas naval battle had previously been characterized by gunnery duels, destructive force could now be delivered in great pulses of power. As with armored warfare, the breakthroughs in carrier warfare depended upon a number of developments: modifying airplanes so that they were rugged enough to withstand the problems associated with landing and taking off at sea, developing techniques to manage space on a crowded deck, employing carriers in combined strike forces to attack land and sea targets, etc. By the autumn of 1943, when American building programs began to amass the sheer numbers of platforms required for sustained large-scale carrier operations, the transformation of war wrought by the ascendance of naval air power had become complete.

The Nuclear Revolution. The detonation of atomic bombs over Hiroshima and Nagasaki provided evidence of another military revolution. Far exceeding the prophesies of even the most zealous pre-war strategic bombing theorists, subsequent developments in intercontinental ballistic missiles and nuclear fusion brought the prospect of nearly instantaneous destruction of whole societies into the strategic calculus. As with previous revolutions, the advent of nuclear weapons saw the emergence of new warfighting doctrines and military organizations. In the minds of most strategists, however, the sole purpose of the new weapons had shifted from warfighting to deterrence.[76]

The question, however, remains whether the military and strategic contributions of spacepower to date constitute an RMA. Some analysts make the case that spacepower's contributions in the Gulf War (the first space war) already mark it out as an RMA. Others make the case that, regardless of its specific performance in any individual war, spacepower *is* the RMA.[77] It is probably more useful, however, to view the current relationship between spacepower and RMAs in two primary ways: first, in terms of spacepower's preeminent *contributions* that enable the global reconnaissance, precision strike RMA that first emerged in the Gulf War; and, second, in terms of spacepower's *autonomous* but nascent potential for a space weaponization RMA.

Many systems combine into the system of systems that create the global reconnaissance, precision strike RMA that has more clearly emerged and become increasingly powerful over the course of the past decade. Some of the more important systems for this RMA include: modern communications, command, control, computers, intelligence, surveillance, and reconnaissance (C4ISR) systems, stealth platforms, and precision weapons. Spacepower makes the single most comprehensive and important contribution to this RMA. Among other things, spacepower fuels this RMA with 24/7 global ISR, it binds it together with communications connectivity, and it enables precision strike via GPS. In many cases, space provides the best or even the only medium from which to make these enabling contributions. In sum, it is clear that spacepower has now moved beyond merely enhancing terrestrial forces and has become the single most important contribution that enables the global reconnaissance, precision strike RMA.

Space weapons hold the potential to revolutionize warfare in even more powerful and fundamental ways. They could operate from the lowest tactical level up through the grand strategic level, could provide nearly instantaneous and simultaneous global strikes, and might even minimize the power of offensive nuclear forces. Such systems would create an RMA at least as profound as the six cases of modern RMAs discussed above. The path to space weaponization, however, still contains many extremely difficult political, fiscal, and technical challenges. Moreover, before starting down the path to space weaponization, we must anticipate that such powerful weapons will almost inevitably provoke countermeasures in the unending dialectic between offensive and defensive weapons and we must avoid the fallacy of the last move. Cumulatively, the breadth and depth of the challenges for space weapons to overcome means that this RMA may not emerge for some time to come—despite all its potential. Given these two separate relationships between spacepower and RMAs, this paper returns to an analysis of the military implications of commercial space activity since these factors are more likely to shape spacepower's continuing contributions to the global reconnaissance, precision strike RMA in major ways in the near-term.

Military Implications of the Growth in Commercial Space Activity

This section relies primarily on the Air Force's *Commercial Space Opportunities Study* (CSOS) to assess military opportunities and risks within a number of commercial space areas including: launch services, launch ranges, remote sensing, and navigation.[78] The CSOS report finds a number of areas where the military can leverage commercial activities to create new or improved military capabilities. Overall, however, it has a much harder time identifying many areas for large potential cost savings and it cannot find the "pot of gold" that many had hoped the growth in commercial space activities would create.[79] It is also hard to argue with the judgement in the Space Commission Report: "The U.S. Government, as a consumer, a regulator or an investor, is currently not a good partner to the national security space industry."[80]

Launch Services. According to the CSOS, commercial launch services hold the potential to create the largest cost savings in both percentage and absolute terms of any commercial space area. The military is projected to spend $1.5 billion on launch services in the future years defense program (FYDP) and stands to save some $62-125 million (or 25-50 percent) in annual launch costs once the EELV comes on line beginning in 2002.[81] If the EELV program is successful in significantly reducing costs-per-pound-to-orbit, it will represent a major breakthrough since, despite years of repeated promises from other new launchers such as the Shuttle, launch costs have remained constant or actually risen since the opening of the space age.[82] The EELV program is a novel partnering arrangement between the Air Force and two prime contractors (Boeing and Lockheed-Martin) to build the *Delta IV* and *Atlas 5* as two separate families of medium-to-heavy lift vehicles. Instead of following the normal process of selecting a single prime contractor, in October 1998 the Air Force awarded $500 million each to Boeing and Lockheed-Martin and each of these companies is contributing more than $1 billion of their own funds to develop these systems.[83] The EELV and other commercial launch systems lower costs through a combination of factors including reduced launch staffs, less time-on-pad, standardization of launch vehicles, and bulk launcher purchases. Another process to reduce costs further that was identified by the CSOS is "buy-on-orbit" procurement, a method of transferring total system performance responsibility to the contractor that requires less government oversight.[84] The CSOS touts the EELV program as an outstanding example of how the military can successfully leverage the commercial sector; its primary recommendation is to stay the course on EELV.[85] Potential military risks in this area stem from factors such as competition with the private sector for launchers and pads, having fewer vehicles optimized for military payloads, and unclear future options for both military and commercial RLVs. Perhaps the most potentially significant long-term military risks are associated with RLVs and arise from several factors: NASA rather than DOD has the lead for developing new RLVs, it is unclear whether NASA's current efforts will produce any operational commercial or military vehicles, and RLVs would seem to be better suited for many projected military missions than for most commercial or civil uses.

Launch Ranges. Ranges are a good example of an area where the CSOS could not find a big "pot of gold" for the military due to increased commercial activity. The Air Force currently spends about $600-700 million annually to operate and maintain the nation's primary launch facilities: the Eastern and Western Ranges at Cape Canaveral Air Station and Vandenberg Air Force Base, respectively.[86] The Air Force's Range Standardization and Automation (RSA) program is a $1.2 billion comprehensive effort scheduled for completion in 2006 that is designed to eliminate obsolete equipment, standardize equipment within and between the two ranges, and reduce the number of personnel required for operations (two thirds of the operators today are contractors rather than military or civil service personnel).[87] Once the RSA is completed, the Air Force looks forward to annual savings of $30-60 million (approximately 5-8 percent of annual operation costs). The CSOS recommends pressing ahead with the RSA but what is perhaps most interesting is how little support the report gives to proposals to commercialize range activities. This runs counter to the general trend toward increased commercialization in most industrial sectors worldwide, the fact that commercial launches have already edged ahead of government launches (and this gap is expected to increase), and NASA's apparent success to date in commercializing shuttle operations and maintenance through the United Space Alliance. Bucking these trends, the CSOS recommends that the Air Force "retain responsibility for flight safety, launch decision authority and range scheduling[.]". . . due to "its responsibility for public safety, its independence of private interests, and industry's concerns with liability issues."[88]

Remote Sensing. Commercial remote sensing is a complex area that requires the USG to carefully balance several conflicting goals. It is currently next to impossible to assess all the potential ways in which high-resolution commercial remote sensing will create military opportunities and risks due to the nascent state of this industry and its highly interdependent nature. Inter alia, military effectiveness will depend upon the quality, timeliness, and types of products offered; military efficiency will be based on the optimal mix between commercial and government systems. Under the Land Remote Sensing Policy Act of 1992 and Presidential Decision Directive (PDD)-23 of March 1994, it is now the policy of the United States to create incentives to develop a high-resolution commercial remote sensing industry. By attempting to dominate this market, the U.S. hopes to preserve its defense industrial base and workers trained in this sector, leverage commercial systems for government uses, and shape global standards on acceptable use via mechanisms such as shutter control.[89] Three U.S. firms—Space Imaging, EarthWatch, and OrbImage—are developing high-resolution commercial remote sensing systems (Ikonos, QuickBird, and OrbView, respectively) and they face significant foreign competition from systems such as SPOT, the Indian Remote Sensing (IRS) satellites (marketed by Space Imaging), and EROS (an Israeli-U.S. joint venture).[90] According to the CSOS, the Air Force spends $10 million annually on commercial imagery (this includes the innovative Eagle Vision activities); the report recommends that spending be increased to $80 million annually for each year in the FYDP.[91]

Two congressionally mandated studies reemphasize just how complex and difficult remote sensing issues have become for the USG. Many of the findings and recommendations from the commissions studying the NRO and NIMA go well beyond those in the CSOS by placing a great deal of emphasis on commercial imagery and the Intelligence Community's (IC) tasking, processing, exploitation, and dissemination (TPED) process. According to the NRO Commission report, for example, the USG: "could satisfy a substantial portion of its national security-related imagery requirements by purchasing services from" U.S. firms; it "must" develop a "clear national strategy that takes full advantage of the capabilities of the U.S. commercial satellite imagery industry;" and it should create a system similar to DOD's industrially funded airlift account to help efficiently focus government systems "on targets where their unique capabilities in resolution and revisit times are important, while commercial systems would be used to provide processed 'commodity' images."[92]

The NIMA Commission report goes even further. It found the IC to be "collection centric," "that NIMA was not a good, dependable business partner," and recommended creating a "central commercial imagery fund" to help mitigate problems resulting from the fact "that national technical means (NTM) imagery appears to be 'free' to government agencies, while use of commercial imagery generally requires a distressingly large expenditure of (largely unplanned, unprogrammed) O&M [operation and maintenance] funds."[93] The commission recommended that the central commercial imagery fund start at about $350 million annually for "raw imagery and vendor's value-added offerings."[94] They expect that this figure will rise substantially throughout the FYDP, and were very "distressed by an announcement promising $1 billion for commercial imagery purchase, which subsequently proved to be so much fiction."[95] The NIMA Commission saved its harshest critique for NIMA's TPED shortcomings. These shortcomings "increasingly strains at the fabric of the NIMA organization as a whole" and undermine confidence "that NIMA currently has the system engineering experience, acquisition experience, appropriate business practices, and performance measures" to acquire a cutting-edge TPED system.[96] The commission concludes that NIMA's TPED efforts simply cannot "get there from here" and recommends:

> creation of an Extraordinary Program Office (EPO) armed with special authorities of the Director of Central Intelligence and the Secretary of Defense, augmented by Congress, and staffed beyond ceiling and above "cap" through an heroic partnership between industry, NIMA, and the NRO. The EPO, to be constituted within NIMA from the best national talent, shall be charged with and resourced for all preacquisition, systems engineering, and acquisition of imagery TPED—from end to end, from "national" to "tactical." The first milestone shall be completion of a comprehensive, understandable, modern-day "architecture" for imagery TPED. Other provisions of law notwithstanding, Congress shall empower the Director of the EPO to commingle any and all funds duly authorized and appropriated for the purpose of the "TPED enterprise," as jointly defined by the Secretary of Defense and the Director of Central Intelligence.[97]

Positioning, Navigation, and Timing (PNT). Although perhaps not quite as complex as remote sensing, the current *de facto* role of the Global Positioning Systems (GPS) as the global utility for PNT presents difficult policy challenges in balancing military and commercial interests. Moreover, because commercial PNT applications are already large (more than $8 billion annually)[98] and are expanding rapidly and in many different areas worldwide, it difficult to assess how the military might best leverage the commercial PNT sector. The current GPS constellation consists of 29 Block II, IIA, and IIR satellites launched between June 1989 and January 2001; the system costs over $280 million annually to operate and estimates for the total sunk cost in procuring and launching the current constellation is well over $10 billion.[99] The U.S. policy framework for PNT issues was formalized by National Science and Technology Council (NSTC)-6, "U.S. Global Positioning System Policy," in March 1996. To manage the system, NSTC-6 established the interagency GPS Executive Board (IGEB) that is chaired jointly by DOD and the Department of Transportation. The policy also reemphasized that the USG will continue to operate the GPS "on a continuous, worldwide basis, free of direct user fees;" established the intention to discontinue the use of SA by 2006 (SA was turned off on 2 May 2000); and directed the DOD to "continue to acquire, operate, and maintain the basic GPS" while developing "measures to prevent hostile use of GPS and its augmentations to ensure that the United States retains a military advantage without unduly disrupting or degrading civilian uses."[100]

The USG is attempting to reassess and rebalance various equities as the GPS is modernized to provide significant improvements in its civil, commercial, and military capabilities. In May 2000, President Clinton put more emphasis on the system's growing civil and commercial uses than on its military roots and applications when he described the discontinuation of SA as "the latest measure in an ongoing effort to make GPS more responsive to civil and commercial users worldwide. . . . This increase in accuracy will allow new GPS applications to emerge and continue to enhance the lives of people around the world."[101] Turning off SA has already produced an order of magnitude improvement in accuracy for civil and commercial users; when combined with the two new civil signals (L2 and L5) that are scheduled to first come on line beginning in 2003 and 2005, these sectors clearly seem poised for further accelerating growth. The L2 Coarse/Acquisition (C/A) code is designed for general use in non-safety critical applications and will help to improve "standalone accuracy as low as 8.5 meters (95 percent) compared with approximately 22.5 meters (95 percent) with L1 alone."[102] The second new civil code, L5, is a "safety-of-life" signal designed primarily for aircraft navigation, but "it will also serve as a robust third signal for all users."[103]

Naturally, DOD's perspective on GPS modernization emphasizes the military utility of the system. The U.S. military is already critically dependent on GPS for a wide range of applications and this dependence will only grow over time. For example, most modern U.S. precision-guided munitions (PGMs) use GPS guidance for at least some phase of their flight from weapons release to impact.[104] According to March 2000 testimony by Mr. Keith Hall, Assistant Secretary of the Air Force for Space and Director of the NRO: "While sustainment of the constellation is a top priority, navigation warfare (Navwar) requirements and inherent system vulnerabilities have driven the need to modernize."[105] Current plans call for DOD to invest more than $2.7 billion through fiscal year 2005 to operate, maintain, and upgrade the system.[106] In addition to the two new civil signals, the modernized system will also have new military codes (M-code) "that will 'reuse' portions of the radio spectrum already assigned to the L1 and L2 frequencies while remaining spectrally distinguishable from the L1 and L2 C/A-codes."[107] It is unclear, however, whether this resuse approach will be flexible and robust enough to enable the U.S. military to use GPS effectively even when the enemy is attempting to jam the system.[108]

CONCLUSION

Spacepower is a complex, multidimensional concept that clearly deserves the current attention it is receiving. It should be studied in comprehensive ways that allow analysis of all the many factors that contribute to its efficacy. For the near-term, the links between spacepower and the commercial space sector should be studied most carefully. Carefully examining these linkages will point to how the military can best use commercial space assets and also highlight the areas where it will require dedicated military systems. Although space is not an economic center of gravity today, it may emerge as one in the coming decades. It is less clear, however, that traditional "flag follows trade" arguments will lead to an increased military space presence or provide the best way to protect space assets. Looking beyond just economic considerations, there appear to be a growing number of strategic factors that are creating pressure for increased militarization and probably weaponization of space. To date, military space developments have been the single most important contribution to the global reconnaissance, precision strike RMA that first emerged in the Gulf War. As current political, fiscal, and technological challenges are surmounted, it is likely that space—like every other environment humankind has opened—will become weaponized and will emerge as an independent RMA.

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[1] *The NRO at the Crossroads* (Washington, D.C.: National Commission for the review of the National Reconnaissance Office, 1 November 2000). *The Information Edge: Imagery Intelligence and Geospatial Information in an Evolving National Security Environment* (Washington, D.C.: Independent Commission on the National Imagery and Mapping Agency, December 2000). *Report of the Commission to Assess National Security Space Management and Organization* (Washington, D.C.: Commission to Assess National Security Space Management and Organization, 11 January 2001, hereinafter Space Commission Report). All three reports are available on-line at http://www.space.gov. In addition, in May 2001 under National Security Presidential Directive (NSPD)-5, President Bush ordered a comprehensive review of U.S. intelligence capabilities to be conducted by both internal and external panels that was originally scheduled for completion in September but was delayed following the terrorist attacks of 11 September 2001. See Vernon Loeb, "U.S. Intelligence Efforts to Get Major Review," *Washington Post,* 12 May 2001, 3; and Walter Pincus, "Intelligence Shakeup Would Boost CIA," *Washington Post*, 8

November 2001, 1; and Greg Miller, "Congress to Probe Intelligence Community," *Los Angles Times*, 26 January 2002.

The most important previous groups and their key space policy recommendations include: the 1954-55 Technological Capabilities Panel (TCP) (establish the legality of overflight and develop spy satellites); the President's Science Advisory Committee (PSAC) led by Science Advisor James Killian in 1958 (create the National Aeronautics and Space Administration [NASA]); the SAMOS Panel led by Science Advisor George Kistiakowsky in 1960 (create the NRO); the review led by Vice President Lyndon Johnson in April 1961 (race the Soviets to the Moon for prestige); Vice President Spiro Agnew's 1969 Space Task Group (establish NASA's post-Apollo goals); the U.S. Air Force's (USAF) 1988 Blue Ribbon Panel led by Maj Gen Robert Todd (integrate spacepower into combat operations); NASA's 1991 Augustine Commission (emphasize scientific exploration over shuttle operations); and the USAF's 1992 Blue Ribbon Panel led by Lt Gen Thomas Moorman (emphasize space support to the warfighter, establish the Space Warfare Center).

The Space Commission Report is the broadest-ranging and most important product of the three commissions in 2000. The Space Commission was chaired by Secretary of Defense Donald Rumsfeld and included 12 other members with a broad-range of very high-level military space expertise. They are (listed with the top "space" job they formerly held): Duane Andrews (Deputy Undersecretary of Defense for Command, Control, Communications, and Intelligence); Robert Davis (Undersecretary of Defense for Space); Howell Estes (Commander, U.S. Space Command); Ronald Fogleman (Air Force Chief of Staff); Jay Garner (Commander, Army Space and Strategic Defense Command); William Graham (President's Science Advisor); Charles Horner (Commander, U.S. Space Command); David Jeremiah (Vice Chairman of Joint Chiefs of Staff); Thomas Moorman (Air Force Vice Chief of Staff); Douglass Necessary (House Armed Services Committee staff); Glenn Otis (Commander, Army Training and Doctrine Command); and Malcolm Wallop (Senator). See John A. Tirpak, "The Fight for Space," *Air Force Magazine* 83 (August 2000): 61.

The legislation authorizing the commission was clearly action-oriented and spelled out its duties as follows: "The Commission shall, concerning changes to be implemented over the near-term, medium-term, and long-term that would strengthen United States national security, assess the following: (1) the manner in which military space assets may be exploited to provide support for United States military operations. (2) The current interagency coordination process regarding the operation of national security space assets, including identification of interoperability and communications issues. (3) The relationship between the intelligence and nonintelligence aspects of national security space (so-called "white space" and "black space"), and the potential costs and benefits of a partial or complete merger of the programs, projects, or activities that are differentiated by those two aspects. (4) The manner in which military space issues are addressed by professional military education institutions. (5) The potential costs and benefits of establishing any of the following: (A) An independent military department and service dedicated to the national security space mission. (B) A corps within the Air Force dedicated to the national security space mission. (C) A position of Assistant Secretary of Defense for Space within the Office of the Secretary of Defense. (D) A new major force program, or other budget mechanism, for managing national security space funding within the Department of Defense. (E) Any other change to the existing organizational structure of the Department of Defense for national security space management and organization."

See sec. 1622 of *National Defense Authorization Act for Fiscal Year 2000* (Public Law 106-65; 113 Statute 814; 10 *US Code* 111 note).

In October 2000, Congress added an amendment directing the commission to study (6) the advisability of—

(A) various actions to eliminate the de facto requirement that specified officers in the United States Space Command be flight rated that results from the dual assignment of officers to that command and to one or more other commands in positions in which officers are expressly required to be flight rated;

(B) the establishment of a requirement that, as a condition of the assignment of a general or flag officer to the United States Space Command, the officer have experience in space, missile, or information operations that was gained through either acquisition or operational experience; and

(C) rotating the command of the United States Space Command among the Armed Forces.

See sec. 1091, Additional Duties for Commission to Assess United States National Security Space Management and Organization; sec. 1622(a) of the *National Defense Authorization Act for Fiscal Year 2000* (Public Law 106-65; 113 Statute 814; 10 US Code 111 note).

The key recommendations of the Space Commission Report called for: raising the priority of national security space to a vital national interest; creating a Presidential Space Advisory Group; instituting closer and more regular coordination between the Secretary of Defense and the Director of Central Intelligence; creating an Under Secretary of Defense for Space, Intelligence, and Information; creating a new four-star billet for the Commander of Air Force Space Command that is separate from the Commander in Chief of U.S. Space Command and the North American Aerospace Defense Command; designating the Air Force as the Executive Agent for space within the Department of Defense (DOD) and amending Title 10 of the United States Code to assign the Air Force responsibility to organize, train, and equip for prompt and sustained offensive and defensive air and space operations; assigning the Undersecretary of the Air Force as the Director of the National Reconnaissance Office and the Acquisition Executive for space; and establishing a Major Force Program to consolidate the space budget. (Space Commission Report, xxxi-xxxv). Not surprisingly, Secretary Rumsfeld recently accepted nearly all of these recommendations in his required assessment of the Space Commission Report for Congress. The only major change was that he did not request legislation to establish an Under Secretary of Defense for Space, Intelligence, and Information. See Donald

H. Rumsfeld, letter to Honorable John Warner, Chairman, Committee on Armed Services, United States Senate, 8 May 2001; Donald H. Rumsfeld, National Security Space Management and Organization Memorandum, Office of the Secretary of Defense, 18 October 2001; and Lt Col Peter Hays and Dr. Karl Mueller, "Going Boldly—Where? Aerospace Integration, the Space Commission, and the Air Force's Vision for Space," *Aerospace Power Journal* 15, no. 1 (Spring 2001): 34-49.

[2] This paper uses spacepower as one word; it is also commonly expressed as two words. Air Force Chief of Staff Thomas D. White first used the word *aerospace* in 1958, and the concept that air and space form a seamless operational medium has been the foundational component of Air Force thinking about space ever since. Unfortunately, however, the Air Force is primarily talking to itself by using this word in this way because none of the other Services or DOD offices use the word aerospace according to the Air Force's definition. Aerospace, for example, is only used as an adjective describing industry in the Space Commission Report and the word does not even appear in the DOD's current space policy statement (Department of Defense Directive 3100.10, *Space Policy*, 9 July 1999).

[3] Prior to the opening of the space age, the United States, in particular, was very reluctant to define where space begins. The Eisenhower Administration's secret but highest priority space policy as expressed in NSC-5520 of May 1955 was designed to distinguish between aerial and satellite overflight and to established the legitimacy and legality of the latter. This policy called for using the civilian face of the United States' International Geophysical Year scientific satellite program as a "stalking horse" to establish the precedent of legal overflight in order to open up the closed Soviet state to photoreconnaissance via the secret WS-117L spy satellite system. The term *stalking hors*e is taken from R. Cargill Hall's "Origins of U.S. Space Policy: Eisenhower, Open Skies, and Freedom of Space," in *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program*, ed. John M. Logsdon, vol. 1, *Organizing for Exploration* (Washington, D.C.: NASA History Office, 1995), 213–29. The United States has not subsequently revisited the issue of where space begins in light of the changed geopolitical context and declassification of satellite reconnaissance. By using unclassified sources, primarily at the Eisenhower Library, Walter A. McDougall was the first to break through the veil of secrecy surrounding early U.S. space policy in *. . .the Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985). His book won the Pulitzer Prize for History in 1986.

[4] Barry D. Watts, *The Military Use of Space: A Diagnostic Assessment* (Washington, D.C.: Center for Strategic and Budgetary Assessments, February 2001); Steven Lambakis, *On the Edge of Earth: The Future of American Space Power* (Lexington: University Press of Kentucky, 2001; Everett C. Dolman, *Astropolitik: Classic Geopolitics in the Space Age* (London: Frank Cass, 2002); and Robert Preston, et al., *Space Weapons: Earth Wars* (Santa Monica: RAND Corporation, 2002).

[5] Military use of commercial satellites was a major issue in the 1998 Army After Next wargame and space weaponization, deterrence and preemption, and space-to-

Earth force application were all critical parts of the Air Force's Schriever 2001 and Future Concepts 2001 wargames. See, for example, "Air Force gains insights from first space wargame," Air Force News Archive, available from http://www.af.news/Jan2001/n20010129_0124.shtml.

[6] Many U.S. Government documents list three rather than four space sectors. Upon closer examination, however, these documents reveal the important contributions of each of the four sectors discussed above. For example, the most recent National Space Policy discusses civil, national security (defense and intelligence), and commercial sectors. National Science and Technology Council, "Fact Sheet: National Space Policy" (Washington, D.C.: The White House, 19 September 1996). The term "space sectors" was first used as an organizing typology in President Jimmy Carter's 1978 National Space Policy. National Security Council, "Presidential Directive/NSC-37: National Space Policy" (Washington, D.C.: The White House, 11 May 1978).

[7] Space Commission Report, 10-14.

[8] This section and the next are adapted from Peter L. Hays, James M. Smith Alan R. Van Tassel, and Guy M. Walsh, eds., *Spacepower for a New Millennium: Space and U.S. National Security* (New York: McGraw-Hill, 2000), 3-6.

[9] Satellites in Low Earth Orbit (LEO) fly in the region from less than 100 miles to several hundred miles altitude and complete each orbit in approximately 90 minutes. Polar LEO is ideal for many spysat and weather applications because from this orbit satellites can look down on all parts of the Earth several times each day as the Earth rotates beneath and they also can be aligned in Sun Synchronous Orbits that arrive overhead the same location at the same time each day. Satellites in Semi-Synchronous Orbit are located at approximately 12,500 miles altitude and complete an orbit every 12 hours. Geostationary Orbit (GSO) is located approximately 22,300 miles above the equator, a location where the satellites' orbital velocity matches Earth's rate of rotation and the satellite appears to remain motionless above the same spot—a very valuable attribute for communications and SIGINT satellites. NPOESS is a system that is currently being jointly developed by the National Oceanic and Atmospheric Administration (NOAA) and DOD that will merge their separate meteorological satellite systems into one system scheduled for its first launch in 2005. The AEHF program is developing the successor to the Milstar system and currently plans its first launch in 2005. The WGS is scheduled to launch a satellite in 2004. It is designed to bridge the gap between the current DSCS and GBS systems and a future advanced wideband system. For more information, see the Air Force Association's "Major Military Satellite Systems" webpage at http://www.afa.org/magazine/space/satellite_systems.html.

[10] *Long Range Plan: Implementing USSPACECOM Vision for 2020* (Peterson AFB, Colo: U.S. Space Command, Director of Plans, March 1998), 19-20. Space control or "counterspace operations" are defined in much greater detail in Air Force Doctrine Document (AFDD) 2-2 *Space Operations*: "**Counterspace operations consist of those operations conducted to attain and maintain a desired degree of space superiority by allowing friendly forces to exploit space capabilities while**

negating an adversary's ability to do the same. Counterspace operations include two elements – offensive and defensive counterspace, both predicated on space surveillance and other intelligence. Air, space, land, sea, information, or special operations can perform counterspace functions.

Offensive counterspace (OCS) operations preclude an adversary from exploiting space to his advantage. Should policy allow, OCS actions may target an adversary's space system, forces, and information links, or third-party space capabilities supporting those forces, using lethal or nonlethal means. Possible methods include the use of deception, disruption, denial, degradation, and destruction of space capabilities. The "Five Ds" represent a continuum of options, from spoofing the enemy to hard-kill of a space asset. However, there are tradeoffs along the continuum. At the destruction end of the continuum, airmen can be confident that an adversary's space asset and the effect it produced have been eliminated. However, there may be undesirable collateral effects, such as added debris threats in orbit, or negative world opinion. At the deception end of the continuum, airmen may have less confidence in achieving the desired effect, but have more confidence in not producing any adverse collateral effects.

- **Deception employs manipulation, distortion, or falsification of information to induce adversaries to react in a manner contrary to their interests.**
- **Disruption is the temporary impairment of some or all of a space system's capability to produce effects, usually without physical damage.**
- **Denial is the temporary elimination of some or all of a space system's capability to produce effects, usually without physical damage.**
- **Degradation is the permanent impairment of some or all of a space system's capability to produce effects, usually with physical damage.**
- **Destruction is the permanent elimination of all of a space system's capabilities to produce effects, usually with physical damage**.

Assets designed for the OCS mission may be used to conduct or support counterair, countersea, counterland, counterinformation, or strategic attack missions by performing offensive counterspace actions where the adversary's vulnerable node is a space system.

Defensive counterspace (DCS) operations preserve US/allied ability to exploit space to its advantage via active and passive actions to protect friendly space-related capabilities from enemy attack or interference. Although focused on responding to man-made hostile intent, DCS actions may also safeguard assets from unintentional hazards such as space debris, RF interference, and other natural occurring events. Defensive counterinformation (DCI) operations and force protection measures may be employed in support of DCS.

- **Active defense seeks to detect, track, identify, characterize, intercept, or negate adversary threats and unintentional hazards to friendly space capabilities.**
- **Passive defense seeks to ensure the survivability of friendly space assets, and the information they provide.**

Space situational awareness (SSA) forms the foundation for all counterspace and other space actions. It includes traditional space surveillance, detailed reconnaissance of specific space assets, collection and processing of space intelligence data, and analysis of the space environment. It also encompasses the use of traditional intelligence sources to provide insight into adversary space operations. (Emphases in original.) Air Force Doctrine Document 2-2 *Space Operations* (Maxwell AFB, Ala.: Air Force Doctrine Center, 27 November 2001), 9-10.

[11] Lt Col David E. Lupton, *On Space Warfare: A Space Power Doctrine* (Maxwell AFB, Ala.: Air University Press, June 1988).

[12] Robert S. Dudney, "Washington Watch: The New Space Plan," *Air Force Magazine* 81, no. 7 (July 1998): n.p.; on-line, Internet, 13 December 2000, available from http://www.afa.org/magazine/0798watch.html.

[13] Ibid.

[14] General Howell M. Estes, III, "The Promise of Space Potential for the Future," prepared remarks to the United States Space Foundation's 1997 National Space Symposium, Colorado Springs, Colo., 3 April 1997; on-line, Internet, 11 December 2000, available from http://www.defenselink.mil/speeches/1997/s19970403-estes.html.

[15] *Long Range Plan*, 4-5, 33.

[16] On the sea change caused by growth in the commercial space sector, see Frank G. Klotz, *Space, Commerce, and National Security* (New York: Council on Foreign Relations Press, 1998); Gen Thomas S. Moorman Jr., "The Explosion of Commercial Space and the Implications for National Security," *Airpower Journal* 13, no. 1 (Spring 1999): 6–20; and John M. Logsdon and Russell J. Acker, eds., *Merchants and Guardians: Balancing U.S. Interests in Global Space Commerce* (Washington, D.C.: Space Policy Institute, George Washington University, May 1999). The idea that the "flag follows trade" is from Klotz, 15-20.

[17] "There appears to be no demand from the operators of commercial communications satellites for defense of their multibillion-dollar assets." John M. Logsdon, "Just Say Wait to Space Power," *Issues in Science and Technology* (Spring 2001), n.p.; on-line, Internet, 24 April 2001, available from http://www.nap.edu/issues/17.3/p_logsdon.htm.

[18] General Ronald R. Fogleman and the Honorable Sheila E. Widnall, *Global Engagement: A Vision for the 21st Century Air Force* (Washington, D.C.: November 1996), 8. Emphasis in original.

[19] Klotz, 55; and Lt Col Paul L. Bailey, "Space as an Area of Responsibility," *Air Chronicles*, Winter 1998, on-line, Internet, 13 December 2000, available from http://www.airpower.maxwell.af.mil/airchronicles/apj/apj98/win98/waywin98.html.

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[20] Quoted in Otto Kreisher, "The Move into Space," Air Force Magazine 82, no. 4 (April 1999): n.p.; on-line, Internet, 11 December 2000, available from http://www.afa.org/magazine/0499space.html.

[21] General Richard B. Myers, "Integrating Space in an Uncertain Era," prepared remarks to the Air Force Association Space Symposium, Los Angeles, 13 November 1998; on-line, Internet, 13 December 2000, available from http://www.aef.org/symposia/myers.html.

[22] Quoted in Peter Grier, "The Investment in Space," *Air Force Magazine* 83, no. 2 (February 2000): n.p.; on-line, Internet, 11 December 2000, available from http://www.afa.org/magazine/0200onvestment.html.

[23] Gen. Richard B. Myers, "Space Superiority Is Fleeting," *Aviation Week & Space Technology*, 1 January 2000: n.p.; on-line, Internet, 13 December 2000, available from http://www.awgnet.com/avaiation/newmillen/aw54.htm.

[24] General Michael E. Ryan and the Honorable F. Whitten Peters, *Global Vigilance, Reach & Power: America's Air Force Vision 2020* (Washington, D.C.: Department of the Air Force, June 2000).

[25] Air Force Chief of Staff General Merill McPeak moved away from the aerospace concept in June 1992 by changing the Air Force mission statement by adding the words "air and space." During the tenure of General Michael E. Ryan as Chief of Staff, however, the Air Force returned to the aerospace concept. For the period of General Ryan's tenure, the Air Force emphasized that there are physical differences between the atmosphere and space but defined aerospace as a seamless operational medium comprised of both physical domains. See, for example, Air Force Doctrine Document 2-2 *Space Operations* (Maxwell AFB, Ala.: Air Force Doctrine Center, 23 August 1998), 1 or *Global Vigilance, Reach & Power*. As reflected in recent speeches and the 27 November 2001 edition of AFDD 2-2, General John P. Jumper, the current USAF Chief of Staff, has chosen to return to using "air" and "space" as separate words rather than continuing to use the term "aerospace."

> Let me start off by talking a little bit about air and space versus aerospace. I carefully read the Space Commission report. I didn't see one time in that report, in its many pages, where the term "aerospace" was used. The reason is that it fails to give the proper respect to the culture and to the physical differences that abide between the physical environment of air and the physical environment of space.
>
> We need to make sure we respect those differences. So, I will talk about air *and* space. I will respect the fact that space is its own culture, that space has its own principles that have to be respected. And when we talk about operating in different ways in air and space, we have to also pay great attention to combining the effects of air and space because in the combining of those effects, we will leverage this technology we have that creates the asymmetrical advantage for our commanders.

Prepared Remarks of General John P. Jumper at Air Force Association National Symposium, Los Angeles, CA, 16 November 2001. Available from http://www.aef.org/symposia/jump1101.asp.

In this context, it is very important to note that the other Services and the Office of the Secretary of Defense have never fully accepted the Air Force's definition of aerospace or ceded all operations in this area to the Air Force. For a comprehensive analysis of the aerospace concept's deep roots in airpower theory see Maj Stephen M. Rothstein, "Dead on Arrival? The Development of the Aerospace Concept, 1944-1958," Master's thesis, School of Advanced Airpower Studies, (Maxwell AFB, Ala.: Air University Press, 2001). For a critique of the aerospace concept see Lt Col Peter Hays and Dr. Karl Mueller, "Going Boldly—Where? Aerospace Integration, the Space Commission, and the Air Force's Vision for Space," *Aerospace Power Journal* 15, no. 1 (Spring 2001): 34-49.

[26] General Eberhart did not put much emphasis on commercial space developments and did not even mention the term COG in his 8 March 2000 testimony to the Senate Armed Services Committee Strategic Subcommittee (available from http://www.spacecom.af.mil/usspace/cinc8mar00.htm); or in his 4 April 2000 keynote speech to the United States Space Symposium (available from http://www.spacecom.af.mil/usspace/cinc0404.htm). USSPACECOM picked up the CND mission in 1999 and became responsible for CNA on 1 October 2000. It is not yet clear how the command will organize to perform these new missions. One proposal is for a unified subcommand but that option along with others is the subject of a yearlong study scheduled for completion on 1 October 2001. See George I. Seffers, "Cyberwar Ops May Unify," *Federal Computer Week*, 30 October 2000, 12.

[27] John A. Tirpak, "The Fight for Space," *Air Force Magazine* 83, no. 8 (August 2000): n.p.; on-line, Internet, 13 December 2000, available from http://www.afa.org/magazine/august2000/0800space.html.

[28] Quoted in William B. Scott, "Cincspace: Focus More on Space Control," *Aviation Week & Space Technology*, 15 November 2000, n.p.; on-line, Internet, 19 April 2001, available from http://www.infowar.com/MIL_C4I/00/mil_c4I_111500b_j.shtml.

[29] Futron Corporation, *Satellite Industry Guide* (Bethesda, Md.: Futron Corporation, October 1999).

[30] Ibid., x.

[31] United States GDP figures are available from the Commerce Department's Bureau of Economic Analysis at http://www.bea.doc.gov/bea/ARTICLES/2001/08august/0801GDP.pdf. Aerospace does not qualify as a separate subset within manufacturing but manufacturing of *all* durable goods accounts for only 9.4 percent of GDP.

[32] "The *Fortune* 500 List," is available from http://www.fortune.com/. The *Fortune* 500 list for 2001 is based on data from 2000. Most major aerospace corporations do not report space-only revenues or categorize this part of their business in consistent ways.

[33] Ibid. and Space Commission Report, 11.

[34] $572.945 billion for the energy sector versus $186.081 billion for the aerospace sector. And, again, this represents the *all* the revenues from aerospace corporations rather than the fraction attributable to space activities.

[35] "Comparison of Aerospace Market Valuation to Top 25 U.S. Companies—End of CY 1999," Slide 31 of "Space Industry 2000 Study" presentation by Industrial College of the Armed Forces.
[36] Elaine Gresham, "SIA/Futron Satellite Industry Indicators Survey: 1999/2000 Survey Results," Futron Corporation Slide Presentation to the Office of Net Assessment, the Pentagon, 21 November 2000, slide 6.
[37] Phil McAlister, "1999 Year in Review," Futron Corporation Slide Presentation to Office of Net Assessment, the Pentagon, 21 November 2000, slide 12.
[38] Ibid., slide 10; and Marco Antonio Cáceres, "Expendables Face Tough Market," *Aviation Week & Space Technology*, 15 January 2001, 145. 2001 was the slowest year for space launches in nearly 40 years with only 58 successful orbital launches. "Tsyklon booster launches with cargo of six satellites," *Spaceflight Now*, 28 December 2001. Available from http://www.spaceflightnow.com/news/n0112/28tsyklon/.
[39] Ibid. and *Satellite Industry Guide*, xiii-xvi.
[40] Gresham, slide 5.
[41] Ibid., 2-4.
[42] Colonel David A. Anhalt, "The Changing Nature of Military Advantage in Satellite Communication," Presentation Slides for USSPACECOM, 26 October 2000, slide 11. Slide derived from Mel Mandell, "120,000 Leagues Under the Sea," *IEEE Spectrum*, April 2000, 50.
[43] Ibid. DWDM uses different wavelengths of laser light within each strand of fiber. The capacity of one strand of fiber using DWDM is 1000 Gigabits per second (Gbps). The Hughes Network Systems Spaceway wireless broadband (Ka-band) system is scheduled to begin operation over North America in 2002 using two Boeing 702 GEO comsats and have a capacity of 10 Gbps.
[44] Gresham, slide 5.
[45] *Satellite Industry Guide*, 3-17.
[46] McAlister, slide 3.
[47] Rep. Christopher Cox (R.-Calif.) led a six-month long House Select Committee investigation that produced the "U.S. National Security and Military/Commercial Concerns with the People's Republic of China" Report that was released on 25 May 1999. The report is available from http://www.house.gov/coxreport.
[48] Satellite builders claim that their exports dropped 59 percent in 2000 and that since March 1999 their share of the global market declined sharply (from 75 percent to 45 percent). Not surprisingly, they place most of the blame for this decline squarely on their problems with export controls. See Evelyn Iritani and Peter Pae, "U.S. Satellite Industry Reeling Under New Export Controls," *Los Angeles Times*, 11 December 2000, 1. According to *Space News*, 2000 marked the first time that U.S. firms were awarded fewer contracts for GEO comsats than their European competitors (they show the Europeans ahead 15 to 13). See Peter B. de Selding and Sam Silverstein, "Europe Bests U.S. in Satellite Contracts in 2000," *Space News*, 15 January 2001, 1 and 20. This issue has attracted a great deal of attention in the trade press and elsewhere. See, for example, Representative Dana Rohrabacher, "Reconciling

Commerce with National Security," *Space News*, 12 April 1999; Peter B. de Selding and Warren Ferster, "NATO Allies Decry New U.S. Export Policies," *Space News*, 26 April 1999, 1, 28; Warren Ferster, "Senators Propose Even Tougher Export Reviews," *Space News*, 7 June 1999, 1, 28; Ray A. Williamson, "Time to Repair the Damage to Industry," *Space News*, 14 June 1999, 26; Vernon Loeb, "Satellite Firms Chafe at New Export Controls," *Washington Post*, 12 May 1999, 6; Andrew Pollack, "Export Rules are Said to be a Threat to Satellite Industry," *New York Times*, 1 August 1999; and James Hackett, "Satellite Industry Ensnared," *Washington Times*, 5 August 1999, 17. One particularly difficult, but perhaps overlooked, dimension of this problem is the fact that only about 20 percent of the space launch insurance business is based in the U.S. and the State Department's rules now make it very hard and time consuming for U.S. space businesses to conduct meaningful negotiations with foreign insurers.

[49] Gresham, slide 5.

[50] Ibid.

[51] The 5 August 1994 National Space Transportation Policy is available from http://www.hq.nasa.gov/office/codez/nstc4.html.

[52] Lockheed-Martin was the prime contractor for the X-33 and Orbital Sciences Corporation was the prime for the X-34. Both of these RLV programs ran into very significant technical and programmatic challenges, raising questions whether either system might replace the Space Shuttle or lead to an operational commercial variant. Anticipating increasing demand for launch vehicles, the Air Force is helping to provide funding for two EELV development programs rather than following the normal process of selecting a single system for development. In October 1998, the Air Force awarded $500 million each to the Boeing Delta IV and the Lockheed-Martin Atlas 5 EELV programs. Both contractors are investing approximately twice as much of their own money (approximately $1 billion each) in these families of medium-to-heavy boosters. The first government EELV payloads are scheduled for launch beginning in 2002. See William B. Scott, "EELV Funding: Is It Enough?" *Aviation Week & Space Technology* 1 March 1999, 27.

[53] About $1.2 billion was spent on the X-33 program since it began in 1996 ($350 million from Lockheed Martin and $912 million from NASA). See Peter Pae, "Lockheed Asks Air Force to Fund X-33 Craft Revival," *Los Angeles Times*, 14 April 2001; Frank Morring, "NASA Eyes Military Role in Aerospace Push," *Aviation Week & Space Technology*, 23 April 2001, 36; and Brian Berger and Jeremy Singer, "USAF Plans Major Funding for a Space Plane by 2004," *Space News*, 24 September 2001, 4.

[54] The seven companies attempting to develop commercial RLVs are: Kelly Space and Technology, Kistler Aerospace Corporation, Pioneer Rocketplane, Rotary Rocket Company, Space Access LLC, Vela Technology Development, and Lockheed Martin Skunk Works. See McAlister, slide 7. In January 2001, officials from Kern County, Calif. threatened to seize Rotary Rocket assets and auction them off to pay property taxes owed by the company. "Rotary Rocket's Assets Seized,"

on-line, Internet, 3 January 2001, available from http://www.space.com/news/roton_auction_000102_wg.html.

[55] Paul Meller, "Europe Plans Full Inquiry on G.E.-Honeywell Deal," *New York Times*, 9 May 2001.

[56] "EU Kills GE-Honeywell," on-line, Internet, 28 August 2001, available from http://cnnfn.cnn.com/2001/07/03/europe/ge_eu/.

[57] Current GPS policy is spelled out in Office of Science and Technology Policy and the National Security Council, "Fact Sheet: U.S. Global Positioning System Policy," (Washington, D.C.: The White House, 29 March 1996).

[58] See, for example, Brig Gen Simon Peter Worden, "The Air Force and Future Space Directions: Are We Good Stewards?" *Aerospace Power Journal* 15, no. 1 (Spring 2001): 50-57; and Lt Gen Bruce Carlson, "Protecting Global Utilities," *Aerospace Power Journal* 14, no. 2 (Summer 2000): 37–41. For a more detailed development of this argument with a focus on distinctions between the role of armies and navies, see Brig Gen Simon P. Worden, "Space Control for the 21st Century: A Space 'Navy' Protecting the Basis of America's Wealth," in Hays et al., *Spacepower for a New Millennium*, 225–38.

[59] Several of these individuals were quite prolific; the following list represents their best known works: Alfred Thayer Mahan, *The Influence of Sea Power upon History, 1660-1783* (Boston: Little, Brown, 1980); Julian S. Corbett, *Some Principles of Maritime Strategy*, ed. by Eric J. Grove (Annapolis: Naval Institute Press, 1988. First published 1911); Giulio Douhet, *The Command of the Air*, ed. by Richard H. Kohn and Joseph P. Harahan (Washington, D.C.: Office of Air Force History, 1983. First published 1921); William Mitchell, *Winged Defense: The Development and Possibilities of Modern Airpower—Economic and Military* (New York: Dover, 1988. First published 1925); and John A. Warden III, *The Air Campaign: Planning for Combat* (Washington, D.C.: National Defense University Press, 1988). On the importance of these works see, Jon Tetsuro Sumida, *Inventing Grand Strategy and Teaching Command: The Classic Works of Alfred Thayer Mahan Reconsidered* (Washington, D.C.: Woodrow Wilson Center Press, 1997); Philip S. Meilinger, ed. *The Paths of Heaven: The Evolution of Airpower Theory* (Maxwell AFB, Ala.: Air University Press, 1997); and David R. Mets, *The Air Campaign: John Warden and the Classical Airpower Theorists* (Maxwell AFB, Ala.: Air University Press, April 1999).

[60] Virtually all of these concepts are applied throughout the Chief of Staff-directed yearlong study by Air University that is published as *SPACECAST 2020* (Maxwell AFB, Ala.: Air University, 1994). See also, for example, Arnold H. Streland, "Clausewitz on Space: Developing Military Space Theory through a Comparative Analysis," Air Command and Staff College Research Paper, April 1999; and Charles H. Cynamon, "Protecting Commercial Space Systems: A Critical National Security Issue," Air Command and Staff College Research Paper, April 1999.

[61] In 1997, then-CINCSPACE Howell M. Estes III attempted to remedy the lack of a comprehensive space-power vision or theory by commissioning Dr. Brian R. Sullivan to write a book on space-power theory. This project was taken over by

James Oberg and published as *Space Power Theory* (Washington, D.C.: Government Printing Office, 1999). On the enduring nature of strategy and problems with developing space-power theory, see also Colin S. Gray and John B. Shelton, "Spacepower and the Revolution in Military Affairs: A Glass Half-Full," in *Spacepower for a New Millennium*, 239–58; and Colin S. Gray, *Modern Strategy* (Oxford: Oxford University Press, 1999), 243–67. The 2001 publications by Watts, Lambakis, and especially Dolman (*The Military Use of Space*, *On the Edge of Earth*, and *Astropolitik*) will undoubtedly go a long way towards filling the yawning spacepower theory gap in the literature.

[62] Hays and Mueller. "Going Boldly—Where?" 37.

[63] Lt Col Dennis M. Drew, "Of Leaves and Trees: A New View of Doctrine," *Air University Review* 33, no. 2 (January–February 1982): 40–48; Lt Col Charles D. Friedenstein, "The Uniqueness of Space Doctrine," *Air University Review* 37, no. 1 (November–December 1985): 13–23; and Col Kenneth A. Myers and Lt Col John G. Tockston, "Real Tenets of Military Space Doctrine," *Airpower Journal* 2, no. 4 (Winter 1988): 54–68.

[64] The Air Force published AFM 1-6 on 15 October 1982, and its release was designed to coincide closely with the stand-up of Air Force Space Command on 1 September 1982. For a detailed critique of AFM 1-6, see Peter L. Hays, "Struggling towards Space Doctrine: U.S. Military Space Plans, Programs, and Perspectives during the Cold War," unpublished Ph.D. dissertation, Fletcher School of Law and Diplomacy, Tufts University, May 1994, 400–422.

[65] Friedenstein, 21, 22.

[66] Myers and Tockston, 59. A more up-to-date and outstanding blueprint for developing space doctrine is provided by Maj Robert D. Newberry, *Space Doctrine for the Twenty-First Century* (Maxwell AFB, Ala.: Air University Press, October 1998).

[67] Turner first presented his ideas in a paper, "The Significance of the Frontier in American History," at a gathering of historians in Chicago, site of the World's Columbian Exposition, an enormous fair to mark the four-hundredth anniversary of Columbus' voyage.

[68] Cited in New Perspectives on the West, on-line, Internet, 20 May 2001, available from http://www.pbs.org/weta/thewest/people/s_z/turner.htm.

[69] Ibid.

[70] The original *Star Trek* series aired from 1966-68. Creator Gene Roddenberry originally sold the series concept to the NBC network as *Wagon Train* in space. Science fiction has probably been more important in shaping our perceptions of spacepower than any other single factor. Gerard K. O'Neill, *The High Frontier: Human Colonies in Space* (New York, Morrow, 1977).

Report of the National Commission on Space, *Pioneering the Space Frontier: An Exciting Vision of Our Next Fifty Years in Space* (New York: Bantam Books, 1986).
See, for example, Senator Bob Smith, "The Challenge of Space Power," *Airpower Journal* 13, no. 1 (Spring 1999): 32-39.

[71] Gerard K. O'Neill founded the Space Studies Institute at Princeton University in 1977 and is probably most famous for *The High Frontier*. Representative works in this tradition include James E. Oberg and Alcestis R. Oberg, *Pioneering Space: Living on the Next Frontier* (New York: McGraw-Hill, 1986) and Robert Zubrin, *Entering Space: Creating a Spacefaring Civilization* (New York: Jeremy P. Tarcher/Putnam, 1999). Carl Sagan cofounded the Planetary Society in 1980 and was one of the most famous and articulate spokesmen for planetary science; *Pale Blue Dot: A Vision of the Human Future in Space* (New York: Random House, 1994) was one of the last major books before his death in 1996. Frank White, *The Overview Effect: Space Exploration and Human Evolution* (Boston: Houghton Mifflin, 1987).
[72] McDougall, 4.
[73] Ibid., 460-61.
[74] Available from the Center for Strategic and Budgetary Assessments website, http://www.csbaonline.org/2Strategic_Studies/1Revolution_in_Military_Affairs/Revolution_Military_Affairs.htm.
[75] Ibid.
[76] Ibid.
[77] Gray and Shelton, "Spacepower and the Revolution in Military Affairs," in *Spacepower for a New Millennium*, 239–58. Emphasis in original.
[78] Headquarters Space and Missile System Center, Developmental Planning Directorate and Headquarters Air Force Space Command, Directorate for Plans and Programs, *Final Report: Commercial Space Opportunities Study* (Los Angeles AFB, Calif.: Commercial Exploitation Planning Office, 16 February 2000).
[79] Ibid., quotation from ES-4.
[80] Space Commission Report, 72.
[81] CSOS, ES-5, 3-2.
[82] Estimating actual costs-per-pound-to-orbit for various launch vehicles is a cottage industry and such calculations are well beyond the scope of this paper. Two outstanding recent discussions of basic problems with spacelift and current launch programs are found in Oberg, 87-95; and Watts, *The Military Use of Space* 55-63.
[83] CSOS, 3-2.
[84] Ibid., 3-5.
[85] Ibid., 3-4.
[86] Ibid.
[87] Ibid., 3-6, 3-9; and Lieutenant General Lance Lord, "Range Modernization: The Rest of the Story," *Space News*, 22 March 1999, 13.
[88] CSOS, 3-8.
[89] PDD-23 is explained in a press release and fact sheet released on 10 March 1994 (available from http://www.fas.org/irp/offdocs/pdd23-2.htm). The press release quoted Vice President Al Gore on the many advantages of improved resolution for benign civil applications and environmental monitoring and the importance of the $15 billion total annual worldwide market for remote sensing data and applications that were expected to develop by the year 2000. The fact sheet covers the specifics

of PDD-23 in considerable detail. Significant restrictions on commercial U.S. remote sensing systems remain in effect including licensee requirements to:

Maintain a record of all satellite taskings for the previous year and allow the USG access to this record.

Refrain from making changes to satellite operational characteristics without formal approval from the Department of Commerce.

Limit data collection and distribution when the Secretaries of Defense or State determine that national security, international obligations, and/or foreign policy may be compromised. The actual decision to limit data will be made only be the Secretary of Commerce in consultation with the Secretaries of Defense and State. (This restriction is known as shutter control).

Use only USG approved encryption devices for the purpose of denying unauthorized access to others during periods when national security, international obligations, and/or foreign policy may be compromised. The data downlink format must allow USG data access during these periods.

Notify the USG in advance of intent to enter into significant or substantial agreements with new foreign customers.

PDD-23 also allows for the transfer of "turnkey" advanced capability U.S. remote sensing systems on a case-by-case basis, subject to significant diplomatic steps that may include a formal government-to-government agreement. The most stringent restrictions are placed on the sale of sensitive components, subsystems, and information on the U.S. Munitions List for U.S.-unique remote sensing capabilities. These transfers will be made only on the basis of a government-to-government agreement.

To date, shutter control has not been formally requested or invoked. For the campaign against terrorism in Afghanistan, NIMA has established *de facto* shutter control by signing an "agreement of assured access" with the Space Imaging Corporation, reportedly for $1.9 million per month. Under the terms of this agreement, Space Imaging is not to sell or share its Afghanistan theater imagery with anyone except the USG until 5 December, and the contract may be extended beyond that date. Kerry Gildea, "NIMA Extends Deal with Space Imaging for Exclusive Imagery Over Afghanistan," *Defense Daily*, 7 November 2001, 2; and "Eye Spy," *The Economist*, 10-16 November 2001. This agreement opens many interesting issues related to the utility of limiting information dissemination for public diplomacy, the media, and exploitation of enemy information channels. It also raises the issue of whether this agreement using market mechanisms has set a precedent that might well make it more difficult to invoke formal shutter control in the future. For background and analysis on this issue see, Lt Col Peter L. Hays and Lt Col Roy F. Houchin, II, "Commercial Spysats and Shutter Control: The Military Implications of U.S. Policy on Selling and Restricting Commercial Remote Sensing Data," paper prepared for the USAF Institute for National Security Studies, 1 October 1999.

[90] The first commercial one-meter resolution remote sensing system became operational following the successful launch of the Ikonos 2 satellite aboard a Lockheed-Martin Athena II booster from Vandenberg AFB on 24 September 1999.

See Vernon Loeb, "Spy Satellite Will Take Photos for Public Sale," *Washington Post*, 25 September 1999, 3. The Ikonos system can provide resolutions of 0.82 meters ground sample distance per pixel for digitized panchromatic images and four meters for multispectral images. EarthWatch's QuickBird 1 was launched aboard a Cosmos 3M ELV from Plesetsk on 21 November 2000 but failed to reach the proper orbit and was presumed destroyed. Jason Bates, "QuickBird Loss Hits Firm, Remote Sensing Industry," *Space News*, 4 December 2000, 3. ImageSat (formerly West Indian Space)—a joint venture between two Israeli companies (Israel Aircraft Industries and Electro-Optics Industries) and Core Software of Pasadena, California—successfully launched its EROS A1 0.82-meter resolution system (that is derived from Israel's Ofeq 3 spysat) aboard a Start 1 ELV from Svobodni, Siberia on 5 December 2000. ImageSat "does not believe it is subject to U.S. jurisdiction regarding export licenses." See "West Indian Space Changes Name to ImageSat, Announces Product Offerings," *SPACEandTECH Digest*, on-line, Internet, 23 January 2001, available from http://www.spaceandtech.com/digest/sd2000-22/sd2000-22-007.shtml; and ImageSat's website, http://www.imagesatintl.com. In December 2000, the National Oceanic and Atmospheric Administration (NOAA) awarded the first two half-meter resolution licenses to Space Imaging and EarthWatch. The half-meter licenses "contain a provision that calls for a 24-hour delay from collection of an image to distribution to a customer." See Jason Bates, "U.S. approves Licenses for Two Imaging Satellites with Half-Meter Resolution," *Space.com*, 18 December 2000, on-line, Internet, 19 December 2000, available from http://www.space.com/businesstechnology/business/satellite_licenses_001212.html.

EarthWatch's corporate roots go back to WorldView Imaging (the first licensee for a high-resolution commercial system) and Ball Aerospace. Space Imaging's lineage includes the Eosat, Lockheed-Martin, and Raytheon corporations. In addition, from the 1950s until losing a $4.5 billion NRO Future Imagery Architecture (FIA) contract to Boeing in 1999, Lockheed had been the NRO's primary spysat contractor. See Tim Smart, "Lockheed Loses Big U.S. Contract," *Washington Post*, 8 September 1999, E1. OrbImage is a corporate affiliate of the Orbital Sciences Corporation. On the security implications of high-resolution commercial remote sensing see Yahya A. Dehqanzada and Ann M. Florini, *Secrets for Sale: How Commercial Satellite Imagery Will Change the World* (Washington, D.C.: Carnegie Endowment for International Peace, 2000); Gerald M. Steinberg, "Dual Use Aspects of Commercial High-Resolution Imaging Satellites," Security and Policy Studies No. 37, (Bar-Ilan University, Israel: Begin-Sadat Center for Strategic Studies, February 1998); and Vipin Gupta, "New Satellite Images for Sale," *International Security* 20 (Summer 1995): 94-125.

[91] CSOS, 3-13.

[92] Report of the National Commission for the Review of the National Reconnaissance Office, *The NRO at the Crossroads* (Washington, D.C.: National Commission for the Review of the National Reconnaissance Office, 1 November 2000), quotations from pages 67, 74, and 71.

[93] Report of the Independent Commission on the National Imagery and Mapping Agency, *The Information Edge: Imagery Intelligence and Geospatial Information in an Evolving National Security Environment* (Washington, D.C.: Independent Commission on the National Imagery and Mapping Agency, December 2000), quotations from pages viii, 60, and 33.
[94] Ibid., 56.
[95] Ibid., 16. On DOD's pledge to buy $1 billion worth of commercial imagery over the FYDP see, for example, Warren Ferster, "U.S. to Buy Private Imagery for Intelligence," *Space News*, 12 April 1999, 1 and 34.
[96] *The Information Edge*, 89.
[97] Ibid., 90.
[98] CSOS, 3-14. Sales of GPS equipment and services are expected to exceed $16 billion by 2003. See Stephen G. Moran, "GPS Policy: Past Accomplishments and Future Opportunities," *Institute of Navigation Newsletter* 8, no. 4 (Winter 1998-99), on-line, Internet, 17 January 2001, available from http://www.ion.org/newsletter/v8n4.html.
[99] Block II satellites, the satellites that completed the first full-scale constellation, were built by Rockwell International and launched from February 1989 through October 1990. Rockwell International was also the prime contractor for Block IIA; these satellites have a design life of 7.3 years, contain two Cesium and two Rubidium atomic clocks (the primary driver of overall system accuracy), have Selective Availability (SA) and Anti-Spoof (A-S) capabilities, and were launched November 1990 through November 1997. Lockheed-Martin is the prime contractor for Block IIR satellites; these satellites have a design life of 7.8 years, contain three Rubidium atomic clocks and SA and A-S capabilities, and are designed with cross-links that allow up to 180 days of autonomous operations. Block IIR satellites were first launched in January 1997 and the most recent launch was on 30 January 2001. See United States Naval Observatory (USNO) Automated Data Service (ADS), "Block II Satellite Information," on-line, Internet, 31 January 2001, available from http://tycho.usno.navy.mil/gpscurr.html. "SA was a technique to reduce the accuracy of unaugmented, single-receiver GPS measurements. This was accomplished by altering (or 'dithering') the GPS satellite clock signals, and by modifying orbital elements of the broadcast navigation message. These alterations were done in a coded fashion, and could be removed by authorized users. This alteration caused horizontal position errors on the order of 100 meters (95%), and varied in a manner that prevented rapid averaging of positional data." SA was first implemented on 25 March 1990 on all Block II satellites. It was discontinued in September 1990 in order to provide better support to the U.S. and allied forces in Operation Desert Storm who had to rely on civilian GPS receivers because there were not enough military receivers capable of receiving the encoded precise positioning signal. SA was returned to standard level on 1 July 1991. With SA set to zero, users should "immediately expect better than 20 meter horizontal accuracy on the ground." The largest error sources are now solar disturbance of the ionosphere and the orbital parameters broadcast on the navigation message; if these

are controlled, "one may be able to achieve around 1-3 meter positioning." Discontinuation of SA will not eliminate the need for systems that use Differential GPS ("a technique to improve GPS accuracy by incorporating error corrections provided by a GPS monitoring station") such as the Federal Aviation Administration's (FAA) Wide Area Augmentation System (WAAS). See Removal of GPS Selective Availability (SA), "GPS & Selective Availability Q & A," on-line, Internet, 31 January 2001, available from http://www.ngs.noaa.gov/FGCS/info/sans_SA/docs/GPS_SA_Event_QAs.pdf.

[100] Office of Science and Technology Policy and National Security Council, "Fact Sheet: U.S. Global Positioning Policy," (Washington, D.C.: The White House, 29 March 1996). Available from http://www.ostp.gov/html/gps-factsheet.html. USSPACECOM established the Navigation Warfare (Navwar) program to protect U.S. and allied military GPS use within an area of operations, prevent enemy exploitation of GPS, and preserve civil GPS service outside military areas of operations.

[101] The White House, Office of the Press Secretary, "Statement of the President Regarding the United States' Decision to Stop Degrading Global Positioning System Accuracy," 1 May 2000, available on-line from http://www.ostp.gov/html/0053_2.html.

[102] Ibid.

[103] A.J. Van Dierendonck and Chris Hegarty, "The New L5 Civil GPS Signal," *GPS World Online*, on-line, Internet, 24 January 2001, available from http://www.gpsworld.com/1000/1000inov.html. The JCS spells out basic military policy on PNT and the use of GPS as follows: "General Military Policy. In conducting military operations described in Joint Vision 2020, it is essential that PNT services be available with the highest possible confidence. These services must meet or exceed mission requirements. In order to meet these mission requirements, military operators may use a mix of independent, self-contained, and externally referenced PNT systems. DOD PNT users may use US civil PNT systems for peacetime operations where their use does not jeopardize DOD's ability to carry out its military mission. Civil PNT systems will not be used for combat, combat support, and combat service support operations. Use of foreign PNT systems is prohibited unless a specific memorandum of agreement (MOA) has been established with that respective nation. DOD ships and aircraft may use civil PNT system(s) in peacetime scenarios as long as the system(s) in use meet International Maritime Organization (IMO), International Civil Aviation Organization (ICAO), and/or FAA specifications. Global Positioning System. GPS is now and will continue to be the primary radio-navigation system source of PNT information for the Department of Defense. All DOD combatant users must acquire, train with, and use GPS systems capable of receiving the encrypted, military GPS signal, the Precise Positioning Service (PPS). The National Defense Authorization Act for FY 1994 (Public Law 103-160), as amended by National Defense Authorization Act for FY 1999 (Public Law 105-261), mandates that '. . . after September 30, 2005, funds may not be obligated to modify or procure any Department of Defense aircraft, ship, armored

vehicle, or indirect-fire weapon system that is not equipped with a Global Positioning System receiver.' DOD PNT users may use civilian GPS augmentations for peacetime operations where their use does not jeopardize DOD's ability to carry out its military mission. Examples include the US Coast Guard's Differential Global Positioning System (DGPS) and the Federal Aviation Administration's Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS), currently under development. It is essential for users to understand that these systems may not be reliable during conflict, as they do not incorporate the same level of security and survivability as military systems." *2000 CJCS Master Positioning, Navigation, and Timing Plan*, CJCSI 6130.01B (Washington, D.C.: Chairman of the Joint Chiefs of Staff, Department of Defense, 15 June 2000), A-1 through A-2, available from http://www.dtic.mil/doctrine/jel/cjcsd/cjcsi/6130_01b.pdf.

[104] The current and near-term inventory of GPS-enhanced PGMs includes the Conventionally Armed Air Launched Cruise Missile (CALCM), the Joint Air to Surface Standoff Missile (JASSM), the Joint Standoff Weapon (JSOW), and the Joint Direct Attack Munition (JDAM). See John A. Tirpak, "Brilliant Weapons," *Air Force Magazine* 81 (February 1998); available online at http://www.afa.org/magazine/0298brill.html. On GPS use in the Gulf War in 1991 and the Air War over Serbia in 1999, see Watts, "Military Use of Space," 41-46. In 1999, B-2 bombers using JDAMs and their GPS-aided targeting system were able to hit within approximately five meters of their intended target when bombing from 40,000 feet. In addition, JDAMs are relatively inexpensive for PGMs at less than $20,000 per round.

[105] Mr. Keith R. Hall, "Presentation to the Committee on Armed Services Subcommittee on Strategic Forces," Washington, D.C.: United States Senate, 8 March 2000, available on-line from http://www.nro.gov/speeches/sppo3-8.html.

[106] "GPS & Selective Availability Q & A."

[107] Michael Shaw, Kanwaljit Sandhoo, and David Turner, "Modernization of the Global Positioning System," *GPS World Online*, on-line, Internet, 18 January 2001, available from http://www.gpsworld.com/1000/1000shaw.html. Finding and securing permission to use portions of the frequency spectrum requires extensive domestic and international coordination (with agencies such as the Federal Communication Commission and the International Telecommunications Union) and can be among the most difficult and time-consuming aspects of developing an operational space system. L1 is located at 1575.42 MHz, L2 at 1227.60 MHz,

[108] Russia is marketing handheld GPS jammers with effective ranges of 80 and 192 kilometers. See Space Commission Report, 19-20; and Tom Wilson, "Threats to United States Space Capabilities," Paper Prepared for the Commission to Assess United States National Security Space Management and Organization, available from https://www.space.gov/commission/support-docs/article05/article05.html.

SPACE-RELATED ARMS CONTROL AND REGULATION TO 2015: PRECEDENTS AND PROSPECTS

Prior to the 11 September 2001 terrorist attacks on the World Trade Center and the Pentagon, a confluence of trends and recent developments had elevated national security space issues close to the top of the American defense policy agenda. Within the span of the last decade commercial space activities grew at such a rapid pace that they moved from being the smallest to the largest sector of space activity.[1] This trend is likely to accelerate and carries large national security implications because most space technologies and systems are inherently dual-use. Questions concerning how to balance economic considerations with national security concerns are and will remain key issues in U.S. space policy for the foreseeable future. During 2000, national security space issues were carefully reviewed in three of the most important congressionally mandated studies ever convened on this subject: The National Reconnaissance Office (NRO) Commission, the National Imagery and Mapping Agency (NIMA) Commission, and the Commission to Assess National Security Space Management and Organization (Space Commission).[2] The emergence of a strong commercial space sector and these studies—along with the arrival of the George W. Bush Administration; the installation of Donald H. Rumsfeld as Secretary of Defense; and ongoing sweeping changes in senior military leadership positions including General Richard B. Myers as the new Chairman of the Joint Chiefs of Staff, General John P. Jumper as the new Chief of Staff of the Air Force, and General Lance W. Lord in the new four-star billet as commander of Air Force Space Command—create an outstanding opportunity to examine current space issues. The role of arms control and other regulatory mechanisms in structuring the interrelationships between economic considerations, space, and global security are fundamental issues that are ripe for reexamination in this context.

Arms control is a complex and contentious field of study within global politics. There is, for example, little consensus on how effective arms control was in stabilizing the superpower relationship during the Cold War or on the role that arms control played in ending the Cold War.[3] The proper scope for analysis within this field is also controversial. Some analysts argue that the field is best construed narrowly and they focus almost entirely on armaments and formal treaties. Others believe that the field is much more useful when viewed in a broader way and include in their analysis other regulatory structures and fields that relate to security issues. Even the proper objectives of arms control remain unclear. The three “classic” objectives of reducing the likelihood of war, reducing the severity of war if it should occur, and reducing the costs of preparing for war may not be broad enough to capture the most salient multidimensional security challenges in the post-Cold War world.[4]

For reasons that should become clearer in the analysis below, this essay bolsters the skeptical view on the importance of space arms control during the Cold War and construes the field broadly in order to examine regulatory mechanisms for space more comprehensively. The growth in commercial space activity and the inherently dual-use nature of most space systems make the interrelationships between space and security more complex and multidimensional than ever. Given these fundamental trends, it seems clear that only broad approaches to space arms control and regulation stand much chance of structuring the space security environment in significant and useful ways. It is far from clear, however, that such broad approaches can be developed, let alone implemented, or that they would necessarily benefit the United States.

This essay looks at precedents in space arms control and regulatory mechanisms, evaluates the utility of these mechanisms in dealing with current challenges, and uses these challenges to speculate on the prospects for space arms control and regulation through 2015. It first examines the major precedents in space-related arms control. Table 3 contains a comprehensive overview of all arms control and international agreements that affect U.S. military operations in space. Instead of discussing all of these cases, this essay focuses on a few areas in greater depth. It then turns to speculate on the prospects for space arms control and regulation to 2015. It does so by assessing the potential for arms control and regulation in a number of areas that contain elements of conflict or controversy today and that are likely to remain contentious into the future. In addition to the longstanding and unresolved controversies over weaponizing space, this essay also discusses: high-altitude nuclear detonations; commercial high-resolution remote sensing; global utilities such as the positioning and timing signals provided by the global positioning system (GPS); and crowding of radio spectrum, orbital debris, and space traffic control.

Table 3[5]

Impact of Arms Control and Other International Agreements on United States Military Operations in Space

Prohibited/Constrained Activity	*Source of Prohibition*	*Comments*
Nuclear testing and nuclear explosions in space	Limited Test Ban Treaty	Nuclear detonations in space could be highly effective in disrupting U.S. space systems

Appropriation of space or celestial bodies by claims of sovereignty	Outer Space Treaty	No prohibition against space mining; establishment of permanent “keep out zones” probably not acceptable
Deploying weapons of mass destruction in space	Outer Space Treaty; Geneva Protocol; Biological/Chemical Weapons Conventions; START I	Nuclear, chemical, and biological weapons banned; Deployment, and support of nuclear-powered space objects, conventional weapons and passive systems not constrained
Building military bases on celestial bodies	Outer Space Treaty	No prohibition against military space stations in orbit
Testing weapons of any kind on celestial bodies	Outer Space Treaty	No prohibition against testing of conventional weapons in free space
Conducting military maneuvers on celestial bodies	Outer Space Treaty	Conducting military maneuvers in free space permitted
Interfering with other states’ space-related activities without prior consultations	Outer Space Treaty	Should not jam, blind, or otherwise disrupt unless required for self-defense or during hostilities
Causing harmful contamination of the Moon or other celestial bodies	Outer Space Treaty; Environmental Modification Convention	
Threatening use of force against another state’s territorial integrity	United Nations Charter; Outer Space Treaty	Necessary and proportional self-defense is permitted
Hindering the rescue and return of astronauts and space objects	Astronaut Rescue Agreement	Inspection of space objects before return to launching party (in order to assess capability) not prohibited
Avoid paying compensation for damage caused by space objects on surface of Earth or to aircraft in flight	Convention for International Liability for Damage Caused by Space Objects	Political risk in admitting causation

Launching space objects without notifying the United Nations (UN)	Convention on the Registration of Space Objects	Operational security issue for covert activity; amount of detail provided on purpose; timing of notification; subsequent maneuvering of space object
Causing damage "elsewhere" (i.e., space)	Convention for International Liability for Damage Caused by Space Objects	Liability depends on determination of fault
Numerical and locational restrictions on ICBMs and SLBMs used to launch objects into space, as well as the launchers and space launch facilities used to support them	START I	Currently minor impact to space launch flexibility; ICBM and SLBM boosters are not normally used to support military space launches
Broadcast, record, and provide unencrypted telemetry on ICBM or SLBM used for delivering objects into the upper atmosphere or space	START I	For objects delivered by ICBMs or SLBMs into the upper atmosphere or space, the telemetry provisions only apply until the object(s) being delivered either are in orbit or have achieved escape velocity
Advance notification requirement for any launch of an ICBM or SLBM (including space launches)	START I; Ballistic Missile Launch Notification Agreement	May influence testing and operations for space weapons concepts using ballistic missiles
Airplanes that meet the definition of a heavy bomber are subject to START I provisions and restrictions	START I	As currently envisioned and unless otherwise agreed, the U.S. Air Force's proposed Space Operations Vehicle could be captured as a heavy bomber under START I due to its expected range of greater than 8000 km
Prohibition against interference with National Technical Means (NTM) or use of deliberate concealment measures	ABM Treaty; START I;	NTM assets used to support aggression may be considered legitimate space control targets

Pre and post-launch notification and exchange of early warning data for space launches	Joint Data Exchange Center (JDEC) Memorandum of Agreement; Pre- and Post-Launch Notification System (PLNS) Memorandum of Understanding	Not currently in effect; will commence once Joint Data Exchange Center is completed; agreements allow for "exceptions"
Using environmental modification techniques on Earth or in space	Environmental Modification Convention	Creation of orbital debris or enhanced radiation belts illegal; changes to Earth's weather or atmosphere also prohibited
Developing, testing, or deploying air or space-based ABM systems or components	ABM Treaty	Space-Based Infrared System (SBIRS); Space-Based Laser; Space Operations Vehicle; and space-based radar potentially impacted. Exotic technology systems and components subject to discussion
Developing, testing, or deploying space-based interceptor missiles to counter theater ballistic missiles, or space-based components based on other physical principles, that are capable of substituting for such interceptor missiles	Standing Consultative Commission Second Agreed Statement Relating to the ABM Treaty	Space-Based Laser, and Space Operations Vehicle potentially impacted; there is some debate over whether these modifications are substantial enough to warrant submission to the Senate for their advice and consent
Interfering with communication systems of other states without prior consultation	International Telecommunication Convention	Jamming or disruption only legitimate in self-defense or war

SPACE ARMS CONTROL PRECEDENTS

A number of space treaties and other regulatory mechanisms have been created since the opening of the space age in the 1950s. This section concentrates on the five most important regimes: the policies of President Dwight D. Eisenhower and subsequent administrations designed to legitimize reconnaissance satellite overflight, regulatory mechanisms for communications satellites, the Outer Space Treaty (OST), the Anti-Ballistic

Missile (ABM) Treaty and the regime for space-based ballistic missile defenses (BMD), and anti-satellite (ASAT) developments and ASAT arms control. It emphasizes the most controversial and contentious parts of these regimes in order to highlight some of the most important challenges associated with interpretation, verification, and compliance. These current challenges foreshadow many of the largest problems for space arms control through 2015.

Spysat Overflight Regime

It would be difficult to overstate the importance of reconnaissance satellites (spysats) in world politics.[6] Spysats are often credited with stabilizing the relationship between the superpowers, enabling strategic arms control, and contributing to the transformation of the international system represented by the end of the Cold War. They have been described as "the most important technological development since thermonuclear weapons."[7] Their development and operation were triumphs for American technology and diplomacy. Despite their importance, however, spysats and even the legal regime that legitimizes their overflight remained shrouded in secrecy for more than three decades. The overflight regime with its secret roots emerged from the shadows as customary international law with very few codifying written references in treaties or elsewhere. Understanding the origins and evolution of the spysat overflight regime is an essential foundation for analyzing all other dimension of space policy and is an especially important subtext for evaluating space arms control and regulatory mechanisms.

Eisenhower Administration Space Policy. The Eisenhower Administration structured the global arms control and legal regimes for space in fundamental and comprehensive ways. Much of space arms control, other regulatory mechanisms, and even the language still used today are the legacy of Eisenhower's approach. The most important legacy of the Eisenhower Administration's policy for opening the space age, however, was its secret design to create a legal regime that would legitimize overflight by spysats in order to open up the closed Soviet Union and stabilize the superpower relationship. In May 1955, the National Security Council secretly laid out these overriding priorities for United States space policy in NSC-5520—a policy President Eisenhower approved more than two years prior to the launch of *Sputnik* I on 4 October 1957.[8] The policy in NSC-5520 was the most important factor in shaping the opening of the space age and, in retrospect, it helps to explain much of the United States' behavior during this period. It explains, for example, why the United States did not race the

Soviets into space, why it used its International Geophysical Year (IGY) scientific satellite program as a "stalking horse" to test the acceptability of overflight, why it was not interested in drawing a clear demarcation line between air and space, and why it strongly emphasized that space is for "peaceful purposes" in public diplomacy.[9]

Following the *Sputnik* shock to America's preferred self-image, in October 1958 the Eisenhower Administration created an explicitly civilian organization, the National Aeronautics and Space Administration (NASA), to conduct its civil space program for science and exploration. NASA received the lion's share of public attention, especially in the early years of the space age and during the Moon Race. By contrast, the very existence of the National Reconnaissance Office (NRO), the deep black organization created in August 1960 to procure and operate U.S. spysats, was not publicly acknowledged until September 1992.[10] Eisenhower's policy was also the strongest hand in guiding the development of early international space law. The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) was established in November 1958 and this body not only adopted the American rhetoric of space for peaceful purposes that legitimized overflight for spysats but more importantly it also shied away from creating overarching control mechanisms for space.[11] Thus, by the end of its tenure, the Eisenhower Administration had established the basic and largely informal regulatory structure for space that remains in place today.

The Limited Test Ban Treaty. The first substantive U.S.-U.S.S.R. arms control agreement of the Cold War era, the Limited Test Ban Treaty (LTBT), had several important space-related dimensions. The LTBT bans all types of nuclear testing except underground and was designed to address rising worldwide concerns about radioactive fallout from nuclear tests and perceptions of a spiraling arms race. The personal involvement of President John F. Kennedy and Premier Nikita S. Khrushchev following the Cuban Missile Crisis of October 1962 was an important part of bringing the LTBT negotiations to fruition. When the U.S.S.R., the U.K., and U.S. signed the LTBT in August 1963 they closed eight years of often highly contentious negotiations. The central and most persistent barrier to reaching agreement during the negotiations had been the issue of how to verify compliance with the ban. The U.S. Government (USG) turned to space to address this problem by instructing the Air Force to develop a secret and highly capable space-based nuclear detection system known as Vela Hotel as a primary means to verify compliance.[12] Vela Hotel thus became the first space-based arms control compliance verification system—a function that would take on increasing importance in subsequent arms control agreements and become euphemistically referred to as "national technical means" of verification

(NTM).

NTM in International Law. The spysat regime matured in important ways beginning in the 1960s. Following the successful operation of spysats by both parties in the early 1960s, the Soviets stopped objecting to U.S. spysat overflights and the superpowers reached an informal modus vivendi that legitimized space-based reconnaissance and surveillance.[13] Article XII of the 1972 Anti-Ballistic Missile (ABM) Treaty contains the most important and formalized legitimization of spysats in international law and is also where they are first called NTM. Prior to the ABM Treaty, most U.S.-U.S.S.R. strategic arms control negotiation efforts had broken down, often over the contentious issue of how an agreement was to be verified. The United States consistently insisted on verification through on-site inspections (OSI) and the Soviet Union consistently rejected this intrusion on their national sovereignty. By 1968, however, U.S. policy-makers had enough faith in the data gathering capabilities of their NTM (mainly spysats), that they were willing to begin negotiating on an agreement that might not be verified by OSI. In this way spysats were the essential element in spanning the clear and wide conceptual divide between NTM and OSI—their promise helped to establish a new type of arms control regime based on a "bridge" of trust between the superpowers.[14] They played a critical role in enabling the 1969-72 Strategic Arms Limitation Talks (SALT I) and their crucial role as NTM continued in almost every subsequent strategic arms control agreement. The language in Article XII of the ABM Treaty is repeated essentially verbatim in subsequent arms control treaties predicated on NTM verification such as the 1972 Interim Agreement, the 1974 Threshold Test Ban Treaty, the 1976 Peaceful Nuclear Explosions Treaty, and the 1979 SALT II Treaty. Moreover, it is included in the treaties whose verification is also dependent on the OSI breakthrough reached at the end of the Cold War: the 1987 Intermediate-Range Nuclear Forces (INF) Treaty, and the 1991 and 1993 Strategic Arms Reduction Treaties (START I and II).[15]

Three dimensions of NTM are particularly relevant to this discussion: their role as the primary enabler of arms control, the links between NTM capabilities and units of limitation in arms control treaties, and the level of protection that arms control treaties provide for NTM. Each dimension of the NTM-arms control relationship is addressed after examining the language in the treaty. The specific language in Article XII of the ABMT was carefully crafted and is very important:

> 1. For the purposes of providing assurance of compliance with the provisions of this Treaty, each Party shall use national technical means of verification at its disposal in a

> manner consistent with generally recognized principles of international law.
> 2. Each Party undertakes not to interfere with the national technical means of verification of the other Party operating in accordance with paragraph 1 of this Article.
> 3. Each party undertakes not to use deliberate concealment measures which impede verification by national technical means of compliance with the provisions of the Treaty. This obligation shall not require changes in current construction, assembly, conversion, or overhaul practices.[16]

Article XII is the only discussion of inspection or verification mechanisms in the ABMT and thereby establishes that NTM are the most important mechanism by which the superpowers can assure compliance with the provisions of the treaty. As such, it is the best illustration of the essential, enabling, and symbiotic relationship between NTM and arms control. This article also helped to close the loop on the superpower disagreements of the 1950s and early 1960s over whether the concept of "peaceful uses" of outer space included the right to spy on one another from space. In this context, the exact wording of Article XII is important. Each party is to use NTM "in a manner consistent with generally recognized principles of international law" which thereby links NTM both to customary international law based on the prior practices of the superpowers and to the concept of peaceful uses of space that was introduced by the United States in the 1950s and somewhat more formalized in the OST. In sum, then, these provisions not only highlight the fundamental interrelationship between NTM and arms control but also help to legitimize NTM as a peaceful use of space under international law.

Second, NTM and arms control are directly interrelated because of the close relationship between NTM capabilities and the units of limitation in the agreements. Put another way, these units of limitation could only be as precise as could be "seen" by NTM—especially prior to the OSI breakthrough in the INF Treaty. The operation of this relationship can be observed in practice by noting that underground nuclear testing was not limited in the LTBT due to difficulties in monitoring these types of tests but that the development of NTM such as the Vela Hotel satellite series allowed the prohibited area for nuclear testing to be expanded into space. Consider also the improvements in NTM capabilities implied by the differences in the units of limitation between SALT I and SALT II: In 1972, NTM was asked to count very large immobile objects such as missile silos and Large Phased-Array Radars; by 1979, NTM was expected to be able to distinguish between types of ICBMs and to count numbers of warheads. The impact of this fundamental interrelationship between NTM capabilities and arms control units of limitation was a very important motivation in driving the U.S. aggressively to improve the capabilities of its spy satellites and to optimize these systems for arms control verification purposes throughout the remainder of the Cold War.

The final issue-area associated with the relationships between NTM and arms control focuses on the types of protection for NTM that are afforded by these agreements. The language in Article XII of the ABMT and the subsequent practice of the signatories undoubtedly establish some degree of protection for spysats in customary international law. Under a positivist interpretation of this language, however, it is questionable just how much protection or legitimization it provides for NTM or satellites more generally. The language clearly stops well short of being a blanket anti-satellite (ASAT) weapons ban or even a clear approval of all spying from space. The prohibitions on interference with NTM and on the use of deliberate concealment measures seem to apply only when the NTM are being used to verify compliance with the treaty and are not comprehensive bans on these type of activities. Thus, the ABMT language draws a distinction between the use of NTM for compliance verification (which is supposed to be accepted) and the use of NTM for more general espionage (which may be acceptable as a peaceful use of space but is not necessarily legitimized by the ABMT). Of course, the difficulty in this regard comes in attempting to draw this fine distinction in practice. Two attributes of actual spysat operations highlight these difficulties: First, spysats do not perform only NTM verification missions (sometimes they are just spying); and, second, the generally recognized principles of international law cannot draw a distinction between NTM and other spysat missions because the details of spysat operations are still deep black regarding specific systems and their function. How are the parties to judge whether space-based NTM are engaged in legitimate treaty compliance verification or in general espionage and how much noninterference should they be given in either case? An ASAT attack on space-based NTM attempting to verify compliance with the treaty would surely constitute “interference” but how about lesser levels of non-destructive interference such as laser “dazzling”? What about interference that takes place in portions of the orbit that do not pass over the territory of the treaty signatories? Based on these questions and despite the NTM protection these provisions were often alleged to provide in the heyday of détente, the provisions in the ABMT should not be seen as constituting an ASAT prohibition or as granting a strong and specific level of legal protection for NTM at all times. Even more importantly, the amount of “protection” this language provides for all other civil, commercial, and military space systems—including commercial remote sensing systems that might or might not be performing NTM missions—would seem to be even more tenuous.

Comsat Regulatory Regime

The regulatory regime for comsats is complex and evolving. The recent growth in the commercial space sector has largely been driven by the growth in space-enabled telecommunications services. Despite slowing recently, growth in the commercial space sector is still forecast to continue and accelerate. The comsat regulatory regime has been and will continue to be a critical factor in shaping the global comsat market but it is just one part of the broader global telecommunications regulatory regime. The global comsat market is also fundamentally shaped by technological considerations such as the competition between fiber optic cables and comsats. Over time, the primary debates over shaping telecommunication markets have moved from the North-North and East-West issues of the 1960s, to the North-South issues of the 1970s and 1980s, and have now returned to North-North economic competition issues. These trends carry increasing implications for national security as the military becomes more reliant on new commercial space services. In addition, the current pressures to reallocate for commercial use portions of the radio frequency spectrum that are now used by the military are likely to continue and increase. All of these factors illustrate why the comsat regulatory regime has become an increasingly important component within space-related arms control and regulatory mechanisms.

The Communications Satellite Act of 1962. In contrast to the largely informal mechanisms that evolved to legitimize spysats, the United States was also the primary driver behind the creation of several important formalized arms control and regulatory regimes for space. In the first of these, the regulatory regime for communications satellites (comsats), Washington moved to structure the commercial environment of space and set several precedents for commercial space that are still in place today. The Communications Satellite Act of 1962 was the first step in creating this regime. The Act was a compromise that reflected a hard fought battle in the Senate over the issue of whether comsat ownership should be public or private. It created the Communications Satellite Corporation (COMSAT) as "a new animal in American political economy: a chartered company of the sort founded by European princes in the age of the mercantilist power-state."[17] Ownership of COMSAT was initially equally shared between private stockholders and existing public common-carrier telecommunication corporations. In addition, NASA was to continue providing COMSAT the fruits of its research and development efforts on comsats at no cost, to launch COMSAT satellites at cost, and the Federal Communications Commission (FCC) was to regulate COMSAT services by approving new services, rate structures, and stock offerings.[18] Most importantly, however, the COMSAT regime was structured to advance U.S. foreign policy and national security goals. In July 1961, at the urging of his Science Advisor and the National Aeronautics and Space Council, President Kennedy issued a statement formally inviting "all nations to participate in a communications satellite system, in the interests of world peace and a close brotherhood among peoples throughout the world."[19] At the height of the Cold War competition for the allegiance of the third world, the Kennedy Administration clearly saw satellite communications as a potentially important way of helping states develop and cooperate. In its public diplomacy the administration emphasized these factors associated with comsats far more than their commercial implications.

The 1964 INTELSAT Interim Agreement and 1971 Definitive Agreement. The Communications Satellite Act of 1962 was just the first step in creating a global comsat system. Section 102 of the Act envisioned three basic criteria for an international system: 1) a single global system open to participation by any state in the world; 2) a commercial enterprise; and 3) a system designed to provide service to both the developed and developing states of the world. Following the generous allocation of up to 15 percent of the radio spectrum for space services on both a permanent and shared basis at the 1963 Extraordinary Administrative Radio Conference of the International Telecommunications Union (ITU), delegates from 14 states were able to hammer out the August 1964 Interim Agreement that marks the unofficial birth of the International Telecommunications Satellite Consortium (INTELSAT).[20] The largest controversies during the negotiations on the Interim Agreement were between the United States and European states eager to develop indigenous comsat capabilities and create economic structures in which they could flourish. In the end, the Europeans agreed to an initial structure for INTELSAT that was dominated by the United States and COMSAT as the price they had to pay to gain admittance to the global comsat market.[21]

Several factors altered the political context for the negotiations on the INTELSAT Definitive Agreement that began in February 1969. First, INTELSAT was growing rapidly. The number of member states had increased from 14 to 84 and most of the new states were third world nations that often had very different agendas for comsats than the developed states that had founded the organization. In addition, the United States was on the verge of its triumph in the moon race with the Soviet Union and felt less threatened by Soviet commercial comsat competition. And, finally, INTELSAT had proved itself as an economically viable enterprise. Accordingly, the most significant controversies during the negotiations moved somewhat away from the North-North and East-West issues that had dominated the Interim Agreement negotiations and moved toward North-South issues as well. The Definitive Agreement helped to assuage the concerns of developing states by creating new INTELSAT administrative structures that gave significant political power to each member state.[22] North-North economic competition, again primarily between the United States and Europe, remained a contentious issue. Ironically, in light of subsequent U.S. policy, the United States pushed most strongly during the negotiations to make INTELSAT a single universal system by arguing that excessive competition would make INTELSAT less economically viable. By contrast, the Europeans, in particular, did not want to be locked into INTELSAT as their only means of satellite telecommunications. A compromise was reached whereby the goal of a single system was urged in the Preamble and various other Articles in the Definitive Agreement but the agreement also contained procedures for creating separate systems.[23]

Separate Systems and INTELSAT Privatization. Following the signing of the Definitive Agreement in August 1971, INTELSAT experienced a period or relative stability and prosperity for the remainder of the 1970s.[24] By the early 1980s, however, significant controversies again swirled around the organization's purpose and focus. President Ronald W. Reagan's Administration was eager to reap the benefits that it believed would follow from breaking up government regulated domestic monopolies such as the American Telephone and Telegraph (AT&T) Corporation and also favored removing protections from international monopolies such as INTELSAT. The Consent Decree of August 1982 began the process of breaking up AT&T. On the international side, Presidential Determination 85-2 of November 1984 found "that international satellite systems separate from INTELSAT are required in the national interest" but this finding was balanced by the 1985 separate system policy (SSP). The SPP prohibited INTELSAT competitors from accessing the public switched networks (i.e., the public telephone system) to serve U.S. customers.[25] This was a formidable entry constraint because it protected INTELSAT from competition on services that accounted for almost three-quarters of its revenues.[26]

This opening for limited comsat competition began to erode INTELSAT's dominance in the markets for every service it provides (voice, data, video, and audio). But it was the emergence of a very strong transoceanic fiber optic cable infrastructure that began in the late 1980s and accelerated throughout the 1990s that ended INTELSAT's once dominant position.[27] By the late 1990s, through the Open-market Reorganization for the Betterment of International Telecommunications (ORBIT) Act, Congress moved U.S. comsat policy full circle by amending the Communications Satellite Act of 1962 and adding new provisions that created incentives for competition and privatization. More specifically, the ORBIT Act called for INTELSAT to be privatized in a pro-competitive manner no later than 1 April 2001 and prohibits the FCC from issuing or renewing licenses to INTELSAT or its privatized successor organization unless they will not harm competition in the U.S. telecommunication market.[28] The privatization of INTELSAT on 18 July 2001 marks the final major development in this area to date and is another indication of just how completely the regulatory regime for comsats has been reordered from its original design in the early 1960s.[29]

The Role of Comsat Regulatory Organizations: the ITU, FCC and NTIA. The ITU operates under a "federal" permanent structure but its most important decisions for regulating the radio spectrum are negotiated at the World Radiocommunication Conferences (WRCs) now held every two to three years.[30] Along with INTELSAT, the ITU has played and will continue to play a primary role in structuring the place of comsats in the world telecommunications regime. Unlike INTELSAT, however, it is not likely this specialized UN agency will be a candidate for privatization, primarily because it serves in a more purely regulatory fashion, licenses a limited resource, and provides a global public good by reducing harmful interference between transmissions throughout the radio spectrum. This is not to say that the ITU is unimportant or has escaped controversy over how this limited resource should be managed. Obtaining a license for the radio frequencies required to operate a comsat can be among the most difficult and time-consuming parts of bringing a system into operation. Similar to the case of INTELSAT, the primary axes of controversy over ITU regulation of the limited radio spectrum have shifted from North-North and East-West issues in the 1960s to North-South issues during the 1970s and 1980s and recently have returned primarily to North-North issues of economic competitiveness. The WRCs held in 1985 and 1988 developed an Allotment Plan and Improved and Simplified Procedures for the ITU satellite coordination/registration process that were particularly important in helping to resolve North-South conflict caused by increasing use of GSO and the fears of the developing world that they would not have access to this limited resource.[31] Conflicts during the past several WRCs have increasingly centered on controversies associated with the perceived need for new and expanded spectrum for commercial applications, disagreements over communications protocols and standards, and the targeting of different current services as potential sources of additional commercial spectrum. At the 2000 WRC, for example, some of the most significant disagreements surfaced over attempting to find spectrum to support the proposed European Galileo positioning system, deconflicting GSO and non-geostationary (NGSO) satellite spectrum, and the standards for and spectrum requests for International Mobile Telecommunications (IMT-2000) or so-called third generation (3G) mobile wireless systems.

The FCC and the Department of Commerce's National Telecommunications and Information Agency (NTIA) are the final major players in the comsat regulatory regime.[32] The FCC has jurisdiction over the entire frequency spectrum except for the portion used by the federal government that is managed by the NTIA. These organizations are the United States' domestic regulatory counterparts to the ITU and they work in conjunction with the Department of State to regulate and represent the commercial and diplomatic interests of the United States and its comsat industry. The FCC is an independent United States government agency that was established by the Communications Act of 1934 and is charged with regulating interstate and international communications by radio, television, wire, satellite and cable. It is directed by five Commissioners appointed by the President and confirmed by the Senate for 5-year terms and is organized around seven operating Bureaus and ten Staff Offices.[33] NTIA is the president's principle advisor on telecommunications and information policy issues. It was created in 1978 by merging the White House Office of Telecommunication Policy with the Commerce Department's Office of Telecommunications.[34]

One of the greatest distinctions between the approach of the FCC and the ITU in granting spectrum allocations is that since 1994, the FCC has used auctions to award licenses to the highest bidders. The FCC's authority to conduct auctions was first provided under the Omnibus Budget Reconciliation Act of 1993; prior to this it had used comparative hearings and lotteries to award licenses to applicants.[35] As of June 2001, the FCC had conducted 34 auctions that yielded over $41.6 billion in net high bids.[36] Most analysts believe that the FCC's use of auctions to allocate scarce radio frequency resources has been a success story. In addition to creating an economically rational system for allocating spectrum and generating income for the government, it has reduced the time for processing a license from up to four years to less than six months.[37] As of this writing, the FCC has not auctioned off spectrum allocations for what it considers to be "international satellites" that are designed to provide fixed satellite services (FSS) or mobile satellite services (MSS)—even if these services are focused primarily on the United States.[38] But the FCC has held auctions on the spectrum for other satellite services such as direct broadcast satellite (DBS) and digital audio radio service (DARS).[39] This seeming inconsistency again illustrates that both domestic and international regulation generally is organized around the services provided and the frequency spectrum used rather than the location of the hardware in space or elsewhere. Finally, the growing use of auctions to allocate comsat spectrum by the FCC and other state's domestic regulators may put increasing pressure on the ITU to consider the use of auctions to allocate comsat spectrum internationally.[40]

Conflict Over Military Spectrum. Growing commercial use of the radio spectrum, particularly plans to implement International Mobile Telecommunications-2000 (also known as third generation mobile wireless services or 3G), has created increasing pressure to open up portions of the spectrum identified for these applications.[41] In the United States, the Department of Defense (DOD) is the current primary user of this spectrum and employs it to control some 120 satellites including the Defense Support Program (DSP) infrared early warning satellites and the GPS, among others. In October 2000, President William J. Clinton directed the FCC and NTIA to study the feasibility of making parts of the bandwidth identified at WRC-1992 and WRC-2000 available for commercial use. The original plan called for the NTIA to identify by July 2001 the specific portions of the spectrum to be used and for the FCC to auction this spectrum in September 2002. DOD's Office of Spectrum Management within the Defense Information Systems Agency provided a report on the 1755 to 1850 MHz band to NTIA in February and NTIA issued its final report in March 2001. The NTIA report

> concluded that unrestricted sharing of the 1755 to 1850 MHz band is not feasible and any other sharing option would require considerable coordination. Further, the report notes that issues involving the availability of comparable spectrum, reimbursement, and the time required for federal entities to either modify or replace equipment would need to be addressed before a decision could be made whether federal users could share or vacate a band of spectrum.[42]

The General Accounting Office (GAO) completed a report on this issue in August 2001 that found it would be premature to make spectrum allocation decisions at that time, largely because DOD and the commercial sector used different models to estimate harmful interference and because DOD should conduct additional analysis on the programmatic, budgeting, and scheduling implications of commercial use of this spectrum.[43] In addition, the GAO report recommended that the Secretary of Defense

> • complete a system-by-system analysis to determine existing and future spectrum needs and requirements of systems in the 1755 to 1850 MHz band;
> • prepare a long-range spectrum plan and make programmatic decisions necessary to carry out that plan; and
> • complete the technical, operational, and cost assessments of satellite systems in the 1755 to 1850 MHz band and review and complete assessments of other systems as necessary.
>
> To provide DOD with adequate time and guidance to complete its plans and analysis, we recommend that the Secretary of Commerce
> • incorporate a sufficient amount of time into the new NTIA plan to select spectrum for third generation mobile wireless systems to address the issues discussed in this report, specifically with respect to satellite operations;
> • direct NTIA, in conjunction with FCC, to identify comparable alternative spectrum for use by the DOD systems before a decision is made to reallocate the 1755 to 1850 MHz band, should such an action be contemplated; and
> • coordinate with appropriate executive branch agencies to review existing national spectrum management plans and policies, and, if necessary, to establish a clearly defined national spectrum strategy reflecting DOD requirements for international agreements and spectrum requirements to operate overseas.[44]

On 5 October 2001, the NTIA removed all but 15 MHz of the 1755-1850 MHz band from consideration for commercial applications pending further study and future petitions from 3G wireless license applications.[45] More generally, however, this specific case illustrates how complex and difficult it has become to find new or reassigned spectrum allocations for emerging commercial applications such as 3G. For the foreseeable future, pressures to reallocate bandwidth presently used by the DOD are likely to continue or even increase.[46]

The Outer Space Treaty Regime

The OST is the most important space-related arms control agreement to date; it has been described as the Magna Carta for space. The terms of this agreement and the regime it represents affect potential military operations in space in important, fundamental ways and prohibit significant military options. For example, the OST bans extreme military space plans such as using the Moon as the ultimate nuclear doomsday base.[47] This section emphasizes the military's role in the bureaucratic processes that led to the OST and examines the enduring impact of the treaty. It focuses, in particular, on points of controversy concerning the treaty's interpretation and verification.

The NASM 156 Committee. The superpowers had advanced several different space arms control initiatives beginning prior to the opening of the space age. Most of these earliest initiatives seemed to be designed more for political posturing than as serious negotiating positions. The Kennedy Administration took what has come to be known as a "two-track" approach to ASAT development and space arms control efforts—deploying a minimum number of ASATs to mitigate against a Soviet orbital nuclear weapon threat while simultaneously pursuing arms control efforts to ban such weapons in space and thereby removing a major incentive for deploying ASATs.[48] Early in the Kennedy Administration, however, efforts to achieve space arms control were severely hampered by a lack of interagency coordination on space policy. Accordingly, on 26 May 1962, Kennedy issued National Security Action Memorandum (NSAM) 156. This document found that that different organizations and differing parts of U.S. space policy had too often been moving in opposite directions and directed the Department of State to create a high-level coordinating body for U.S. space policy to address this problem.[49]

The interagency group created as the result of this directive was known as the NSAM 156 Committee. The primary responsibility of this group was to develop policies designed to protect and legitimize U.S. spysats, but they were also chiefly responsible for creating the U.S. initiatives aimed at banning nuclear weapons from outer space. During the Summer and Fall of 1962 the NSAM 156 Committee was the scene of intense interagency disputes on the desirability of attempting to ban nuclear weapons from space and over the most appropriate political mechanism by which the U.S. might attempt to achieve this goal. The State Department and the Arms Control and Disarmament Agency (ACDA) were the most supportive of a ban. The Joint Chiefs of Staff (JCS) most strongly opposed such a ban because it precluded military options in space and, further, the JCS objected to the political mechanism of a U.S. unilateral declaratory statement of its intent not to station nuclear weapons in space.[50] The debates within the NASM 156 Committee and the National Security Council (NSC) gradually moved toward the position of State and

ACDA and was issued as NSAM 183 and NSAM 192 on 27 August and 2 October, respectively.[51]

UNGA Resolutions 1721, 1884, and 1962. A public diplomacy competition between the United and the Soviet Union to out-cooperate each other in the General Assembly and the COPUOS led to the adoption of United Nations General Assembly (UNGA) Resolution 1721 on 20 December 1961. UNGA 1721 was the first significant piece of space arms control and established several foundational principles. It extended international law to outer space and celestial bodies, established that the exploration and use of space was to be free and open to all states, called for registration of all space launches, and sought cooperative agreements on international communication and meteorological space systems.[52]

NSAM 192 set in motion the informal and formal initiatives that eventually led to the international declaratory ban on placing nuclear weapons or weapons of mass destruction in outer space expressed in UNGA Resolution 1884 (XVIII) on 17 October 1963.[53] It should be emphasized that "NSAM 192 represented, possibly for the first time, the willingness of the US government to conclude an arms control agreement with the Soviet Union that did not make inspection or verification a necessary prerequisite."[54] This willingness to obtain an unsecured agreement with the Soviets on banning nuclear weapons from space over the objections of the JCS was an illustration of the administration's general de-emphasis on military space programs in favor of peaceful and civil uses of space. It was also an expression of the administration's judgements that nuclear weapons in space: lacked military utility, were not required by U.S. military space doctrine, and were better dealt with through this declaratory ban than via ASAT weapons.

UNGA Resolution 1884 (XVIII) of 17 October 1963 was an international declaratory ban on placing nuclear weapons or weapons of mass destruction in outer space. UNGA Resolution 1962 (XVIII) of 13 December 1963 "signaled a breakthrough in the evolution of space law."[55] Specifically, UNGA Resolution 1962 declared:

> outer space free for exploration by all and out of bounds to national sovereignty; space activities to be carried on for the benefit and in the interest of all mankind in accordance with the UN Charter and international law; states to bear responsibility for all their national space activities, whether carried on by government or nongovernmental agencies; states to be guided by principles of cooperation and mutual assistance, with "appropriate international consultations" to precede any activity potentially harmful to peaceful uses of

> space; spacecraft to remain under the jurisdiction of the launching state, with the latter accepting liability for any damage caused to foreign property by accidents; astronauts to be regarded as "envoys of mankind" and rendered every assistance in case of peril.[56]

Thus, UNGA Resolution 1962 was clearly a very significant and wide-ranging statement that dealt with civil, commercial, and national security aspects of space.

OST Negotiations. During the Johnson Administration, the State Department and the NSAM 156 Committee continued their efforts to achieve even more significant space-related arms control agreements. The State Department held that the U.S. should negotiate an international space treaty based on the precedent of the 1959 Antarctic Treaty in order to codify the principles in UNGA Resolutions 1884 and 1962 more formally. DOD and JCS generally opposed this initiative and specifically opposed further restrictions on national sovereignty in space or on celestial bodies and rejected positions that would require the U.S. to release more data on its space vehicles.[57] Moreover, the JCS counseled caution in negotiating a space treaty due to the psychological impact such an agreement might have on general U.S. military exploitation of space and especially urged "the provisions of the treaty should not preclude the conduct of intelligence activities deemed essential to U.S. security."[58] However, by 11 March 1966, State had watered down its original position on several of these issues enough to win DOD acceptance of a preliminary draft treaty.[59] On 5 April, National Security Advisor Walt W. Rostow wrote a memorandum to the president which recommended that the U.S. rapidly propose a "Celestial Body Treaty" in order to score international public relations points by advancing this proposal before the Soviets tabled their own draft treaty on this issue.[60] Accordingly, President Johnson publicly outlined the basic provisions of the U.S. draft treaty on 7 May.

On 16 June, both the U.S. and the U.S.S.R. submitted draft treaties on regulating activities in outer space to the UN. The original Soviet proposal was much more comprehensive than the American proposal; negotiations between July and December resolved the differences between the two proposals and resulted in treaty language acceptable to the UN.[61] The UNGA endorsed the agreement on 17 December and by 27 January 1967 the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies was open for signature. Sixty-two states initially signed the OST and the agreement went to the U.S. Senate for advice and consent to ratification on 7 February.

OST Interpretation and Ratification. Many provisions of the OST echo UNGA Resolution 1884 and especially UNGA Resolution 1962. The treaty purports to "contribute to broad international co-operation in the scientific as well as the legal aspects of the exploration and use of outer space for peaceful purposes."[62] To these ends, provisions in the OST: reaffirm the principle of freedom of use of outer space, make activities in space subject to international law including the UN Charter, and stipulate that the use and exploration of space "shall be carried out for the benefit and in the interest of all countries" while outer space itself shall be the "province of all mankind."[63] This vision for cooperative, noncommercial exploration and use of space was rooted in the Antarctic Treaty of 1959 and culminated in the 1979 Moon Treaty's emphasis that space is the common heritage of mankind. In addition, the OST laid a specific foundation for every subsequent international space agreement: the 1968 Rescue and Return Agreement, the 1972 Liability Convention, and the 1975 Registration Convention.[64]

Most importantly for our arms control focus, several sections of the treaty have direct military relevance. Article II indicates "[o]uter space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."[65] The most specific military prohibitions are found in Article IV:

> States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner.
>
> The moon and other celestial bodies shall be used by all States Parties to the Treaty exclusively for peaceful purposes. The establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military maneuvers on celestial bodies shall be forbidden. The use of military personnel for scientific research or for any other peaceful purpose shall not be prohibited. The use of any equipment or facility necessary for peaceful exploration of the moon and other celestial bodies shall also not be prohibited.[66]

Cumulatively, these provisions seem to preclude significant military operations on the moon or other celestial bodies and to restrict military space options in earth orbit and elsewhere.

The most detailed public discussions of the terms of the OST and its military impact took place during the Senate hearings on advice and consent to ratification during March and April 1967. Although the U.S. had already accepted nearly all of the provisions of the OST either through unilateral policy statements or support of UNGA resolutions 1884 and 1962, the Senate nonetheless closely questioned the administration witnesses and carefully considered the political and national security impact of a treaty formalizing these positions. As a result of this close questioning, a more complete picture of the United States' understanding of several key provisions of the OST and of general U.S. space policy emerged. In the end, the testimony of the administration witnesses as well as the terms and purpose of the OST proved unanimously acceptable to the Senate as reflected in the 88-0 vote in support of ratification on 25 April.

Several space arms control issues were clarified during the hearings. Many senators were concerned with how the U.S. would verify the OST prohibition of nuclear weapons and weapons of mass destruction from space. In response to questioning on this issue, administration witnesses highlighted several important U.S. positions: First, while the U.S. could not presently or in the near term future determine with high confidence the purpose or content of any individual space object, U.S. NTM were asserted to have the ability to detect larger-scale deployments of nuclear weapons or weapons of mass destruction in space before they became "militarily significant."[67] Second, this U.S. difficulty in identifying the purpose and function of space objects would exist whether or not the U.S. ratified the OST.[68] Third, as Chairman of the Joint Chiefs of Staff (CJCS) General Earle G. Wheeler reemphasized several times during his testimony, despite these potential verification difficulties, the United States would prefer to rely upon its own NTM to address the verification issue rather than attempting to create an international on-site inspection regime for objects in space.[69] And, fourth, Secretary of State Dean Rusk asserted that while the U.S. was confident in its ability to adequately verify the OST prohibition on nuclear weapons and weapons of mass destruction, that "[t]he treaty does not inhibit, of course, the development of an antisatellite capability in the event that should become necessary."[70]

Other testimony on the OST helped somewhat to clarify what was meant by the term "weapons of mass destruction." Deputy Secretary Vance indicated that this term "would include such other weapons systems as chemical and biological weapons . . ." or future systems "which would have the capability of mass destruction such as that which would be wreaked by nuclear weapons."[71] Finally, these hearings also gave CJCS Wheeler the opportunity to emphasize that the Chiefs were concerned with aspects of inspection and verification in the OST and were worried that the psychological impact of the OST might cause a diminution of U.S. military space efforts. The JCS therefore specifically called for "intensified U.S. efforts to develop capabilities to detect and verify the orbiting of nuclear weapons or those threatening mass destruction" as well as a general "increase in our military efforts in space not prohibited by the treaty."[72]

Legacy of the OST. The OST certainly marks an important constraint on military space plans and programs. By banning nuclear weapons and weapons of mass destruction from space and prohibiting military installations on the Moon and other celestial bodies, the terms of the OST essentially foreclose the possibility that space could openly serve as the high ground for deterrence or actual warfare at the strategic level. After the ratification of the OST, the U.S. military had very little incentive to consider space plans or doctrines based upon the "high ground" school of thought.[73] The possibility of space for non-nuclear strategic defense remained open but most uses of space for strategic deterrence or strategic offense appeared to be closed.

The more subtle influences and implications of the OST are perhaps just as significant. As discussed above, the UN declaratory ban on nuclear weapons in space of October 1963 was the first instance where the U.S. was willing to declare such an unenforceable and non-verifiable ban. This, coupled with the lack of enforcement and verification mechanisms in the OST, signaled that the U.S. was not overly concerned with the security implications of nuclear weapons in space. And if the U.S. was not overly concerned with the verification mechanisms for guarding against even potential nuclear weapons in space, how important could other types of weapons or systems in space be? The very limited verification provisions in the OST and the divergence between inspection procedures for space versus the moon or other celestial bodies also seem to point again to the overriding importance of U.S. spy satellites in shaping all other space applications and policies. Additionally, many commentators have stated that the OST should be seen primarily as an international public relations effort because it basically only codified the space developments to date and only banned those military options in which the superpowers had little interest. However, this interpretation does not sufficiently underscore the significant restraining effect of the OST on the U.S. military's plans and programs for space. Cumulatively, then, the OST was a clear message that the U.S. civilian leadership did not believe that space held a great deal of military utility, except as a sanctuary for spysats, and that space doctrines and systems which did not match with this approach would not be treated seriously.

Later in 1967, Secretary McNamara revealed that the Soviets had been testing a new type of ballistic missile delivery system known as a fractional orbital bombardment system (FOBS). During 1965 and 1966 the Soviets had conducted a series of tests in which an SS-9 intercontinental ballistic missile (ICBM) launched a payload into an orbital trajectory that was then de-orbited before the completion of one orbit. The apparent purpose of this system was to allow ballistic missile attacks on the U.S. from the south rather than via the normal ballistic trajectory over the north polar regions. Such a system would afford the Soviets greater flexibility in attack planning and allow an approach towards the U.S. from the direction with the least strategic surveillance. Following McNamara's 3 November 1967 public announcement that the Soviets had developed a FOBS, he attempted to downplay its significance by stating that this system did not pose a major new strategic threat to the U.S. or violate the OST since the payloads were not in sustained orbit.[74] Secretary McNamara did not publicly reveal that the JCS and the Air Force, in particular, regarded the FOBS as a considerable security concern as a possible first-strike weapon that would be able to avoid much of the U.S. early warning system by attacking from the south.[75] Overall, the announcement of this new type of system did arouse considerable concern within the U.S. and illustrated that the OST would not be the last word on the security implications of space.

The ABMT Regime and Space-Based Defenses

The SALT I agreements consisting of the Treaty on the Limitation of Anti-Ballistic Missile Systems (ABMT) and the Interim Agreement on the Limitation of Strategic Offensive Arms (IA) represent one of the most important milestones in arms control during the Cold War. They were the first major and comprehensive strategic arms control agreements ever reached between the superpowers. These agreements attempted to codify and take advantage of mutual assured destruction (MAD) as the basis for strategic stability between the superpowers. The signing of these agreements on 26 May 1972 also officially signaled the arrival of the era of détente between the superpowers.[76] As discussed above, spysats played a central role in enabling the ABMT, served as the primary means of verification for the treaty, and the treaty helped to legitimize NTM under international law. For our purposes in this section, the four most important aspects of this regime are: 1. the roots of BMD systems prior to the ABMT; 2. subsequent technological and political developments such as the Strategic Defense Initiative (SDI); 3. the unclear prohibitions on space-based ABM systems found in the ABMT and discussed in subsequent negotiations; and 4. space and missile defense in the 1990s and beyond.

BMD Plans and Developments Prior to the ABMT. The roots of U.S. BMD efforts go back to before the opening of the space age. On 16 January 1958, Secretary Neil H. McElroy had assigned the Army primary responsibility for developing an ABM system over Air Force objections but the Army's primary program in this area, known as Nike-X, made only halting progress in the early 1960s.[77] The growing opposition of Secretary McNamara to large-scale ABM deployments became clearer as he refined the concepts behind MAD; McNamara's opposition was a key factor in slowing movement towards ABM deployments.

During the 1967-1969 period, the Army and the Johnson and Nixon Administrations grappled with great controversy as they moved to deploy America's first ABM system. The Army's Nike-X system, now renamed Sentinel, was first approved as a "thin" defense of cities—primarily against the emerging threat of People's Republic of China (PRC) missile deployments. The incoming Nixon Administration reoriented the Sentinel system towards defending ICBMs and renamed the program Safeguard. The Safeguard system survived a series of very close votes in Congress and was fundamentally shaped by the ongoing SALT I negotiations; it emerged as a one-site system designed to defend the Minuteman ICBM fields at Grand Forks AFB in North Dakota. The Safeguard system became operational on 1 October 1975. However, by 18 November, both the House and the Senate had voted to scrap this system and deactivation began in February 1976.[78] The torturous path towards Safeguard deployment and its rapid demise as well as its primary mission of defending Air Force ICBMs clearly soured the Army on the whole concept of strategic defense. Likewise, the Air Force had very little incentive at this time to follow the Army down this rocky road and, moreover, retained the strong institutional bias towards offensive forces that had justified its development as a separate Service.

Space-Based BMD Plans and Developments after the ABMT. While the U.S. military had almost no interest in exploring new BMD systems following the demise of the Safeguard system, several new potential BMD technologies, such as space-based laser systems, began to excite renewed interest in BMD within groups outside the military by the late 1970s. The four key figures in helping to generate increased U.S. interest in exploring the potential of space-based laser BMD systems in the late 1970s included: Lockheed aerospace engineer Maxwell W. Hunter II, Senator Malcolm Wallop (R.-WY), Dr. Angelo M. Codevilla of Wallop's staff, and *Aviation Week & Space Technology* Senior Editor Clarence J. Robinson, Jr.[79] On 31 October 1977, Hunter completed an important study for Lockheed entitled "Strategic Dynamics and Space-Laser Weaponry."[80] At Wallop's urging, Hunter put together a team of leading experts on the technologies involved in a space-based laser system and this team presented a series of briefings during the Fall of 1979 to Senators, staffers, and DARPA officials.[81] While these briefings were generally well received by those in attendance, other DOD and Air Force officials were reportedly "so rankled" that they pressured "those companies funded under laser contracts to keep members of the briefing team out of Washington."[82]

One of the most specific achievements resulting from the strong advocacy of these individuals and Hunter's briefings was the addition of $30 million to the fiscal year (FY) 1982 Air Force budget for the development of space-based lasers. Wallop also recognized and attempted to deal with the conceptual opposition and bureaucratic inertia of the Services on this issue. Specifically, his bill required the Air Force to establish a program office for airborne and spaceborne lasers and work towards an early demonstration of high-energy lasers in earth orbit. If the Air Force did not vigorously pursue this laser research, Wallop threatened to have the program shifted to Army control. There was also some support for establishing a new military Service to take responsibility for space operations, since none of the established Services was showing adequate interest. One reason no Service wished to become the patron of space weaponry was the fear that these expensive systems would consume resources that could be used for purposes the Services considered more important.[83] Overall, this first group was quite successful in bringing the substantial BMD potential of space-based lasers to the attention of many key defense decision-makers in Washington and in reenergizing the concept of strategic defense more generally. Thanks to the efforts of this group, many at least began to consider the revolutionary potential of space-based weaponry such as high-energy lasers.[84]

With the advent of the Reagan Administration, a new group of civilians became most directly responsible for strongly advocating the continuing exploration of America's strategic defense options. Initially spearheading these efforts was the High Frontier Organization headed by Lieutenant General Daniel Graham, U.S. Army (Retired), and the High Frontier Panel chaired by Karl Bendetsen, a former Under Secretary of the Army.[85] Beginning in late 1982, two other key actors came to strongly support a strategic defense initiative and these individuals, along with the president, shaped the developments that culminated in Reagan's 23 March 1983 "star wars" speech.[86] The key actors at this time were National Security Advisor Robert "Bud" McFarlane and Chief of Naval Operations (CNO) Admiral James Watkins.[87] By the end of 1982, the administration's plans to deploy the MX "Peacekeeper" ICBM were in disarray due to public and congressional opposition to various basing modes. Moreover, McFarlane was convinced that the nuclear freeze movement was gaining momentum and might block all other U.S. strategic modernization efforts as well. Against this backdrop, McFarlane was strongly drawn towards strategic defenses as "a way to outflank the freeze movement[.]", exploit U.S. technological prowess, and expand U.S. strategic options.[88] From an organizational focus, it is most interesting that virtually the only major early conceptual support for SDI from the military was developed by the Navy, the Service with the least experience in and the least vested interest in deployments of BMD systems.

Thus, in early 1983 everything finally came together to produce a policy decision in favor of investigating strategic defenses. During January 1983, Watkins and his staff worked hard to convince the other Chiefs of the importance of moving out of their strategic valley of death by investigating the potential of new technologies for strategic defense. At a 5 February executive session of the JCS, Watkins was able to get JCS concurrence on this recommendation for the president and was undoubtedly aided by McFarlane's admonition that if the Chiefs were "all over the lot on this issue, there's not a chance in the world he [Reagan] would support a missile defense program."[89] A critical meeting took place at the White House on 11 February involving the JCS, Secretary of Defense Caspar W. Weinberger, National Security Advisor McFarlane, and the president. At this meeting, the president responded favorably to the unanimous support of the JCS for investigating new strategic defense possibilities. Immediately after the formal meeting, McFarlane requested that each of the Chiefs submit a thorough report on this issue to him and charged his staff with the same responsibility. Reagan's personal interest in this issue was evident when he pushed McFarlane to produce a public announcement of this policy before the completion of these reports and when he participated extensively in the drafting of the 23 March speech.

Reagan's SDI speech did change the terms of the strategic debate within the U.S. and worldwide by reintroducing a fundamental strategic concept while simultaneously outflanking the nuclear freeze movement. Moreover, because Reagan's initiative shocked those who believed that MAD should continue to form the basis for stable deterrence, the administration had a short reprieve of several months before widespread and committed opposition to the SDI became organized and publicized. During this time, the administration completed three critical studies on the SDI and set the bureaucratic structure for the SDIO into motion. On 25 March 1983, Reagan signed National Security Decision Directive (NSDD)-85, "Eliminating the Treat from Ballistic Missiles," which formally directed the start of the initiative he had publicly announced two days earlier. Soon thereafter, National Security Study Directive (NSSD) 6-83 ordered two major studies on the SDI concept be completed within the administration by October. The largest of these studies examined in detail the current and likely technologies available for BMD. Formally titled the "Defensive Technologies Study," this effort is better known as the Fletcher study after its chairman, former (and future) NASA Administrator James C. Fletcher. The other major study was titled the "Future Security Strategy Study" and focused on the political and strategic implications of the SDI. Two groups undertook this study, an interagency team led by Franklin Miller and a team of outside experts chaired by Dr. Fred Hoffman. Generally speaking, all of these reports strongly supported starting the type of long-term research and development (R & D) program on strategic defenses called for by the president.[90] On 6 January 1984, NSDD-119, "Strategic Defense Initiative," officially accepted the recommendations of these studies and formally started the SDI. Accordingly, in January a new office, SDIO, was established within DOD. The Fletcher study "was used as a general guide for initiating the program."[91] SDIO was made directly responsible to the Secretary of Defense and placed outside of the normal Service and other bureaucratic structures of DOD. On 15 April, Lieutenant General James A. Abrahamson moved from his position as Associate Administrator for Manned Spaceflight at NASA to become the first director of SDIO. The SDIO first demonstrated the potential of new BMD technologies on 10 June when a kinetic energy weapon (KEW) known as the Homing Overlay Experiment (HOE) launched from Meck Island in the Pacific Test Range successfully intercepted a test reentry vehicle (RV) launched atop a Minuteman ICBM from Vandenberg AFB.[92]

Beginning in 1985 and continuing throughout the remainder of this period, SDI faced well-organized and increasing political opposition in Congress and elsewhere. This increasing political opposition deflected SDIO's attentions away from broad long-term strategic planning and onto narrow short-term budgetary and political issues. The protracted debate over SDI's place in the broad versus narrow ABMT interpretation dispute discussed below is an example of one major factor that drained SDIO's attention away from strategic defense developments per se. Thus, there was little focus at SDIO on developing long-range doctrine for space weaponry. Moreover, SDIO's research only focus and BMD charter also generally tended to serve as an intellectual blinder to thinking about the other very significant military applications of space weaponry. Additionally, there is little open evidence that the Air Force or DOD picked up this slack and carefully considered the military potential of the technologies being explored under the SDI for applications other than BMD. Given all of these difficulties, it is not surprising that even the Commander-in-Chief's strong support for SDI was not powerful enough to overturn the deeply ingrained psychological and doctrinal preferences for massive retaliation or MAD within much of the U.S. military hierarchy.[93]

Reevaluations of the political role of strategic defense, the sustained political opposition to SDI, and the changing political environment on the way to the end of the Cold War combined to result in significant refocusing of the program away from the very robust "astrodome" type population defense implied by Reagan's original vision. In an address on 20 February 1985, Ambassador Paul Nitze officially codified two criteria by which SDI developments would be judged: first, that any defense systems be highly survivable, and second, that defense systems "be cost effective at the margin—that is, they must be cheap enough to add additional defensive capability so that the other side has no incentive to add additional offensive capability to overcome the defense."[94] A series of SDIO experiments conducted on 5 September 1986 known as the Delta 180 test confirmed the ability of space-based infrared sensors and KEW to perform simulated boost-phase intercepts.[95] During 1987, the JCS "formally provided operational requirements for a Phase I Strategic Defense System" by establishing a classified "minimum performance level which must be achieved" in a Phase I strategic defense deployment.[96] This was followed by Secretary Weinberger's announcement on 18 September that the Defense Acquisition Board had approved the entry of six elements of the Phase I SDI program into the demonstration and validation phase of the defense acquisition process.[97] Lieutenant General Abrahamson resigned his post at the end of January 1989 without making full general.[98] In a final major development at the end of the Cold War, Dr. Lowell Wood of the Lawrence Livermore National Laboratory, proposed an enhanced and proliferated space-based interceptor system known as Brilliant Pebbles.[99]

Restrictions on Space-Based BMD in the ABMT and Subsequent Developments. The third major space arms control issue raised by the ABMT involves the unclear prohibitions on space-based ABM systems found in the treaty and how they have been interpreted over time. During the heyday of détente, most of the terms of the ABMT were seen as clear and unambiguous. In this context, the specific prohibition on space-based ABM systems found in Article V seem straightforward: "Each Party undertakes not to develop, test, or deploy ABM systems or components which are sea-based, air-based, *space-based*, or mobile land-based."[100] Over time and under different interpretations, however, the ABMT's prohibitions on certain types of ABM systems have become far cloudier. Moreover, beginning in the Reagan Administration and continuing to the present, the fundamental provisions of the ABMT and the treaty's strategic utility have become mired in controversy. This section briefly examines the most controversial portions of the ABMT as well as subsequent space-based BMD developments. Debates over the strategic utility and proper interpretation of the ABMT are usually the outward manifestation of more fundamental, underlying issues such as divergent views on the strategic value of MAD, space-based BMD, and the general military utility of space.[101]

Particularly during the 1980s, controversy swirled around the issue of whether or not the ABMT prohibits the development, testing, or deployment of space-based ABM systems based upon so-called “exotic” technologies. The parts of the ABMT most relevant to this debate are Articles II and V and Agreed Statement D. Article II defines ABM systems as follows:

> 1. For the purposes of this Treaty an ABM system is a system to counter strategic ballistic missiles or their elements in flight trajectory, currently consisting of:
>
> (a) ABM interceptor missiles, which are interceptor missiles constructed and deployed for an ABM role, or of a type tested in an ABM mode;
>
> (b) ABM launchers, which are launchers constructed and deployed for launching ABM interceptor missiles; and
>
> (c) ABM radars, which are radars constructed and deployed for an ABM role, or of a type tested in an ABM mode.[102]

Taken together, Articles II and V along with Articles III and IV clearly seem to prohibit testing, development, or deployment of any ABM systems except at each state’s declared 100 launcher fixed land-based ABM site and at a maximum of fifteen fixed land-based test launchers located at agreed test ranges (Kwajalein and White Sands for the United States and Sary Shagan for the Soviet Union).[103]

The debate over the proper interpretation of the ABMT on this issue comes when attempting to reconcile the seemingly clear prohibitions discussed above with the far broader limitations contained in Agreed Statement D:

> In order to insure fulfillment of the obligation not to deploy ABM systems and their components except as provided in Article III of the Treaty, the Parties agree that in the event ABM systems based on other physical principles and including components capable of substituting for ABM interceptor missiles, ABM launchers, or ABM radars are created in the future, specific limitations on such systems and their components would be subject to discussion in accordance with Article XIII and agreement in accordance with Article XIV of the Treaty.[104]

Taken alone, Agreed Statement D seems to imply that the parties are free to develop and test (and thus to “create”) any type (space-based, mobile land-based, etc.) of ABM system (at locations other than the agreed test ranges) so long as these new ABM systems are based on other physical principles (OPP).

The Reagan Administration contended that this interpretation based on Agreed Statement D was the legally correct interpretation (LCI) of the ABMT because U.S. negotiators were unsuccessful in their attempts to achieve a more comprehensive ban on exotic technologies when the Soviets resisted these efforts during negotiations in 1972.[105]

Many complex issues are raised by this ABMT interpretation dispute including: debates over the military utility of space-based BMD, elements of the MAD versus warfighting for deterrence debate, unanswered constitutional questions concerning the proper role of the Senate in providing advice and consent to treaty ratification and the subsequent responsibilities of the Legislative and Executive branches, questions on the ability of the Executive branch to keep negotiating records secret under Executive Privilege after a treaty has been ratified or to change its interpretation of a treaty, violations of the ABMT found when examining the subsequent practice of the parties, and questions on how to reconcile U.S. constitutional requirements with international law obligations such as those contained in the Vienna Convention on the Interpretation of Treaties.[106] These are very important arms control issues but are well beyond the scope of our focus and are not discussed further here.

It is important to recall that the debate over the proper interpretation and strategic utility of the ABMT was not a major public issue until raised by the Reagan Administration in October 1985 but that this debate has remained controversial ever since.[107] Regardless of the "proper" interpretation of the ABMT, for our purposes, the most important aspect of the treaty during this period was its very significant restraining effect on any possible military plans for space-based BMD systems and even on planning for new types of ASAT systems. The debate also clearly illustrates how ill defined parts of the process remain and the power of both the Executive and Legislative branches in interpreting and reinterpreting treaty obligations.

Space and Missile Defense in the 1990s and Beyond. As technology has improved, the potential for "high ground" space systems such as space-based ballistic missile defenses has improved and this has placed increasing strains on the ABMT regime. But any BMD system—and particularly a space-based BMD system—still faces huge political, fiscal, and technical challenges. Despite an intense focus on strategic defense and the expenditure of more than $58 billion on research and development during the last 17 years, the United States still does not have *any* (space- or other-based) deployed strategic defense systems or even the near-term prospect for deploying any comprehensive system.[108] Throughout, the implications of space-based ballistic missile defenses have remained one of the most politically charged issues related to arms control and military space.

Four recent major developments are most important in shaping the environment in which near-term policy decisions on space-based defenses will be made. The first two developments moved the United States away from deploying BMD while the last two have moved deployment closer. Early in his first term, President Clinton and his administration reflected traditional Democratic Party ambivalence toward strategic defenses by transforming the Strategic Defense Initiative Organization (SDIO) into the Ballistic Missile Defense Organization (BMDO). The direction of many strategic defense programs was changed along with this semantic change. Most importantly, BMDO moved away from the priorities of SDIO and placed its major focus on developing theater missile defenses (TMD) rather than on national missile defenses (NMD). In concert with this reordering of priorities, BMDO ended SDIO programs to develop and deploy the Brilliant Pebble (BP) space-based kinetic kill vehicle as the mainstay of the Global Protection Against Limited Strikes (GPALS) architecture, deemphasized sea-based systems built around Aegis cruisers and destroyers, and ended negotiations on managing a cooperative transition to defense deployments with the Russians.[109] Overall, these changed priorities moved BMDO almost exclusively into developing land-based kinetic-kill terminal defense systems—an area that may be the most politically acceptable and easiest from an arms control perspective but is arguably the least effective and most technologically challenging for defense systems.

The Clinton Administration also changed the political and legal context for defensive systems in several ways as it was reorienting the technical focus of the program. First, following the breakup of the Soviet Union, it used the Standing Consultative Commission (SCC) to negotiate a multilateralization of the ABMT to include Russia, Ukraine, Belarus, and Kazakhstan as states parties to the treaty. Second, as announced at the March 1997 Helsinki Summit, the Clinton Administration negotiated a demarcation agreement that was intended to strengthen and maintain the ABMT regime by drawing a line between TMD and NMD. Operationally, the demarcation agreement means that defensive systems with velocities of less than three kilometers per second (3 km/s) are deemed compliant with the treaty so long as they are tested only against targets with velocities of less than 5 km/s and ranges under 3500 km.[110] Finally and most importantly for our focus, the Helsinki agreement also bans all types of space-based TMD. This prohibition was somewhat overshadowed by the implications of the demarcation agreement but is potentially far more significant. As Dennis Ward explains:

> Although Article V of the ABM Treaty bans space based ABM systems, space based TMD interceptor missiles are not restricted, except insofar as Article VI(a) precluded giving them "capabilities to counter strategic ballistic missiles." And, since Article VI(a) applies only to non-ABM missiles, launchers, and radars (not non-ABM "systems" as is commonly believed), there is no prohibition on space based lasers for TMD in the ABM Treaty. Thus, Helsinki represents an unquestionable expansion of the ABM Treaty into the sphere of TMD. . . . the Helsinki agreement expands the treaty by foreclosing permanently one of the most promising ways to conduct missile defense—from space.[111]

Further complicating matters, the Clinton Administration never submitted its multilateralization and demarcation agreements for the Senate's advice and consent to ratification.[112]

The third set of major arms control developments that will shape the environment for missile defense came at the end of the Clinton Administration and include: the June 1999 Cologne Joint Statement by Presidents Clinton and Boris Yeltsin that the United States and Russia will negotiate on modifications or amendments to the ABM Treaty that would allow the United States to deploy a more robust NMD system, the congressional declaration that it is the policy of the United States to deploy an NMD system "as soon as technologically possible," and the reorientation of the Clinton Administration's so-called "3+ 3" program for NMD. The 3+ 3 program originally called for accelerated research and testing so that, if warranted by the threat and technological progress, a decision to deploy NMD could be made in June 2000 and the system deployed by 2003. Like almost everything associated with missile defense, the 3+ 3 program became highly politicized. Supporters of NMD criticized it for not being a development effort commensurate with the threat and because it lacks a specific commitment to deploy NMD; critics of NMD argued that the technology to support deployment was immature and opposed this approach because it undermines the ABM Treaty and START II.[113] In this context, Defense Secretary William S. Cohen's January 1999 statements are quite significant because they indicated a higher level of support for NMD and were a clear evolution away from previous Clinton Administration NMD policy. Specifically, Secretary Cohen announced that DOD would budget funds necessary to pay for an NMD deployment by increasing its future years budget by $6.6 billion, affirmed that there is a growing threat not only to troops overseas but also to Americans at home, indicated that deployment might require modification of the ABM Treaty, and kept the June 2000 deployment decision date but slid the deployment date from 2003 to 2005.[114] Cumulatively, the BMD developments at the end of the Clinton Administration mark a clear retreat from some of the changes associated with standing up BMDO and the Helsinki agreement and moved the focus of U.S. missile defense efforts closer to its orientation prior to 1993.

Finally, of course, George W. Bush's Administration has moved rapidly away from the ABMT regime and toward near-term BMD testing and deployments. During the course of three meetings with Russian President Vladimir Putin, President Bush made it clear that his administration intends to move forward with defenses, preferably in cooperation with the Russians and within the confines of modifications to the ABMT. Administration officials also made it clear, however, that they are committed to deploying defenses even if that means the United States must do so unilaterally and withdraw from the ABMT.[115] Bush also faces considerable domestic opposition to his plans for accelerating defense deployments and moving away from the ABMT, particularly from leading Democrats in the Senate such as Tom Daschle (D.-SD) and Carl Levin (D.-MI).

On 13 December 2001, the Bush Administration provided formal notification of the United States' withdrawal from the ABMT. In accordance with Article XV of the Treaty, the effective date of withdrawal will be six months from this formal notification.[116] In addition, Secretary of Defense Donald H. Rumsfeld on 2 January 2002 "approved a major restructuring of the Ballistic Missile Defense Organization that includes a name change [to the Missile Defense Agency] and creates a leaner process for developing and fielding the Defense Department's missile defense programs."[117] Following the 11 September terrorist attacks and the creation of an international coalition against terrorism, it is unclear how domestic and international support for BMD may change and exactly what types of BMD deployments the Bush Administration intends to advocate or will successfully implement. It is likely, however, that they will find more international and domestic opposition the further they press beyond limited, ground-based deployments and, as in the past, plans for space-based BMD are likely to evoke the most opposition of all.

ASAT Developments and ASAT Arms Control

Current space policy analysts too often assert that international law somehow bans ASAT weapons and that any plan to develop or deploy ASAT weapons represents a dangerous escalation of the space "arms race." Neither premise is true. As discussed above, broad space treaties such as the OST and

ABMT do not ban ASATs or even necessarily provide much protection to NTM from ASATs. This section also debunks the idea that any current ASAT plans or testing is new and destabilizing by briefly recapping all the major ASAT tests and deployments in the past. Along the way, it examines all significant ASAT arms control efforts to date. Three major facts emerge from this analysis that should be most instructive to us today: First, despite considerable effort, the superpowers were unable to reach any agreement on ASAT arms control, agree to space “rules-of-the-road,” or even define what constitute offensive or defensive space systems; second, both superpowers conducted extensive testing and limited deployments of ASATs during the Cold War and both sides chose to end their deployments without reaching an ASAT arms control agreement; and finally, all the ASAT testing, deployments, and deactivations to date are an excellent illustration of how arms can be controlled without a formal arms control treaty. For pluralist democracies like the United States in particular, arms are *always* controlled both as a part of the normal democratic debates over guns versus butter and by open debates over the strategic utility of specific weapons systems.

Early ASAT Plans. Plans, testing, and then actual deployments of ASAT weapons began shortly after the opening of the space age. Because of their focus on actual weapons systems, ASAT plans and programs often received more support and enthusiasm from within the military than did other types of space systems such as force enhancement systems. But the development of ASATs and the doctrine for their use was a very sensitive issue that was constrained by the space policies of the Eisenhower and Kennedy Administrations. Thus, despite Service support for the deployment of ASAT weapons (especially manned ASATs) in the early days of the space age, ASAT programs moved forward only haltingly and did not result in deployed systems until 1963.

The *Sputniks* shock provided a clear rationale for the U.S. military to explore the need for ASAT systems. Each of the Services advanced some type of ASAT proposal prior to the end of November 1957.[118] In June 1957, General James Gavin had requested that the Army Ballistic Missile Agency (ABMA) begin a comprehensive study of this problem; the Army proposal briefed to the Office of Special Assistant for Science and Technology on 19 November was undoubtedly the most detailed and complete of these early ASAT proposals.[119] The earliest policy guidance on ASATs came following a 13 February 1958 meeting of the NSC and the adoption of NSC 5802/1, entitled “U.S. Policy on Continental Defense.”[120] NSC 5802/1 specified that “Defense against Satellites and Space vehicles” was an area of “particular importance” warranting a “vigorous research and development program . . .”[121] Despite this approval for vigorous ASAT R & D in NSC 5802/1, other political factors strongly mitigated against substantial U.S. ASAT efforts at this time.[122]

The major ASAT R & D program underway during the Eisenhower Administration was the satellite interceptor system known as the SAINT. The idea for an on orbit satellite inspection system had originated in an Air Research and Development Command (ARDC) study conducted in 1956.[123] The Advanced Research Projects Agency (ARPA) kept this Air Force idea alive with very limited contracts for the Radio Corporation of America (RCA) to study such an inspection system until the Air Force formally proposed on 5 April 1960 that prototypes of the SAINT system be built.[124] In order to sell its proposal, the Air Force had to stress the inspection feature rather than any possible ASAT capability of the SAINT but the proposal still faced considerable political pressure and the staunch opposition of Science Advisor George Kistiakowsky.[125] As the result of this emphasis on only the non-lethal aspects of SAINT (which was unpopular within the Air Force) and the fact that the Air Force had been directed by the Director of Defense Research and Engineering (DDRE) Herbert York to pay all costs associated with its development, the system now had to face increasing pressures within the Air Force as well. By 1962, technical problems with the program, the international law implications of on orbit inspection, fears of instigating a space-based ASAT race, and the open possibility of accomplishing this mission more easily and cheaply in other ways combined with the dwindling support for SAINT both within and outside of the Air Force; the Air Force decided to "reorient" the SAINT program on 3 December 1962.[126]

Several other very limited ASAT studies and demonstrations were also underway during this period. The most significant of these was the world's first ASAT test conducted by ARDC on 19 October 1959 as a part of Project Bold Orion. In this test, a Martin missile was air-launched from a B-47 at the *Explorer VI* satellite as it passed overhead the Eastern Test Range at Cape Canaveral.[127] Additionally, the Navy studied the feasibility of ship or submarine launched ASATs under the code names Early Spring and Skipper in the early 1960s. In April and July 1962, the Navy conducted two tests of an air-launched ASAT missile that were similar to the Bold Orion test.[128]

Program 505 and 437 ASAT Systems. The advent of the Kennedy Administration, rising U.S.-Soviet tensions over Berlin and elsewhere, improving space technology, more strident Air Force and industry lobbying for space weapon development, and especially the increasingly bellicose Soviet space rhetoric combined to cause the U.S. to rethink ASAT issues and eventually field its first limited ASAT systems in the early 1960s. As an example of the threatening Soviet space rhetoric of the day consider the following statement made by General Secretary Nikita S. Khrushchev on 9 August 1961 at a reception honoring Gherman Titov's orbital spaceflight:

> You do not have 50 and 100-megaton bombs. We have bombs stronger than 100 megatons. We placed Gagarin and Titov in space and we can replace them with other loads that can be directed to any place on earth.[129]

These pressures prompted Secretary of Defense Robert McNamara to make a highly secret decision in May 1962 that directed the Army to develop a modified Nike Zeus missile as an ASAT system.[130] This decision resulted in Program 505, a nuclear tipped Nike Zeus ASAT system stationed at Kwajalein Atoll in the Pacific Missile Range. Tests of the Program 505 ASAT began in December 1962 and the system was declared operational on 1 August 1963.[131]

As a means of providing further insurance against Soviet orbital threats, on 15 February 1963 the Air Force was directed to prepare for "operational standby capability" with the nuclear tipped Thor ASAT missile it planned to begin testing from Johnson Island in the Pacific.[132] Designated Program 437, the Thor ASAT began testing in February 1964 and reached initial operational capability (IOC) on 10 June of the same year.[133] President Johnson publicly revealed the existence of a U.S. ASAT capability on 17 September 1964 and McNamara discussed these two systems in limited detail at a news conference the following day.[134] Both of these initial ASAT systems suffered from a number of very significant operational deficiencies including: an inability to attack many satellites in many types of orbits due to the range and azimuth limitations imposed by the missiles themselves and by having only two launch sites for these direct-assent ASATs; an inability to discriminate in attacking individual targets due to the nuclear kill mechanisms on these ASATs; and a limited number of ASAT missiles, inadequate tracking and targeting support, and a weak logistical infrastructure.[135]

Following the deployment of the Program 505 and 437 ASAT systems, neither DOD nor top civilian leadership was very interested in aggressively pursuing new ASAT capabilities and by the early 1970s these deployed systems gradually withered away into non-operational status.[136] Meanwhile, the Soviets developed a non-nuclear co-orbital ASAT that was initially tested between 1968 and 1971. By the mid-1970s, U.S. recognition of the growing significance of military space systems and of the vulnerability of these systems prompted Washington to reexamine the need for an ASAT system. Following the resumption of Soviet ASAT testing in February 1976, President Ford issued National Security Decision Memorandum (NSDM)-345 on 18 January 1977. This directive authorized DOD to develop a new non-nuclear ASAT system. President Carter attempted to take a two-track approach to the ASAT issue by entering into ASAT negotiations with the Soviets while simultaneously continuing the development of the ASAT system authorized by Ford. However, by the end of the 1970s, ASAT negotiations had broken down and the increasing U.S.-U.S.S.R. tensions made the prospects for ASAT arms control very dim.

Soviet ASAT development efforts during this period provided an important impetus for the United States to continue examining its own ASAT programs, satellite survivability efforts, and arms control countermeasures. The first "*full* and unambiguous" Soviet ASAT test took place during October 1968 although several elements of this system and other ASAT related components had been tested as early as 1963.[137] This earliest Soviet co-orbital system employed a modified SS-9 ICBM booster with a radar-guided explosive warhead.[138] Between October 1968 and December 1971, the Soviets conducted seven tests of their radar guided ASAT system; generally, five of these tests are deemed to have been successful.[139] The Nixon Administration did not publicly discuss these Soviet ASAT tests for several years; indeed, according to Stares, the first public official U.S. recognition of the Soviet system was not made until the Soviets were listed as having an "Orbital Antisatellite System" in a table for the FY 1972 congressional hearings.[140] The Soviets suspended their dedicated ASAT testing for slightly more than four years following their December 1971 test. The rationale behind this test hiatus remains unclear but undoubtedly relates to "a combination of budgetary, political, and technical factors."[141]

In February 1976, the Soviets resumed their dedicated ASAT testing, beginning a thirteen launch test series that lasted until June 1982.[142] This resumption of Soviet ASAT testing, coming on the heels of other evidence that the fruits of détente were less than originally expected, caused considerable consternation within the Gerald R. Ford Administration, especially after it recognized that the U.S. did not have a well developed policy towards ASAT or satellite survivability at this time.[143] Following a series of studies for the NSC staff and confirmation from DOD that their efforts to remedy U.S. satellite vulnerability had not proceeded very far, Ford issued NSDM-333 in the Fall of 1976.[144] NSDM-333 directed DOD to work harder to solve its satellite vulnerability problems and resulted in the creation of a separate Systems Program Office (SPO) for Space Defense Programs at the Space and Missile Systems Office (SAMSO) and in increased funding for these types of efforts.[145] The Buchsbaum Panel completed its report in late 1976 and concluded that a U.S. ASAT would not enhance the survivability of U.S. satellites by deterring use of the Soviet ASAT because the U.S. was more dependent upon space than the Soviets.[146] However, the report also concluded that a U.S. ASAT could be used to counter the threat to U.S. forces posed by Soviet space-based targeting systems and that the development of a U.S. system could serve as a "bargaining chip" in possible U.S.-U.S.S.R. ASAT arms control negotiations.[147] In one of the final acts of his presidency, on 18 January 1977 Ford signed NSDM-345, which directed the DOD to develop an operational ASAT system.[148] This directive initiated the miniature homing vehicle (MHV) ASAT program described below.

The 1978-79 ASAT Negotiations. The Carter Administration arrived in Washington imbued with a Wilsonian sense of idealism and convinced that the Cold War and the nuclear arms race could be ended. These sentiments motivated Secretary of State Cyrus Vance's journey to Moscow in March 1977 to present the Soviets with the administration's "comprehensive proposal" for strategic arms control. Just prior to Vance's journey, Carter publicly announced that the U.S. had already proposed ASAT negotiations to the Soviets and, at this same time, he secretly issued Policy Review Memorandum (PRM)-23 which directed the NSC Policy Review Committee (PRC) to "thoroughly review existing policy and formulate overall principles which should guide our space activities."[149] The Soviets soundly rejected the administration's comprehensive proposal but did agree to set up various working groups to discuss specific arms control issues, including one for ASAT issues.[150] Thus, early in his administration, Carter set the stage for the U.S. to pursue ASAT arms control and to review space policy comprehensively as called for by PRM-23.

Carter's two-track policy for simultaneously pursuing ASAT development and ASAT arms control began to take definite form by the Fall of 1977. The Vought Corporation was named prime contractor for the Air Force's Miniature Homing Vehicle (MHV) ASAT on 3 September.[151] The Decision Paper from PRM-23 was completed on 23 September. According to the later testimony of DDRE William Perry, the PRM Decision Paper required "that we seek a comprehensive ASAT agreement prohibiting testing in space, deployment and use of ASAT capability . . . ."[152] It soon became apparent, however, that there were major disagreements within the administration over ASATs. The primary battle lines were drawn between State and ACDA on the one hand and the JCS and OSD on the other with the former favoring a comprehensive ASAT ban and the latter looking to avoid such comprehensive measures and proposing "rules of the road" for space instead.[153] This considerable divergence of opinion was not resolved at the working group level and Carter apparently directed that a date be set for negotiations as a means to encourage compromises within the administration.[154] This tactic did not work and the U.S. delegation entered the first round of talks without a formal negotiating position.[155]

U.S. and Soviet negotiators met for three rounds of ASAT talks: 8-16 June 1978 in Helsinki, 23 January-16 February 1979 in Bern, and 23 April-17 June 1979 in Vienna. Apparently, the two sides were far apart on most issues during the first two sessions and by the third session the sides had drawn closer together but mainly by limiting the depth and scope of what they were trying to accomplish. Some of the controversies which have publicly emerged include debates over: an ASAT ban versus limitations or rules of the road; the degree of protection afforded to third-party satellites; long versus short testing moratoria; and how to deal with systems having residual ASAT capabilities—for example, the Soviets insisted that the U.S. Space Shuttle then under development be included as an ASAT system.[156] By the third session, both sides had apparently tabled draft agreements that only covered provisions on "no use" of ASAT weapons but even at this longest negotiating session they were unable to reach closure on this most basic issue.[157]

Both sides expected that the negotiations would continue but several factors intervened. Most importantly, President Carter and General Secretary Leonid I. Brezhnev signed the SALT II Treaty on 18 June 1979—from that point until the invasion of Afghanistan, the Carter Administration was consumed with attempting to get public support for and Senate advice and consent to ratification of the treaty and the ASAT negotiations along with many other issues were placed on the back burner. The breakdown of U.S.-U.S.S.R. relations following the invasion of Afghanistan and the arrival of the Reagan Administration with its initial lesser enthusiasm for arms control spelled the end of the ASAT negotiations.

These ASAT negotiations were the most militarily focused space-related arms control efforts of the Cold War era; as such, these negotiations offer important general lessons about ASAT arms control issues and the general prospects for space-related arms control. First and foremost, the failure to reach any agreement at these negotiations highlights the extreme conceptual and operational difficulties involved in attempting to reach a significant ASAT arms control agreement. The unresolved doctrinal conflicts regarding the military utility of space and the considerable overlap between civilian and military space systems and infrastructures contribute directly to the amorphous nature of military space issues and to the lack of clarity regarding the proper scope or object of ASAT arms control. ASAT arms control involves extremely difficult issues in many areas such as: whether the objective should be to ban the development and testing of dedicated ASAT systems or to create confidence- and security-building measures (CSBMs) such as rules of the road and keep out zones; conceptual and verification problems related to systems with significant residual ASAT capability and the significant military potential of even a few covert ASAT systems; and questions concerning whether the scope of the negotiations should cover some superpower satellites, all military satellites, or all (including third-party) satellites.

As Stares details, the failure of the 1978-79 ASAT negotiations also highlights difficulties with two-track approaches to arms control. Two-track approaches are seemingly attractive for dealing with divergent positions within an administration but they may actually impede progress towards eventual resolution of policy differences by creating committed constituencies behind each track that oppose the compromises that may be required to create coherent policy. Stares argues that the U.S. two-track approach to ASAT arms control legitimized and perpetuated the MHV ASAT system—a system which he believes had value only as a bargaining chip. Finally, the failure to reach an agreement also highlights what Ashton Carter refers to as the "basic paradox of ASAT arms control": the inverse relationship between ASATs and the incentive to place very threatening military systems in space.[158] Clearly, space weapons cannot be divorced from the natural offense-defense dialectic and the trade-offs inherent in all strategic thinking. Accordingly, analysts should consider not only the supposedly destabilizing effects of ASATs on stabilizing space systems such as those which provide the hotline, early warning, or NTM for arms control but should also consider the possibly stabilizing effects of ASATs in discouraging the development of potentially destabilizing space missions such as force targeting and space-to-Earth force application. This basic paradox, together with the major conceptual difficulties outlined above call into question the overall desirability of ASAT arms control.

ASAT Developments and Restrictions in the 1980s. The Reagan Administration's first space policy, National Security Decision Directive (NSDD)-42 issued on the 4th of July 1982, clearly moved the United States toward deploying ASATs:

> the U.S. national security space program would be guided by the following four policies: an emphasis on the survivability and endurance of all space system elements and "an aggressive, long-term program" to "provide more assured survivability"; the development of an operational ASAT system capable of deterring threats to U.S. space systems and denying enemy space-based force enhancement capabilities; a program to "develop and maintain an integrated attack warning, notification, verification, and contingency reaction capability" to detect and react to threats to U.S. space forces; and maintenance of appropriate security classifications for space systems in accordance with Executive orders and applicable directives.[159]

By this time the MHV ASAT system had taken a definitive shape.[160] After considering several basing modes, the Air Force decided on an air-launched version of this system and developed plans to modify 40 F-15 fighters as ASAT launch platforms.[161] The ASAT weapon consisted of three parts: the first stage was a modified Boeing short-range attack missile (SRAM), the second stage a Vought Altair III booster, and the final stage was the MHV itself. The MHV was a small KEW about the same size as a juice can (12 by 13 inches) that used eight cryogenically cooled infrared telescopes to acquire its target and several dozen small solid rocket thrusters designed to align the MHV laterally on course to its target.

Meanwhile, Soviet ASAT testing and ASAT arms control proposals continued. In January and March 1981, the Soviets tested their dedicated co-orbital ASAT system with the former being an unsuccessful test of their newer optical-thermal guidance system and the latter being a successful test of their older radar guidance system.[162] Then, on 18 June 1982 the Soviets conducted their last unambiguous ASAT test as a part of a major strategic forces exercise.[163] The Soviets were also busy on the ASAT arms control front during this period. On 20 August 1981, Soviet Foreign Minister Anrdei A. Gromyko submitted a “Draft Treaty on the Prohibition of the Stationing of Weapons of Any Kind in Outer Space” to the UNGA. Overall, this draft treaty contained a number of significant conceptual shortcomings including a failure to define adequately the types of weapons which would be covered under its terms, a lack of any coverage for ground-based ASAT weapons, and the apparent sanctioning of the use of force against space objects which a State Party to the treaty determines are not in accordance with the provisions of Article 1 of the treaty.[164]

During the Summer of 1983, the Soviets initiated a second and more comprehensive ASAT arms control offensive which was undoubtedly designed, at least in part, to strengthen domestic U.S. anti-ASAT forces in Congress and elsewhere. On 19 August 1983, Soviet General Secretary Yuri V. Andropov informed a group of U.S. Senators visiting Moscow that the U.S.S.R. would not “be the first to put into outer space any type of antisatellite weapon” and would impose “a unilateral moratorium on such launchings” so long as other countries “will refrain from stationing in outer space antisatellite weapons of any type.”[165] The following day, Gromyko introduced a second draft treaty at the UN. The second draft treaty was a considerable improvement over the first draft in that it was more comprehensive and used more precise language. However, the Reagan Administration remained quite cool to these Soviet initiatives and still did not seek ASAT negotiations; the administration cited significant difficulties including problems with the U.S. ability to verify the apparent Soviet offer to dismantle their existing co-orbital ASAT system, more general verification issues, and the continuing problem of the significant residual ASAT capabilities of both sides.[166] Thus, while these Soviet draft treaties did not serve as the direct basis for reopening U.S.-U.S.S.R. ASAT arms control negotiations, they were certainly important in conditioning the general arms control setting at this time. Superpower ASAT negotiations were restarted in March 1985 as a subset of the broad Defense and Space Talks.[167]

High-level political forces within the United States also interacted with these Soviet initiatives to fundamentally shape the MHV ASAT program during the mid-1980s. Varying types of congressional restrictions on the MHV ASAT program began in 1983 and continued throughout the next five years. Senator Larry Pressler (D.-SD) called the first major hearing on this issue on 20 September 1982.[168] ACDA Director Eugene Rostow and UDRE Dr. Richard D. DeLauer were the principal witnesses at this hearing. In making his case for a measured approach towards ASAT arms control, Director Rostow highlighted the threat posed to U.S. forces by Soviet space systems, the need for a U.S. ASAT to address the current asymmetrical situation and as a possible "inducement for the Soviet Union to explore constructive limits on space weapons[.]", and the difficulties in verifying ASAT arms control.[169] Further hearings on ASAT and related issues were called in April and May of 1983.[170] These hearings were primarily designed to build support within Congress for Senator Pressler's "sense of the Senate" Resolution 43 and Senator Tsongas's Joint Resolution 28. Joint Resolution 28 was more comprehensive and indicated:

That the president shall resume immediately bilateral talks with the Soviet Union for the purpose of negotiating a comprehensive treaty prohibiting

> (1) the testing, production, deployment, or use of any space-based, air-based, or ground-based weapons system which is designed to damage, destroy, or interfere with the functioning of any spacecraft of any nation; and
>
> (2) the stationing in orbit around the Earth, on any celestial body, or at any other location in outer space of any weapon which has been designed to inflict injury or cause any other form of damage on the Earth, in the atmosphere, or on objects placed in space.[171]

By this time a combination of factors including President Reagan's "star wars" speech, the impasse in superpower arms control and the general worsening of U.S.-U.S.S.R. relations, as well as the growing strength of the nuclear freeze movement was pushing the Senate towards the belief that it had to act firmly and rapidly to preserve space as a sanctuary free from further ASAT developments. On 18 July 1983, Senator Tsongas's amendment to the FY 1984 DOD Authorization Act was approved. The Tsongas amendment withheld DOD funds for testing the MHV ASAT system unless the president certified both that the U.S. was negotiating with the Soviets in good faith on this issue and that such testing was in the interests of U.S. national security.[172] The House Appropriations Committee went even further and withheld $19.4 million in FY 1984 advanced procurement funds from the MHV ASAT; following intense administration lobbying, the conference with the Senate restored this funding with the proviso that the administration provide Congress with a report on U.S. ASAT policy by 31 March 1984.[173]

The Reagan Administration mounted some efforts to counter these congressional restrictions on testing the MHV ASAT system. The "Report to Congress: U.S. Policy on ASAT Arms Control" delivered to Congress on 31 March 1984 raised several questions concerning the basic strategic utility of an ASAT ban and strongly reiterated the administration's many concerns with ASAT arms control.[174] The report detailed more than four pages of "Problems Facing ASAT Arms Control" and summarized the current situation facing U.S. space systems as follows:

> Deterrence provided by a U.S. ASAT capability would inhibit Soviet attacks against U.S. satellites, but deterrence is not sufficient to protect U.S. satellites. Because of the potential for covert development of ASAT capabilities and because of the existence of non-specialized weapons which also have ASAT capability, no arms control measures have been identified which can fully protect U.S. satellites. Hence, we must continue to pursue satellite survivability measures to cope with both known and technologically possible, yet undetected, threats.[175]

In hearings on the FY 1985 DOD appropriations, Air Force Under Secretary Pete Aldridge allowed that the Air Force did have "some concerns" with the Tsongas and the McHugh amendments.[176] Despite this rather limited and unenthusiastic Air Force support for removing the congressional restrictions on MHV ASAT testing, the administration was successful during the Summer of 1984 "in preventing further limitations on US ASAT testing and also managed to water down the restrictive language of the Tsongas Amendment."[177]

The lessening of these restrictions was important in allowing MHV ASAT testing to continue during 1985. The most complete test of this system took place on 13 September 1985 when the MHV successfully intercepted and destroyed Air Force satellite P78-1.[178] Although it was not clear at the time, this proved to be the only MHV ASAT test against a satellite in space. In December, an amendment sponsored by Representatives Norman D. Dicks (D.-WA) and Les AuCoin (D.-OR) banned testing of the U.S. MHV ASAT against objects in space unless the President certified that the Soviets had violated their moratorium by conducting a dedicated ASAT test.[179] This restriction gave the Soviets, who had developed two types of guidance systems and conducted at least 20 tests in space of their dedicated co-orbital ASAT system between 1968-1982, a virtual veto over further U.S. testing of its MHV ASAT. In February 1986, the Air Force developed a plan to skirt this congressional restriction on testing against objects in space by testing the MHV's ability to lock onto the heat of a distant star.[180] On 22 August and 30 September, the Air Force conducted two "successful" ASAT tests in space against the infrared energy of stars under the interpretation of the congressional restriction it had developed in February.[181]

Despite continuing controversy and administration efforts to ease testing restrictions, Congress imposed similar bans on testing the MHV unless the Soviets tested first during FY 1987 and 1988 as well.[182] By this time, these testing restrictions combined with major funding cutbacks were starting to have a very serious impact on the prospects for completing the testing and development of the MHV system.[183] At a news conference on 10 March 1987, Secretary Weinberger announced plans to resume MHV testing against points in space during the last quarter of 1988 as one part of a three-part plan to enhance U.S. ASAT capabilities and field operational systems by the early 1990s.[184] At this same conference, Air Force Brigadier General Robert R. Rankine, Jr., Director of Space Systems in the Air Force Research Development and Acquisition Office, discussed plans to study a new ground-launched ASAT system which would double the range of the MHV.[185] Most significantly, however, Rankine appeared to contradict Weinberger's earlier statement about the value of resumed MHV testing by indicating that the program had "reached the point where it is 'not meaningful' to proceed unless tests can be conducted against space targets."[186] In December 1987, the Air Force, publicly citing continuing congressional testing restrictions for FY 1988 and the need to cut the DOD budget, proposed cancellation of the MHV ASAT program.[187] Following the lifting of congressional ASAT testing restrictions for FY 1989, in December 1989 the Army took the lead in developing a new U.S. ASAT system.[188]

In retrospect, it is very revealing to analyze the role of DOD and especially the Air Force in attempting to sell the MHV ASAT to Congress and in attempting to overturn the congressional restrictions on this system. The strength of these efforts should provide an excellent indication of the doctrinal importance of an operational ASAT system to DOD and the Air Force. In this regard, it is immediately apparent that neither DOD nor the Air Force mounted anything near an all-out effort to sell the MHV ASAT or to remove the congressional restrictions on this system. Granted that the ASAT was not a large program in comparison with many other important and troubled programs of this era and that many broader strategic concerns during this volatile time were more important, it is nonetheless remarkable how little overall support the MHV ASAT received from the Pentagon. Even more telling is the fact that the MHV generally received its strongest Pentagon support from the civilian defense officials of OSD and the Office of the Secretary of the Air Force rather than from the uniformed military. Generally, DOD officials did not mention the MHV forcefully or often during the mid-1980s.[189] Overall, the MHV received even less support from Air Force organizations at this time. Indeed, at times it would have been difficult determining that the MHV ASAT was an Air Force program. Under Secretary Aldridge's 1984 testimony noting his limited concerns with the Tsongas and McHugh amendments was already discussed above. During 1985 and 1986, neither the Office of the Secretary of the Air Force, AFSPACECOM nor USSPACECOM mounted effective campaigns on behalf of the MHV or the general need for U.S. space control capabilities.[190] The course of ASAT developments during this period again clearly demonstrates that, for this issue in particular, civilian defense decision-makers were dominant over the military and that perceptions of national security rather than organizational behavior shaped these developments.

Recent Space-Related Arms Control Developments

With the end of the Cold War, many formal arms control efforts have been deemphasized and most space-related arms control efforts are no exception. There have been, nonetheless, some very important space-related provisions in recent treaties and agreements. Moreover, the recent growth in commercial space activity undoubtedly creates an opportunity if not a need for expanded regulation and control in this area. This section briefly reviews some of the most important recent developments.

START I and II. The 1991 Strategic Arms Reduction Treaty I (START I) is a bilateral treaty between the United States and Soviet Union designed to reduce the number of deployed strategic offensive arms (warheads and delivery vehicles) maintained by each.[191] Several of the broad provisions in START I build on previous arms control treaties. For example, START I repeats the NTM provisions first contained in the ABMT but also relies on extensive OSI verification protocols to assure compliance.[192] In addition, START I strengthens the OST prohibition on the placement of weapons of mass destruction in outer space. Article V, Paragraph 18 of the Treaty prohibits each party from producing, testing, or deploying systems, including missiles, for placing nuclear weapons or any other kinds of weapons of mass destruction into Earth orbit or a fraction of an Earth orbit.[193] This is an important provision designed to ban fractional orbital bombardment systems (FOBS) such as the one successfully tested by the Soviet Union from 1965 to 1971.[194]

START I has many new implications for military space operations as well. There are several restrictions on the use of ICBMs or Submarine Launched Ballistic Missiles (SLBMs) as space launch boosters. For example, the Treaty places restrictions on the number, type and location of ICBMs and SLBMs used to boost objects into the upper atmosphere or space, and limits the number and location of space launch facilities used to support such launches.[195] Objects launched by ICBMs or SLBMs into the upper atmosphere or space are also subject to the Treaty's telemetry requirements. In a major departure from past practice, the treaty requires the party conducting any peacetime launch of an ICBM or SLBM to make on-board technical measurements, broadcast all telemetric information obtained from such measurements in a way that allows full access to the information, and then provide a recording and analysis of that data to the other party. For objects delivered by ICBMs or SLBMs into the upper atmosphere or space, the telemetry provisions only apply until the object(s) being delivered either are in orbit or have achieved escape velocity.[196] Furthermore, advance launch notification must be made to the other treaty party whenever an ICBM or SLBM is used as a booster for delivering objects into the upper atmosphere or space. Such notification is provided in accordance with the provisions of START I and the Ballistic Missile Launch Notification Agreement.[197] START I might also affect on-going space control and force application initiatives. For example, if the planned Space Operations Vehicle was designed with a conventional strike capability, it might be held accountable under START I limitations on heavy bombers equipped for nuclear armaments other than long-range nuclear air launched cruise missiles. No exhibition would be required but the vehicle's distinguishing features would be listed in the START Memorandum of Understanding. In addition, the facility where the vehicle is based would have to be declared as a heavy bomber base but would not be subject to inspection unless it contained a weapons storage area. A determination of treaty applicability, if any, would be subject to discussion between the parties.[198]

The 1993 Strategic Arms Reduction Treaty II (START II) between the United States and Russia further reduces the number of deployed strategic offensive arms mandated by START I. All of the provisions of START I applicable to outer space described above also apply to START II. This treaty is not yet in force and it currently appears unlikely that it will come into effect anytime soon.[199] A number of major issues currently weigh against START II entering into force or even necessarily serving as the basis for further negotiations including: level at which the "floor" for deployed strategic offensive arms should be set, the proper relationship between strategic offensive and strategic defensive force in President Bush's "new framework," and the Bush Administration's seemingly limited enthusiasm for formal arms control.

Finally, in addition to the notifications required by the START Treaties and the Ballistic Missile Launch Notification Agreement, the United States and Russia have recently signed two new agreements expanding launch notifications to include all space launch vehicles. On 4 June 2000 at the Moscow Summit, President Clinton and Russian President Putin signed a memorandum of agreement to establish a joint data exchange center (JDEC) in Moscow to share early warning information on missile and space launches.[200] Once the JDEC is completed and commences operations, the two countries are supposed to exchange information obtained from their respective ground and space-based early warning systems on U.S. and Russian space launches (with rare exceptions) including time of launch, generic missile class, geographic area of the launch, and launch azimuth. Eventually this exchange of data will also include data sharing on detected space launches of other states. On 16 December 2000 U.S. Secretary of State Madeline K. Albright and Russian Foreign Minister Igor Ivanov signed a memorandum of understanding establishing a Pre- and Post-Launch Notification System (PLNS) for launches of ballistic missiles and, with rare exceptions, space launch vehicles, identifying launch window, time of launch, generic missile class, geographic area of the launch, and launch azimuth.[201] The PLNS Information Center will be an Internet-based system operated as part of the JDEC. Both agreements provide for the voluntary notification of satellites forced from orbit and certain space experiments that could adversely affect the operation of early warning radars, and both agreements leave open the possibility of negotiations on future data sharing on missiles that intercept objects not located on the Earth's surface. The JDEC and PLNS are among the most detailed and comprehensive space-related CSBM ever negotiated. They are designed to enhance stability by limiting flexibility and clandestine operations. The wide spectrum of opinion on the utility of these latest agreements is another excellent illustration of how fundamental disagreements on military space strategy can color all subsequent analysis.[202]

CONTENTIOUS AREAS FOR SPACE-RELATED ARMS CONTROL AND REGULATION TO 2015

The final section of this essay addresses five space-related areas that contain significant conflict today and are likely to remain contentious into the future. The foundation for the analysis in this section was laid by the discussion in many of the issue-areas above and builds on the arms control and regulation analysis already presented. It uses politics and technology as the two primary dimensions for analysis of potential avenues for space-related arms control and regulation.

In general and to the extent possible, most space policies and regulation should be directed towards maximizing the development of robust competition and open markets. This approach will help commercial space grow as quickly as possible and provide spillover benefits to all space sectors. But mature space industries and space markets in all parts of the commercial space sector will not simply spring forth fully formed, as did Athena from the head of Zeus. There will be many opportunities and requirements for the United States and other major space actors to use a variety of tools to shape commercial space and its interaction with the other space sectors. Security considerations should predominate in the defense and intelligence space sectors, and there are also some relatively limited areas within the commercial sector where national security considerations should trump economic concerns. Moreover, the increasing interdependence of the four space sectors due, primarily, to the growth in the commercial space sector now makes crafting enlightened and useful arms control and regulation an increasingly challenging task.

Were it possible, it would undoubtedly be preferable to jump straight to 2015 and discuss the potential utility of various arms control and regulation regimes for the projected global space security environment. If the discussion above shows anything, however, it is that such a leap forward would be an act of hubris and would likely end up being counterproductive. Our vision ahead is limited because the global security implications of space are so complex, multidimensional, and volatile. Moreover, the security implications of the burgeoning commercial space sector throw a novel element into the mix that carries with it compressed timelines for decision-making, new actors, new technologies, and untested markets. Accordingly, this essay inductively builds on today's controversies to analyze areas where space-related arms control and regulation will be most needed rather than deductively speculating about the space security environment of 2015 and how it might be controlled.

Space Weaponization

At a fundamental level, virtually all issues of space strategy turn on broad questions related to weaponizing space such as whether space will be weaponized, how that might happen, which states and other actors might be most interested in leading or opposing weaponization, and how any of these space weaponization issues might best be controlled. At the political level, there is, of course, a broad spectrum of opinion on these issues but most of the major tenets in mainstream views on weaponizing space can usefully be grouped into four major camps: space hawks, inevitable weaponizers, militarization realists, and space doves.[203] Each of these camps is described below and they are used to analyze sources of support or opposition for attempts to control space weaponization.

Space Hawks. Adherents to this camp believe that space already is or holds the potential to become the dominant source of military power. Accordingly, they advocate that the United States move quickly and directly to develop and deploy space weapons in order to control and project power from this dominant theater of combat operations. According to Senator Bob Smith (R-NH), for example, the concerted development of American space weapons "will buy generations of security that all the ships, tanks, and airplanes in the world will not provide. . . . Without it, we will become vulnerable beyond our worst fears."[204] In addition, space hawks often point to space-based BMD as a potentially decisive weapon capable of fundamentally reordering the strategic balance. Space Hawks tend to oppose virtually all space-related arms control or regulation because of its potential to slow or derail rapid and direct space weaponization by the United States.

Inevitable Weaponizers. This group believes that space, like all other environments man has encountered, will eventually be weaponized. They differ from space hawks in two important ways: they are not convinced that space weaponization would be beneficial for U.S. or global security and they are unsure that space will prove to be the decisive theater of combat operations. The Space Commission report is a good example of this camp: "we know from history that every medium—air, land and sea—has seen conflict. Reality indicates that space will be no different. Given this virtual certainty, the U.S. must develop the means both to deter and to defend against hostile acts in and from space."[205] Inevitable weaponizers take a nuanced view of space arms control and regulation. They generally support CSBMs and other mechanisms designed to slow military competition and channel it in predictable ways. But they are less supportive of broad efforts to ban space weapons because they see them as futile or even dangerous due to their potential to lull the United States into complacency or otherwise cause it to be outmaneuvered by states that successfully circumvent space weaponization accords.

Militarization Realists. Members of this camp oppose space weaponization because they believe U.S. security interests are best served by the status quo in space. They believe that the United States has little to gain but much to lose by weaponizing space because it is both the leading user of space and, enabled by this space use, the dominant terrestrial military power. Militarization realists also believe that if the United States takes the lead in weaponizing space, it would become easier for other states to follow due to lower political and technological barriers. For these reasons, militarization realists believe that "fighting *into* space looks feasible and we should plan for the eventuality. Fighting *in* space shows little promise, while fighting *from* space looks impractical for the foreseeable future, with or without treaties."[206] Militarization realists support space-related arms control and regulation that precludes other states from weaponizing or even militarizing space. Most of them believe, however, that this support must be balanced against the increased attention that formalized arms control efforts could draw to the United States' already formidable space-enabled force enhancement capabilities and the political, military, and arms control fallout this increased scrutiny might cause.

Space Doves. Finally, a wide range of organizations and viewpoints can be grouped together in the space dove camp because they all oppose space weaponization for a variety of reasons including moral, arms control, conflict resolution, stability, and ideology arguments. Most space doves also oppose any militarization of space beyond the limited missions they see as stabilizing—NTM, early warning, and hotline communications—because they see any military missions beyond these as the "slippery slope" to space weaponization. Most space doves emphasize how destabilizing most space militarization and all space weaponization would be. "Unlike the strategy for nuclear weapons, there exists no obvious strategy for employing space weapons that will enhance global stability. If the precedent of evading destabilizing situations is to continue—and that is compatible with a long history of US foreign policy—one ought to avoid space-based weapons."[207] They also highlight the deep roots of President Eisenhower's "space for peaceful purposes" policy and argue that, especially in the post-Cold War era, there is no rationale for space weaponization that is strong enough to overturn the basic strategic logic America developed at the opening of the space age. Space doves support space arms control and regulation more strongly than any other camp. Since they do not believe the United States (or other states) would reap strategic benefits from weaponizing space, they are not overly concerned about the numerous arms control challenges identified by the other camps. Moreover, like Stares, most space doves would not support using two track approaches to space arms control.

Given the divergent perspectives on space's strategic utility and the role for space arms control and regulation contained within the four camps, there is, at the political level, no clear path forward for the United States. No clear path emerges when using Allison's rational actor (Model I) lens.[208] Likewise, moving down the ladder of abstraction to Allison's Models II and III by acknowledging the multiplicity of organizations and individuals that contribute to the pulling and hauling of governmental decision-making within a pluralist democracy such as the United States does not highlight a vector for space arms control. Clearly, it would be formidable challenge to provide enough incentives and assemble coalitions capable of pushing any camp's preferred vision for space arms control forward. In this context, it seems quite unlikely that the United States can or will provide strong or consistent leadership for space arms control and regulation. It is more likely that the United States would move forward in response to external space arms control initiatives or trigger events related to the weaponization of space.[209]

On the technical side of the equation, space arms control and regulation designed to control the weaponization of space faces all of the problems that plagued attempts to develop arms control in this area in the past. The most serious of these problems include: disagreements over the proper scope and object of negotiations; basic definitional issues about what is a space system and how they might be categorized as offensive or defensive and stabilizing or destabilizing; and questions concerning how any agreement might be adequately verified. These problems relate to a number of very thorny specific issues such as whether the negotiations should be bilateral or multilateral, what satellites and other systems should be covered, and whether the object should be control of space weapons or CSBMs for space; questions concerning which types of CSBMs such as rules of the road or keep out zones, for example, might be most useful and how these might be reconciled with existing space law such as the OST; and verification problems such as how to address residual ASAT capabilities or deal with the significant military potential of even a small number of covert ASAT systems. New space system technologies, the growth of the commercial space sector, and new verification technologies interact with these existing problems in complex ways. Some of the changes would seem to favor arms control and regulation, such as better radars and optical systems for improved space situation awareness and verification, technologies for better space system diagnostics, and the stabilizing potential of microsatellite-based redundant and distributed space architectures. Many other trends, however, would seem to make space arms control and regulation even more difficult. For example, microsatellites might be used as virtually undetectable active ASATs or passive space mines; the proliferation of space technology has radically increased the number of significant space actors and these ranks now include a number of non-state actors; and growth in the commercial space sector raises issues such as how quasi-military systems should be protected or negated and the unclear security implications of emerging markets for dual-use systems. Cumulatively, just as with the political factors listed above, it seems doubtful that there are many technical factors that will advance space arms control and regulation designed to control space weaponization significantly through 2015.

High-Altitude Nuclear Detonations (HAND)

The threat caused by HAND is sufficiently different and potentially damaging that it warrants discussion and analysis separate from the broad space weaponization issues raised above. Just one such detonation holds the potential to disable *all* non-hardened Low-Earth Orbit (LEO) satellites. Today, these assets are worth tens of billions of dollars; this class of assets is very likely to be worth far more by 2015; and this threat poses daunting detection, deterrence, and defense challenges—not least of which is the fact that such an attack would take place outside the sovereign jurisdiction of any state and not directly kill a single person.[210] As such, HAND is a unique asymmetric threat that is the single "most potentially disruptive and dangerous possibility."[211] This section first briefly examines the nature of the threat and then discusses potential technical and political responses.

HAND can destroy or disrupt LEO satellites in two primary ways. First, prompt X-rays can upset or burnout the electronics for the five to ten percent of each LEO constellation within line of sight of the explosion.[212] Second, in weeks to months, potentially all non-hardened LEO satellites can fail due to the cumulative effects of phenomena such as transient-radiation effects on electronics (TREE) and system generated electromagnetic pulse (SGEMP) as the satellites operate in the greatly increased radiation belts the explosions cause in LEO orbits.[213] One of the largest problems, however, in assessing the specific level of threat posed by HAND is a lack of experimental data on the effects of HAND on satellites (especially on modern satellite systems) and this contributes to a range of assessments concerning the severity of the threat.[214] The United States conducted two high-altitude nuclear test series before such testing was banned by the LTBT; the tests were conducted in

August and September of 1958 and again during the Summer and Fall of 1962.[215] The ARGUS series was designed to test and did confirm the theory of Nicholas Christofilos of the University of California's Radiation Laboratory that the high-energy electrons produced in a high-altitude explosion would become trapped in the Earth's magnetic field.[216] As predicted, these trapped particles do "pump" up the radiation belts through which LEO satellites pass during each orbit and slowly build a potentially fatal radiation dose for the satellite's electronics. The good news is that satellites can be hardened against nuclear effects including TREE and SGEMP. According to the HALEOS study: "sufficient hardening to survive HAND-induced total radiation dose could **add 2-3 percent to satellite costs** beyond what is required to harden against the natural environment."[217]

What are the best technical and political options for the United States to mitigate the risks associated with HAND? Watts is surely correct is his assessment that "for the next 15-20 years, the most sensible stratagem for preventing an exo-atmospheric nuclear detonation is a combination of deterrence and hardening the satellites themselves."[218] These two best options are emphasized below. However, as with the other most difficult security challenges such as counterproliferation or the other most challenging space cases discussed below, a comprehensive, layered, and synergistic approach to this threat would seem to offer the best prospects for success. For these cases, the United States should pursue a range of policies designed to move up the escalatory ladder from denial, to reassurance and dissuasion, cooperative and involuntary reversal, deterrence, passive and active defenses, through counterforce operations including preemptive strikes.[219] For HAND more specifically, the United States should begin by continuing its arms control efforts such as the Non-Proliferation Treaty (NPT) and Missile Technology Control Regime (MTCR) designed to deny potential adversaries the tools necessary to carry out a HAND. It should reassure and dissuade these actors by attempting to imbed them in the global information infrastructure by sharing the fruits of LEO architectures (perhaps by cross-subsidies, as required) and by positive and negative security assurances.[220]

Moving up the ladder, the United States may, unfortunately, face very difficult challenges in the areas of deterrence, passive and active defense, and counterforce. Deterrence may be strengthened because it would be very difficult to launch a HAND without attribution in almost all scenarios; but deterrence could be undermined because the attack takes place outside U.S. territory and does not directly kill anyone so it might not generate support for a swift and sure response. Unambiguous declaratory policy statements that the United States will respond forcefully to any purposeful interference with its space systems might strengthen deterrence but there are a number of specific crosscutting issues associated with this problem such as how best to deter attacks on multinational and commercial systems.[221] Through 2015, the potential for active defense against HAND is extremely limited due to the nature of the threat and the defensive technologies available. Active defenses would have just a fleeting moment in which to operate because of the very limited flight time of a HAND booster (a couple of minutes at most), they would somehow have to discriminate between HAND-weapon launches and all other launches within this fleeting window, and, to be effective, would need to be 100 percent successful since leakage of even one can spell the end for all non-hardened LEO satellites. Likewise, the prospects for the United States carrying out a preemptive strike on a HAND weapon prior to launch are minimal. Not only would the preparations for such a strike require breathtakingly prescient intelligence data, but also, and perhaps more significantly, carrying out a preemptive strike would require a level of political will the United States has seldom displayed in the past.

Hardening of LEO satellites to withstand HAND-induced radiation stands out as one of the least costly and potentially effective means of addressing this threat. It is not a panacea but, according to Wilson, "[h]ardening of a space system's elements is the single most effective survivability measure."[222] Most military satellites are already hardened against nuclear effects so the real issue comes down to hardening civil and commercial systems and, even more specifically, how to create incentives or requirements for civil satellites to be hardened. As mentioned above, the HALEOS study indicates that satellites can be hardened against TREE and SGEMP upset for approximately 2-3 percent of program costs above the hardening required for natural radiation.[223] This is a significant additional expense for commercial space businesses, but it is not so large that the United States should not consider making it a routine part of the costs of doing business in space. United States should carefully consider making radiation hardening to this level a requirement to obtain a "Spaceworthiness License" and requiring this license for all commercial space components that bid in FCC spectrum auctions, apply for export licenses, or compete for government business. Deterrence and especially hardening of LEO satellites offer the best possibility to mitigate against a nuclear terrorism attack in which just one weapon could ruin the global information infrastructure and destroy tens of billions of dollars of space systems, yet not take place on U.S. soil or kill anyone directly.

High-Resolution Commercial Remote Sensing

High-resolution commercial remote sensing is an evolving, complex issue area that requires carefully considered arms control and regulation in order to balance several interdependent goals.[224] High-resolution commercial imagery creates opportunities and risks across a wide range of diplomatic, military, economic, and political considerations. Among the largest considerations are: how these systems contribute to global transparency and the implications of a more transparent world; economic competition and the viability of the high-resolution commercial remote sensing industry worldwide; competition from other remote sensing providers and the quality, timeliness, and types of products offered by space-based systems; the optimal mix between commercial and government systems; and mechanisms for controlling and regulating this industry.

Following the end of the Cold War, the United States completely reoriented its policy on high-resolution commercial remote sensing away from the secret spysat regime crafted by the Eisenhower Administration at the opening of the space age. Under the Land Remote Sensing Policy Act of 1992 and Presidential Decision Directive (PDD)-23 of March 1994, it is now the policy of the United States to create incentives to develop a high-resolution commercial remote sensing industry. By attempting to dominate this market worldwide, the U.S. hopes to preserve its defense industrial base and workers trained in this sector, leverage commercial systems for government uses, and shape global standards on acceptable use via mechanisms such as shutter control. This section explains how the provisions of PDD-23 such as shutter control are designed to operate, briefly outlines the strategic implications of these systems, and then discusses additional control and regulatory mechanisms the United States should consider.

Presidential Decision Directive 23. PDD-23 is designed to balance economic considerations with national security concerns. It includes a number of specific restrictions on high-resolution commercial imagery systems and data. For example, licensees must:

- Maintain a record of all satellite taskings for the previous year and allow the USG access to this record.
- Refrain from making changes to satellite operational characteristics without formal approval from the Department of Commerce.
- Limit data collection and distribution when the Secretaries of Defense or State determine that national security, international obligations, and/or foreign policy may be compromised. The actual decision to limit data will be made only be the Secretary

of Commerce in consultation with the Secretaries of Defense and State. (This restriction is known as shutter control).

- Use only USG approved encryption devices for the purpose of denying unauthorized access to others during periods when national security, international obligations, and/or foreign policy may be compromised. The data downlink format must allow USG data access during these periods.
- Notify the USG in advance of intent to enter into significant or substantial agreements with new foreign customers.

In addition, PDD-23 allows for the transfer of "turnkey" advanced capability U.S. remote sensing systems on a case-by-case basis, subject to significant diplomatic steps that may include a formal government-to-government agreement. The most stringent restrictions are placed on the sale of sensitive components, subsystems, and information on the U.S. Munitions List for U.S.-unique remote sensing capabilities. These transfers will be made only on the basis of a government-to-government agreement.[225]

The provisions of PDD-23 are potentially a significant control mechanism for limiting the amount of data available to states, groups, and individuals with ill intent. However, the old adage that "the devil's in the details" has never been truer than in this case. How the many gray areas within PDD-23 are adjudicated and resolved—especially as precedents are set with the first test cases—remains to be seen and will largely determine the efficacy of the policy in meeting its stated objectives. Some of the most obvious gray or potentially divisive areas within PDD-23 include: how periods when "national security, international obligations, and/or foreign policy may be compromised" will be identified and the specifics of how shutter control will be implemented; how "significant or substantial agreements with new foreign customers" will be identified and regulated; the dynamics and effectiveness of the specific internal mechanisms that are created by the Departments of State, Defense, and Commerce; and, perhaps most importantly, how the global market will react to all of the above. The United States has not yet exercised shutter control. It is likely that critical precedents will be set in these and other gray areas within the next few years because two separate one-meter resolution systems, SpaceImaging's Ikonos 2 and ImageSat's EROS 1A, are already operational and several other high-resolution systems are scheduled for launch soon.

Strategic Implications of High-Resolution Commercial Imagery. Like most dual-use technologies, high-resolution commercial remote sensing holds both beneficial and threatening potential. By increasing transparency, these systems should help to dampen the security dilemma by illuminating the actual force levels of states and they should also help to increase stability by revealing preparations for an attack. Conversely, by pinpointing potential targets, such systems may create incentives for preemption—especially by states that possess highly accurate, long-range weapons. The utility of actually attacking following a planned exercise or during crisis demobilization also would seem to be increased. Paradoxically, the amount of data available from proliferated commercial imagery systems might actually place even greater value on the type of information usually only available from human intelligence (HUMINT) sources—the intentions of potential adversaries. In addition, this technology can empower non-state actors and provide them with information to support a wide variety of goals.

Two recently released congressionally mandated studies reemphasize the implications of high-resolution commercial remote sensing for the intelligence community (IC). Many of the findings and recommendations from the commissions studying the NRO and NIMA go well beyond those in the Air Force's Commercial Space Opportunities Study (CSOS) by placing a great deal of emphasis on commercial imagery and the IC tasking, processing, exploitation, and dissemination (TPED) process. According to the NRO Commission report, for example, the USG: "could satisfy a substantial portion of its national security-related imagery requirements by purchasing services from" U.S. firms; it "must" develop a "clear national strategy that takes full advantage of the capabilities of the U.S. commercial satellite imagery industry;" and it should create a system similar to DOD's industrially funded airlift account to help efficiently focus government systems "on targets where their unique capabilities in resolution and revisit times are important, while commercial systems would be used to provide processed 'commodity' images."[226]

The NIMA Commission report goes even further. It found the IC to be "collection centric," "that NIMA was not a good, dependable business partner," and recommended creating a "central commercial imagery fund" to help mitigate problems resulting from the fact "that national technical means (NTM) imagery appears to be 'free' to government agencies, while use of commercial imagery generally requires a distressingly large expenditure of (largely unplanned, unprogrammed) O&M [operation and maintenance] funds."[227] The commission recommended that the central commercial imagery fund start at about $350 million annually for "raw imagery and vendor's value-added offerings."[228] They expect that this figure will rise substantially throughout the FYDP, and were very "distressed by an announcement promising $1 billion for commercial imagery purchase, which subsequently proved to be so much fiction."[229] The NIMA Commission saved its harshest critique for NIMA's TPED shortcomings. These shortcomings "increasingly strains at the fabric of the NIMA organization as a whole" and undermine confidence "that NIMA currently has the system engineering experience, acquisition experience, appropriate business practices, and performance measures" to acquire a cutting-edge TPED system.[230] The commission concludes that NIMA's TPED efforts simply cannot "get there from here" and recommends:

> creation of an Extraordinary Program Office (EPO) armed with special authorities of the Director of Central Intelligence and the Secretary of Defense, augmented by Congress, and staffed beyond ceiling and above "cap" through an heroic partnership between industry, NIMA, and the NRO. The EPO, to be constituted within NIMA from the best national talent, shall be charged with and resourced for all preacquisition, systems engineering, and acquisition of imagery TPED—from end to end, from "national" to "tactical." The first milestone shall be completion of a comprehensive, understandable, modern-day "architecture" for imagery TPED. Other provisions of law notwithstanding, Congress shall empower the Director of the EPO to commingle any and all funds duly authorized and appropriated for the purpose of the "TPED enterprise," as jointly defined by the Secretary of Defense and the Director of Central Intelligence.[231]

High-Resolution Commercial Imagery and Deception. Digitized data streams designed to produce imagery are ideally suited for deception. This is because digitized data must always be mathematically processed to create images and this processing is subject to manipulation in a variety of ways—many of which are not available for manipulating film images. As Steven Livingston explains:

> Mathematically altering the value of the pixels alters *seamlessly* the representation. "Since it is purely a mathematically process, the source images can be altered fundamentally and undetectably before and/or during their production." Elements can be added or subtracted, changed in color, brightness, or contrast. Changes are made not by altering the computer code that produces the image, and not in the image itself as in analog manipulation. In fact, it is more accurate perhaps to say that no image exists beyond the

> mathematical equations that create a particular array of pixels. The equations are the image. Therefore as computer processors become faster and more powerful, so too does the ability to alter digital information.[232]

The phrase "altered fundamentally and undetectably" is absolutely loaded with implications. For starters, it means that virtually *anything* can be added, subtracted, or changed in digital imagery (or to any digital information) and that even experts cannot necessarily detect these changes. The possibilities for deception through manipulating digital imagery are literally unlimited. Perhaps even more alarmingly, all of this can happen in real time as the data stream is converted into manipulated imagery. It is no wonder that the digital age creates a number of legal conundrums and that the veracity of digitized information is increasingly being questioned in courtrooms.[233] At the very least, as *No More Secrets* summarizes, "[c]ommercially available high-resolution satellite imagery will trigger the development of more robust denial and deception and antisatellite countermeasures."[234] Given this potential for deception, the U.S. Government and the news media should adopt a "dual phenomenology" requirement as a way to attempt to confirm the veracity of digitized imagery.

Control of High-Resolution Commercial Imagery. There are clearly a number of complex interdependencies that have and will continue to shape the global high-resolution commercial remote sensing market. The United States should continue to study and evaluate the evolution of this market to ensure that its policy objectives are being met. Regulatory mechanisms such as shutter control that the United States has put in place appear to provide an equitable balance between economic considerations and national security concerns. These mechanisms should also be self-regulating to a large degree. If the United States overuses shutter control it may drive potential customers to foreign imagery providers; but such a control is required before the United States should create incentives for its high-resolution commercial remote sensing industry to dominate the global market. This area also offers the potential for novel means of control and exploitation. The requirement for imagery providers to use only USG approved encryption devices that allow USG access during periods of shutter control, especially when coupled with the potential to use digital data for deception, certainly presents some interesting possibilities for control and exploitation by leaving systems operating rather than shutting them off.

Finally, the United States should carefully and continuously reevaluate whether the benefits that PDD-23 is designed to create such as greater transparency and market preeminence do, in practice, actually outweigh the costs such as the use of this data for nefarious ends. So far, the United States has attempted to shape the world market via mostly economic benefits rather than security considerations. It should rebalance that equation toward national security, perhaps by formal arms control restrictions on high-resolution commercial remote sensing, if the benefits do not outweigh the costs. If it becomes prudent to move in this direction, there are a number of unilateral and multilateral regulation and control options that the United States could pursue.[235]

In the latest developments in this area, during the campaign against terrorism in Afghanistan thus far, NIMA has established *de facto* shutter control by signing an “agreement of assured access” with the Space Imaging Corporation, reportedly for $1.9 million per month. Under the terms of this renewed agreement, Space Imaging is not to sell or share its Afghanistan theater imagery with anyone except the USG until after 5 January 2002, and the contract may be extended beyond that date.[236] This agreement opens many interesting issues related to the utility of limiting information dissemination for public diplomacy, the media, and exploitation of enemy information channels. It also raises the issue of whether this agreement using market mechanisms has set a precedent that might well make it more difficult to invoke formal shutter control in the future.

Global Utilities

Because of all the growth in space systems and the services they provide some analysts believe they should now be considered in a new way as global utilities that provide an essential foundation that enables the global information infrastructure. In some ways, the concept of global utilities is just another recognition of how much the commercial space sector has grown and how important it has become; but it is also clear that the global information infrastructure as it currently exists simply could not function without space systems and the services they provide. This section attempts to define what global utilities are and then discusses arms control and regulatory mechanisms that might help to protect and enhance these essential services.

Global utilities have been defined as: “Civil, military, or commercial systems—some or all of which are based in space—that provide communication, environmental, position, image, location, timing, or other vital technical services or data to global users.”[237] To date, all space-based global utilities provide information services but they are analogous to Earth-bound utility services that provide a foundation for modern life such as water and electricity. And like these Earth-bound utility services, space-based global utilities may be subject to regulation and control at the local, state, national, and international levels. Two relatively minor recent failures illustrate just how embedded global utilities have become in the global information infrastructure. In 1996, a controller at the Air Force GPS control center accidentally put the wrong time into just one of the 24 satellites and this erroneous signal was broadcast for just six seconds before automatic systems turned the signal off. That momentary error caused more than 100 of the 800 cellular telephone networks on the U.S. East Coast to shut down and some took hours or even days to recover.[238] In May 1998, "40-45 million pager subscribers lost service; some ATM and credit card machines could not process transactions; news bureaus could not transmit information; and many areas lost television service—all because of the loss of *one* satellite."[239] Clearly, space systems have become an increasingly important part of the global information infrastructure but questions remain about how they should be regulated and protected.

How global utilities should be controlled and regulated is a complex issue that depends on a number of factors such as the specific systems in question, the services they provide, and the primary users. As discussed above, comsats are already subject to significant control and regulation at the international level through the ITU and in the United States through the FCC. This high level of regulation for comsats is justified both because of the threat of harmful interference in the radio spectrum and due to the lucrative nature these services. Other areas within the commercial space sector that have yet to demonstrate much profitability such as high-resolution remote sensing are also subject to regulation and control but it is generally at a lower level. The United States provides other global utility services such as meteorological data and GPS timing signals free to all users worldwide as a public good. Given the current range of existing regulation and control for global utility services, it is not clear what national security or economic objectives would be served by attempting to regulate these services in the same or even similar ways.

In addition, the United States should consider how global utilities might best be protected and fostered as an enabling technology within the global information infrastructure. Unfortunately, no clear or easy answers stand out and there is a wide range of views on the best path forward. Despite the many threats detailed above, to date there has been almost "no demand from the operators of commercial communications satellites for defense of their multibillion dollar assets."[240] The current lack of support from industry for protection of global utilities is particularly disappointing to USSPACECOM because during the late 1990s they had attempted to advance the argument that such protection was needed and would be demanded as space commercialization grew.[241] Some analysts believe that a multilateral approach to protection for global utilities would be best and argue that this function should be performed by an international organization such as the UN. This approach would likely, however, be filled with all the political, economic, and technical difficulties that have plagued almost all international space efforts. The rocky path of the International Space Station certainly does not inspire confidence in this approach to providing protection for global utilities. At the opposite end of the spectrum are those who advocate that the U.S. military, and the Air Force in particular, should take on the global utility protection mission regardless of international opposition or a lack of support from industry. On top of the political opposition to this approach, creating a viable defense for global utilities also faces daunting economic and especially technical challenges such as those discussed in the HAND section above. Based on the technologies currently being examined, only a robust space-based system would stand much chance of providing an effective defense against the most threatening attacks on global utilities.[242]

Spectrum Crowding, Orbital Debris, and Space Traffic Control

The final contentious area examined in this essay is related to the cumulative effects of greater use of space. Current and projected use of space is creating challenges particularly in the areas of crowding of the radio spectrum for space, orbital debris, and the possible need for space traffic control. This section discusses these issues and outlines some potential control and regulation mechanism that might help to address them.

As discussed above, the recent growth in commercial space activity has exacerbated crowding of the radio spectrum for space applications and there are currently significant pressures on portions of the spectrum now allocated to military uses. In particular, today there is a great deal of pressure to move DOD out of the 1755 to 1850 MHz band in order to auction it off for 3G applications. It is not clear, however, that U.S. national security or even economic interests would benefit from moving DOD out of this band. As the GAO report on this issue makes clear, more study is required and, in particular, the issue must be carefully reconsidered in light of the radically reduced bandwidth requirements that will undoubtedly accompany the economic recession the global economy seems to be entering. More generally, the increasing pressure on the radio spectrum due to more commercial use of space has been somewhat balanced by the use of new technologies and different orbits that lessen the effects of increased use. For example, modern satellites in GSO have only two degrees of spacing between them (versus three or more degrees in the past) for most systems providing fixed satellite services. Likewise, increasing use of NGSO for comsat networks has decreased the pressure on overcrowding the GSO in terms of spectrum and spacing. In sum, then, current trends for the space radio spectrum do not augur major changes in the current regulatory structure. Moving the ITU to auctions for its coordination/registration process would undoubtedly produce greater efficiency and generate income but these benefits would need to be weighed against the equal access concerns of the developing world and fact that there currently seems to be little support for moving in this direction.

Orbital debris may represent the single most potentially useful window of opportunity for cooperative space arms control and regulation for the United States and the global spacefaring community through 2015.[243] NASA defines "orbital debris" as "any man-made object in orbit about the Earth which no longer serves a useful purpose."[244] Human space activity has generated a lot of debris: there are over 9,000 objects larger than 10 centimeters (cm) and an estimated 100,000-plus objects between 1-10 cm in size.[245] The largest single source of this debris has been intentional and unintentional satellite explosions on-orbit.[246] Orbital debris generally moves at very high speeds relative to operational satellites and thereby poses a risk to these systems due to its enormous kinetic energy.[247] Only three collisions between operational systems and orbital debris are known to have occurred thus far but concerns about this hazard are growing due to the increasing number of operational space systems and the five percent growth rate in LEO orbital debris each year.[248] There is even concern about the potential for orbital debris "chain reactions" due to collisions in big-LEO comsat constellations or due to the debris clouds that could be created by use of kinetic energy ASATs in LEO.

Since the 1980s, the United States has led the world in publicizing the risks due to orbital debris and it has made programs to mitigate debris an increasingly important part of its overall space policy.[249] There is, however, undoubtedly more the United States could do on the orbital debris front. The United States should explore several options such as unilaterally pledging not to create space debris through testing or operations of any ASAT system, creating strict unilateral regulations that mandate debris mitigation for U.S. commercial space operators (perhaps as part of the "Spaceworthiness License" discussed in the HAND section above), multilateral efforts to "clean up" debris using lasers and other techniques, and creating strict multilateral regulations for debris mitigation. These and other creative approaches should be explored vigorously in order to ensure that man's increasing use of space does not impose unacceptable risks on this activity.

Finally, due again to the increasing use of space, the United States must consider the need for and implications of space traffic control systems (STCS) that could be analogous to current air traffic control systems. The idea for such a system is obviously related to the orbital debris problem discussed above but it goes well beyond just this problem to include a wide range of factors such as: how space traffic might coordinate and be approved for specific orbital positions, how space traffic would be located and tracked, sanctions and liability for noncompliance and collisions under a space traffic control system, and how such a regime might be established and funded. As with many space-related issues, the technology to at least begin implementing such a system appears to be closer at hand than is the political will to begin down this path. For example, the Ballistic Missile Defense Organization's Midcourse Space Experiment (MSX) satellite launched in April 1996 is the only operational space-based surveillance instrument. It has found some "150 objects in the last three years that were completely lost" and demonstrated the potential value of space-based sensors to a STCS.[250] Likewise, GPS positioning signals could be used to very accurately locate many space systems and a transponder-like system aboard space systems could automatically provide this data in response to queries from the STCS.[251] On the political side of the equation, however, the United States must consider very carefully how its objectives in space might benefit or be harmed via the creation and operation of a STCS. It is not obvious that an air traffic control model is the appropriate regime for space, or that the political and financial costs of creating and operating such a system (many of which would likely be borne by the United States) would be outweighed by its benefits. Most of the benefits would seem to be in the commercial and civil space sectors while the potential drawbacks might be most severe for the military and intelligence sectors. The United States most likely would not, for example, want the ephemeris on its military and intelligence-gathering satellites to be pre-approved and available worldwide through a STCS. At the very least, since a STCS could be such a powerful tool for denial, deception, and even targeting, the United States must think through very carefully exactly what type of control regime would be most appropriate for space and how such a regime would operate in practice.

CONCLUSION

This essay discussed the five most important precedents in space-related arms control and regulation: the spysat overflight regime, the comsat regulatory regime, the OST regime, the ABMT regime and space-based defenses, and ASAT developments and ASAT arms control. It also outlined the space-related parts of START I and II, the most recent arms control treaties. These regimes evolved in complex and interdependent ways but three major themes stand out. First, as illustrated by the major evolution in most of the regimes and the radical reordering of U.S. policy for commercial spysats and comsats, space is seldom a stand-alone policy consideration. More often, the United States has viewed space as a means to another, more important end and it has reordered its space policy accordingly. Second, these precedents illustrate the truisms that "arms are always controlled in a democracy" and "arms control works best when it's needed least." The United States has usually led the world into regimes that have emphasized the benign and peaceful uses of space. Likewise, the superpowers were best able to cooperate on arms control for space in areas where they had no major military designs such as in the OST. In areas of greater disagreement such as over missile defenses and ASATs, the superpowers could not reach formal agreement but only limited action-reaction arms race cycles developed due, at least in part, to the restraint shown by the democratic United States. Finally, the complexity of these regimes, their radical reordering over time, and the failure to reach many formal agreements all highlight a number of extreme difficulties for space-related arms control. It is instructive that the Defense and Space Talks were the only area of superpower strategic arms control negotiations during the 1980s and 1990s without an agreement. This situation is not likely to change rapidly in the post-Cold War era and is a caution to those who may believe it would be quick and easy to negotiate major space-related arms control agreements in the near future.

Finally, this essay builds on the space-related arms control and regulation precedents to discuss five space-related areas that contain significant conflict today and are likely to remain contentious into the future: space weaponization; high-altitude nuclear detonations; high-resolution commercial remote sensing; global utilities; and spectrum crowding, orbital debris, and space traffic control. The development of at least four entrenched camps within the United States—space hawks, inevitable weaponizers, militarization realists, and space doves—indicates that it would be difficult for the United States to advance major arms control initiatives on space weaponization for the foreseeable future. Likewise, the United States either faces daunting political and technical challenges or would simply be wise to take a measured approach to arms control or regulation for a number of related issues such as high-resolution commercial remote sensing, global utilities, spectrum crowding, and space traffic control. Opportunities for arms control and regulation in these areas should be studied very carefully, balanced evenly in terms of their costs and benefits for the four space sectors, and weighed against both their opportunity costs and likely unintended consequences. The best near-term opportunity for space-related arms control and regulation may be the "spaceworthiness license" that was described as a way to create incentives for the commercial sector to harden satellites against nuclear effects and to minimize orbital debris.

NOTES

[1] The Futron Corporation, in partnership with the Satellite Industry Association and George Washington University's Space Policy Institute, recently completed the most accurate and comprehensive annual analysis of commercial space activities based on their proprietary database. Total commercial space revenues were estimated to be $5 billion in 1992, then grew to $44.8 billion by 1996, reached $65.9 billion in 1998, and were estimated to be over $80 billion in 2000. They are forecast to reach $240 billion by 2010. For estimates on commercial space revenues see Vice President's Space Policy Advisory Board Task Group Report, "The Future of the U.S. Space Industrial Base," (Washington, D.C.: Vice President's Space Policy Advisory Board Task Group, November 1992), 11; The Futron Corporation, *Satellite Industry Guide* (Bethesda, Md.: Futron Corporation, October 1999); and *Report of the Commission to Assess National Security Space Management and Organization* (Washington, D.C.: Commission to Assess National Security Space Management and Organization, 11 January 2001), 11 (hereinafter Space Commission Report). For comparison, on 31 July 2001 the Acting Assistant Secretary of Defense for Command, Control, Communications, and Intelligence testified before Congress that the more than 120 satellites DOD controls using the 1755-1850 MHz band represent a cumulative investment of about $100 billion. United States General Accounting Office, "Defense Spectrum Management: More Analysis Needed to Support Spectrum Use Decisions for the 1755-1850 MHz Band," (Washington, D.C.: General Accounting Office, August 2001), 17.

[2] *The NRO at the Crossroads* (Washington, D.C.: National Commission for the review of the National Reconnaissance Office, 1 November 2000). *The Information Edge: Imagery Intelligence and Geospatial Information in an Evolving National Security Environment* (Washington, D.C.: Independent Commission on the National Imagery and Mapping Agency, December 2000). Space Commission Report. All three reports are available on-line at http://www.space.gov. In addition, under National Security Presidential Directive (NSPD)-5, President Bush ordered a comprehensive review of U.S. intelligence capabilities to be conducted by both internal and external panels that was originally scheduled to be completed by the end of summer 2001. See Vernon Loeb, "U.S. Intelligence Efforts to Get Major Review," *Washington Post*, 12 May 2001, 3; and Walter Pincus, "Intelligence Shakeup Would Boost CIA," *Washington Post*, 8 November 2001, 1.

The most important previous groups and their key space policy recommendations include: the 1954-55 Technological Capabilities Panel (TCP) (establish the legality of overflight and develop spy satellites); the President's Science Advisory Committee (PSAC) led by Science Advisor James Killian in 1958 (create the National Aeronautics and Space Administration [NASA]); the SAMOS

Panel led by Science Advisor George Kistiakowsky in 1960 (create the NRO); the review led by Vice President Lyndon Johnson in April 1961 (race the Soviets to the Moon for prestige); Vice President Spiro Agnew's 1969 Space Task Group (establish NASA's post-Apollo goals); the U.S. Air Force's (USAF) 1988 Blue Ribbon Panel led by Maj Gen Robert Todd (integrate spacepower into combat operations); NASA's 1991 Augustine Commission (emphasize scientific exploration over shuttle operations); and the USAF's 1992 Blue Ribbon Panel led by Lt Gen Thomas Moorman (emphasize space support to the warfighter, establish the Space Warfare Center).

The Space Commission Report is the broadest-ranging and most important product of the three commissions in 2000. The Space Commission was chaired by Donald Rumsfeld and included 12 other members with a broad-range of very high-level military space expertise. They are (listed with the top "space" job they formerly held): Duane Andrews (Deputy Undersecretary of Defense for Command, Control, Communications, and Intelligence); Robert Davis (Undersecretary of Defense for Space); Howell Estes (Commander, U.S. Space Command); Ronald Fogleman (Air Force Chief of Staff); Jay Garner (Commander, Army Space and Strategic Defense Command); William Graham (President's Science Advisor); Charles Horner (Commander, U.S. Space Command); David Jeremiah (Vice Chairman of Joint Chiefs of Staff); Thomas Moorman (Air Force Vice Chief of Staff); Douglass Necessary (House Armed Services Committee staff); Glenn Otis (Commander, Army Training and Doctrine Command); and Malcolm Wallop (Senator). See John A. Tirpak, "The Fight for Space," *Air Force Magazine* 83 (August 2000): 61.

The legislation authorizing the commission was clearly action-oriented and spelled out its duties as follows: "The Commission shall, concerning changes to be implemented over the near-term, medium-term, and long-term that would strengthen United States national security, assess the following: (1) the manner in which military space assets may be exploited to provide support for United States military operations. (2) The current interagency coordination process regarding the operation of national security space assets, including identification of interoperability and communications issues. (3) The relationship between the intelligence and nonintelligence aspects of national security space (so-called "white space" and "black space"), and the potential costs and benefits of a partial or complete merger of the programs, projects, or activities that are differentiated by those two aspects. (4) The manner in which military space issues are addressed by professional military education institutions. (5) The potential costs and benefits of establishing any of the following: (A) An independent military department and service dedicated to the national security space mission. (B) A corps within the Air Force dedicated to the national security space mission. (C) A position of Assistant Secretary of Defense for Space within the Office of the Secretary of Defense. (D) A new major force program, or other budget mechanism, for managing national security space funding within the Department of Defense. (E) Any other change to the existing organizational structure of the Department of Defense for national security space management and organization."

See sec. 1622 of *National Defense Authorization Act for Fiscal Year 2000* (Public Law 106-65; 113 Statute 814; 10 *US Code* 111 note).

In October 2000, Congress added an amendment directing the commission to study

> (6) the advisability of—
> various actions to eliminate the de facto requirement that specified officers in the United States Space Command be flight rated that results from the dual assignment of officers to that command and to one or more other commands in positions in which officers are expressly required to be flight rated;
> the establishment of a requirement that, as a condition of the assignment of a general or flag officer to the United States Space Command, the officer have experience in space, missile, or information operations that was gained through either acquisition or operational experience; and
> rotating the command of the United States Space Command among the Armed Forces.

See sec. 1091, Additional Duties for Commission to Assess United States National Security Space Management and Organization; sec. 1622(a) of the *National Defense Authorization Act for Fiscal Year 2000* (Public Law 106-65; 113 Statute 814; 10 US Code 111 note).

The key recommendations of the Space Commission Report called for: raising the priority of national security space to a vital national interest; creating a Presidential Space Advisory Group; instituting closer and more regular coordination between the Secretary of Defense and the Director of Central Intelligence; creating an Under Secretary of Defense for Space, Intelligence, and Information; creating a new four-star billet for the Commander of Air Force Space Command that is separate from the Commander in Chief of U.S. Space Command and the North American Aerospace Defense Command; designating the Air Force as the Executive Agent for space within the department of Defense (DOD) and amending Title 10 of the United States Code to assign the Air Force responsibility to organize, train, and equip for prompt and sustained offensive and defensive air and space operations; assigning the Undersecretary of the Air Force as the Director of the National Reconnaissance Office and the Acquisition Executive for space; and establishing a Major Force Program to consolidate the space budget. (Space Commission Report, xxxi-xxxv). Not surprisingly, Secretary Rumsfeld recently accepted nearly all of these recommendations in his required assessment of the Space Commission Report for Congress. The only major change was that he did not request legislation to establish an Under Secretary of Defense for Space, Intelligence, and Information. See Donald H. Rumsfeld, letter to Honorable John Warner, Chairman, Committee on Armed Services, United States Senate, 8 May 2001; Donald H. Rumsfeld, National Security Space Management and Organization Memorandum, Office of the Secretary of Defense, 18 October 2001; and Lt Col Peter Hays and Dr. Karl Mueller, "Going

Boldly—Where? Aerospace Integration, the Space Commission, and the Air Force's Vision for Space," *Aerospace Power Journal* 15, no. 1 (Spring 2001): 34-49.

[3] Contrast, for example, the "sympathetic exploration of arms control" by Thomas C. Schelling and Morton H. Halperin in *Strategy and Arms Control* (New York: Twentieth Century Fund, 1961), 1; with the opposite perspective from Colin S. Gray, "the error is to believe that an arms control process can contribute usefully to the prevention of war." See Gray, *Modern Strategy* (Oxford University Press, 1999), 194; or his *House of Cards: Why Arms Control Must Fail* (Ithaca: Cornell University Press, 1992).

[4] These three objectives for arms control were first laid out in 1961 by Schelling and Halperin in *Strategy and Arms Control*, 2.

[5] Table 3 is a combined and expanded version of four tables which appear in Dana J. Johnson, "The Impact of International Law and Treaty Obligations on United States Military Activities in Space," *High Technology Law Journal* 3 no. 33 (1987), 73-80. It is adapted from Lt Col Thomas W. Billick, "Arms Control Implications for Military Operations in Space," Research Report for the USAF Institute for National Security Studies, (USAF Academy, CO, May 2001), 31-33.

[6] Distinctions can be drawn between the role of satellites in performing reconnaissance (periodic close focus on specific targets) and surveillance (more constant but less detailed examination of wider areas) as well as between photoreconnaissance, signals intelligence (SIGINT), radar imaging, infrared imaging, measurement and signature intelligence (MASINT), and other types of space-based intelligence gathering. These distinctions are critical for development and operational considerations but, to date, they have been less important in relation to the legal regime that legitimizes these activities. This essay does not delve into the distinctions and uses spysat as shorthand to describe all space-based intelligence gathering missions and systems.

[7] Gerald M. Steinberg, "Dual Use Aspects of Commercial High-Resolution Imaging Satellites," Security and Policy Studies No. 37, (Bar-Ilan University, Israel: Begin-Sadat Center for Strategic Studies, February 1998), 4. Available on-line at http://www.biu.ac.il/Besa/books/37pub.html.

[8] The best and most comprehensive analysis of the complex maneuvering by the superpowers at the opening of the space age is Walter A. McDougall's Pulitzer Prize-winning . . . *the Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, 1985). NSC-5520 was signed on 20 May 1955 and is reprinted in John M. Logsdon, ed. *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program*, Vol. I, *Organizing for Exploration* (Washington, D.C.: NASA History Office, 1995), 308-313. McDougall in *Heavens and Earth* and R. Cargill Hall's introductory essay, "Origins of U.S. Space Policy: Eisenhower, Open Skies, and Freedom of Space," in *Exploring the Unknown* do an excellent job in developing the context and purposes for which NSC-5520 was developed.

[9] Hall uses the term *stalking horse* to describe the purpose of the IGY satellite in relation to the WS-117L (America's first spysat program). For the most complete

analysis of the IGY program see Rip Bulkeley, *The Sputniks Crisis and Early United States Space Policy: A Critique of the Historiography of Space* (Bloomington: Indiana University Press, 1991).

[10] A civilian-directed office within the Air Force that reported directly to the Secretary of Defense was established in late August 1960. Secretary Robert S. McNamara formally established this office as the NRO on 6 September 1961. In Executive Order 12951 of 22 February 1995 President William J. Clinton authorized the public release of historical intelligence imagery from the Corona (KH-1 through KH-4B), Argon (KH-5), and Lanyard (KH-6) programs. KH is short for keyhole and refers to the camera system carried aboard these first two generations of U.S. imagery spysats that were operational between 1960 and 1972. See R. Cargill Hall, "The National Reconnaissance Office: A Brief History of its Creation and Evolution," *SPACE TIMES* (March-April 1999): 13-15; and Kevin C. Ruffner, ed. *Corona: America's First Satellite Program* (Washington, D.C.: History Staff, Center for the Study of Intelligence, Central Intelligence Agency, 1995).

[11] McDougall, 180-189. The ad hoc Committee on the Peaceful Uses of Outer Space traces its lineage to a Soviet proposal at the UN on 15 March 1958. The permanent COPUOS was established in December 1959.

[12] The Vela Hotel program was initiated in 1959. In November 1961, the Air Force selected TRW as the prime contractor to build ten satellites. The first launch was in October 1963 (immediately after the LTBT entered into force) and the system first detected a nuclear detonation from space on 17 October 1963. Beginning in the 1970s, Vela Hotel satellites were deactivated as the Integrated Operational Nuclear Detection System (IONDS) became operational on Global Positioning System (GPS) Satellites. But the Vela Hotel system may have reached its greatest prominence on 22 September 1979 when it detected a double flash in the South Atlantic, prompting speculation centered on the possibility of a South African or Israeli nuclear test detonation. President Jimmy Carter convened a panel of scientific experts to conduct a thorough technical review of all available data. The panel concluded that, although it could not rule out the possibility that the signal was of nuclear origin, it was more likely the consequence of the impact of a small meteoroid on the satellite. Other U.S. government agencies investigating the event—including the Defense Intelligence Agency (DIA), the Central Intelligence Agency (CIA) and the Naval Research Laboratory—concluded that a nuclear blast had occurred. See Digital National Security Archive, South Africa: The Making of U.S. Policy, 1962-1989, on-line, Internet, 18 August 2001, available at http://192.195.245.32/saintro.htm; Space Firsts, on-line, Internet, 18 August 2001, available at afa.org/magazine/space/spacefirsts.html; David N. Spires, *Beyond Horizons: A Half Century of Air Force Space Leadership* (Peterson AFB, CO: Air Force Space Command, 1997), 153-54; and Curtis Peebles, *High Frontier: The United States Air Force and the Military Space Program* (Washington, D.C.: Air Force History and Museums Program, 1997), 41-44.

[13] The evolution of the U.S.-U.S.S.R. modus vivendi on spysats is described in Gerald M. Steinberg *Satellite Reconnaissance: The Role of Informal Bargaining*

(New York: Praeger, 1983) and John Lewis Gaddis, “The Evolution of a Reconnaissance Satellite Regime,” in George Farley Dallin, ed., *US-Soviet Security Cooperation* (New York: Oxford University Press, 1988), 353-363. In June 1962, the Soviets submitted to the COPUOS a Draft Declaration of Basic Principles Governing the Use of Outer Space which declared that “use of artificial satellites for the collection of intelligence information in the territory of foreign states is incompatible with the objectives of mankind in its conquest of outer space.” The official United States response was issued in December 1962: “It is the view of the United States that Outer Space should be used for peaceful—that is, non-aggressive and beneficial—purposes. The question of military activities in space cannot be divorced from the question of military activities on Earth. There is, in any event, no workable dividing line between military and non-military uses of space. One of the consequences of these factors is that any nation may use space satellites for such purposes as observation and information gathering. Observation from space is consistent with international law, just as observation from the high seas.” Cited in Paul B. Stares, *The Militarization of Space: U.S. Policy, 1945-1984* (Ithaca: Cornell University Press, 1985), 69-71.
[14] See, for example, Robert Joseph DeSutter, Jr., “Arms Control Verification: ‘Bridge’ Theories and the Politics of Expediency,” Ph.D. diss. University of Southern California, April 1983.
[15] U.S. Arms Control Treaties are available on-line at http://www.state.gov/www/global/arms/bureau_ac/treaties_ac.html.
[16] *Arms Control and Disarmament Agreements: Text and Histories of Negotiations* (Washington, D.C. Arms Control and Disarmament Agency, 1982), 141.
[17] McDougall, 355.
[18] George A. Codding, Jr., *The Future of Satellite Communications* (Boulder: Westview Press, 1990), 38-39.
[19] Quoted in Jonathan F. Galloway, *The Politics and Technology of Satellite Communications* (Lexington: Lexington Books, 1972), 26.
[20] The ITU is a specialized agency of the United Nations and is the world’s largest and oldest continuously operating international regulatory agency. Its basic present structure under the UN was established at the Atlantic City Conference in 1947 but its lineage can be traced back to the International Telegraph Union established in 1865. ITU membership is open to all states (there are 189 member states as of September 2001), only states can be full members, but organizations and corporations can now join as sector members and associate members. It is charged with harmonizing and regulating all international telecommunications. The standard work on the establishment of the ITU is George A. Codding, Jr., *The International Telecommunications Union: An Experiment in International Cooperation* (New York: Arno Press, 1972).
[21] Between the signing of the Interim Agreement in August 1964 and the initiation of negotiations on the Definitive Agreement in February 1969, 92 percent of the $350.5 million INTELSAT spent on its space segment went to U.S. contractors. Galloway, 156.

[22] The Definitive Agreement established a governing structure with four major components within INTELSAT. The Assembly of Parties was comprised of member states and met every two years to discuss overall policy. The Meeting of Signatories was composed of states or their designated representatives (e.g. COMSAT) and met once a year to consider recommendations from the Board of Governors. The Board of Governors consisted of one governor from each state or group of states with more than the minimum investment share in INTELSAT or which represent ITU regions that would not otherwise be represented. INTELSAT's day to day responsibilities for administrative, financial, and legal matters was handled by the Secretary-General and by the Management Service Contractor (COMSAT until 1979) for technical and operational issues. Codding, 41-66.

[23] Under the Definitive Agreement, INTELSAT was to review applications for separate systems based on three criteria: 1) "technical compatibility" with INTELSAT's use of radio frequencies and orbital slots; 2) whether the proposed system would cause "significant economic harm" to INTELSAT; and 3) whether the proposed system would "prejudice the establishment of direct telecommunication links through the INTELSAT space segment among all parties." Codding, 41.

[24] A number of regional competitors to INTELSAT did emerge during the 1970s. The most significant of these systems include: ARABSAT, established in 1976; the European Telecommunications Satellite Organization (EUTELSAT) begun in 1977; the Indonesian Palapa system that was first operational in 1976; and the largest of these competing systems, the International Maritime Satellite System (INMARSAT) initiated in 1979.

[25] Quoted in Andrea Kavanaugh, "Star WARCs and New Systems," *Telecommunications Policy* (June 1986): 94.

[26] Milton Mueller, "INTELSAT and the Separate System Policy: Toward Competitive International Telecommunications," Policy Analysis Number 150 (Washington, D.C. The CATO Institute, 21 March 1991), on-line, Internet, 20 August 2001, available from http://www.cato.org/pubs/pas/pa-150.html. See also Organization for Economic Cooperation and Development, "Reform of International Satellite Organizations," (Paris: OECD, 1996), on-line, Internet, 20 August 2001, available from http://www.oecd.org/daf/clp/roundtables/SATS.PDF.

[27] The first transatlantic fiber optic cable (TAT-8) became operational in 1988. Since then, the capacity of each fiber optic cable has increased dramatically. TAT-8 can carry 280 megabits of data per second (Mbps); TAT-14 is scheduled to become operational by the end of 2001 and will carry 160 gigabits per second (Gbps). The cost per circuit equivalent for cables has dropped from $90 million in 1988 to approximately $2 million in 2000. This helps to explain why fiber's share of global transoceanic telephony grew from 2 percent in 1988 to over 80 percent by 2000. Moreover, because new fiber technologies such as optical switching and dense wavelength division multiplexing (DWDM) are slated to be in widespread use by the end of 2002 and are designed to double (at least) the capacity of each fiber strand, even next generation wireless broadband such as Hughes' Spaceway system may continue to have a very hard time competing with fiber for any fixed, point-to-point

telecommunication service. DWDM uses different wavelengths of laser light within each strand of fiber. The capacity of one strand of fiber using DWDM is 1000 Gbps. The Hughes Network Systems Spaceway wireless broadband (Ka-band) system is scheduled to begin operation over North America in 2002 using two Boeing 702 comsats in geostationary orbit (GSO) and have a capacity of 10 Gbps. The satcom versus fiber tradeoff is just one of the many complex issues that will shape the future of wireless broadband and the role of space systems within these markets. At present, however, it is not clear that large-scale "Internet-in-the-sky" systems such as Teledesic can be developed cheaply, quickly, and flexibly enough to compete effectively with terrestrial alternatives for most applications. See, for example, Mel Mandell, "120,000 Leagues Under the Sea," *IEEE Spectrum* (April 2000): 50; "International Cable Protection Committee: Atlantic Region, In Service Cables," on-line, Internet, 21 August 2001, available at http://www.iscpc.org/; "Comments of INTELSAT Before the National Telecommunications and Information Administration," 8 May 2000, on-line, Internet, 20 August 2001, available from http://www.ntia.doc.gov/ntiahome/occ/oecd2000/intelsat/intelsat.htm; and "Teledesic Set to Choose Prime Contractor for Internet-in-the-Sky," on-line, Internet, 22 August 2001, available from http://www.spacedaily.com/news/teledesic-01a.html.

[28] Open-Market Reorganization for the Betterment of International Telecommunications (ORBIT) Act, Public Law 106-180, 17 March 2000. See Bill Summary & Status available from http://thomas.loc.gov/cgi-bin/bdquery/z?d106:SN00376:@@@D&summ2= m&.

[29] INTELSAT's press release on its privatization is located at http://www.intelsat.int/news/press/2001-15e.asp.

[30] The ITU's present permanent structure consists of Plenipotentiary Conferences, the Secretary-General, the Radiocommunication Bureau, the Telecommunication Standardization Bureau, and the Telecommunication Development Bureau. See "ITU Structure" at http://www.itu.int/aboutitu/structure/index.html. The last WRC was held in Istanbul, Turkey from 8 May to 2 June 2000; the next WRC is scheduled for 2003.

[31] The Allotment Plan moved the ITU away from its traditional "first come-first served" approach to a regulatory regime designed to balance equitable access with economic efficiency. In theory, it reserves at least one frequency position in GSO for each state in the ITU. See, for example, Milton L. Smith, *International Regulation of Satellite Communication* (Dordrecht: Martinus Nijhoff Publishers, 1990).

[32] Other major USG agencies also involved in comsat regulation include the Departments of State, Commerce, and Transportation (DOS, DOC, and DOT). State coordinates with DOC to grant export licenses for U.S. built comsats using foreign launch vehicles. DOT through the Federal Aviation Administration regulates domestic commercial launches. In addition, the White House Office of the United States Trade Representative (USTR) is the principle trade policy advisor to the president and has negotiated launch quotas with the People's Republic of China

(PRC), Russia, and the Ukraine that limit the number of U.S. comsats that can be launched on foreign launch vehicles. The Clinton Administration ended quotas for Russia and the Ukraine in 2000; the agreement with the PRC expires in 2001 and negotiations are underway on whether to renew it. See Marcia S. Smith, "Space Launch Vehicles: Government Activities, Commercial Competition, and Satellite Exports," (Washington, D.C.: Congressional Research Service, 23 May 2001), CRS-7 through CRS-13; on-line, Internet, 30 August 2001, available from http://www.cnie.org/nle/st-59.html.

[33] See "About the FCC," at http://www.fcc.gov/aboutus.html for information about the FCC's current structure.

[34] See "A Short History of NTIA," at http://www.ntia.doc.gov/opadhome/history.html.

[35] The Omnibus Budget Reconciliation Act of 1993 is Public Law 103-66. The FCC's authority to conduct auctions was revised in 1997 and March 2000.

[36] See "FCC Auction Summary," available at http://www.fcc.gov/wtb/auctions/. Winning bidders are required to pay the value of their bid in installments during the term of their license. The U.S. Treasury has not been paid this full amount because some of the winning bidders have declared bankruptcy or otherwise defaulted on their payment schedule.

[37] Richard M. Nunno, "Radiofrequency Spectrum Management," CRS Report 97-218 SPR (Washington, D.C.: Congressional Research Service, 23 April 1998), CRS-6; on-line, Internet, available from http://www.senate.gov/~ dpc/crs/reports/reptsubj.html. See also Congressional Budget Office, "Where Do We Go From Here? The FCC Auctions and the Future of Radio Spectrum Management," (Washington, D.C.: Congressional Budget Office, April 1997), on-line, Internet, available from http://www.cbo.gov/showdoc.cfm?index= 9&sequence= 0&from= 0.

[38] New technologies and services are eroding the distinctions between traditional ways of categorizing spectrum allocations such as FSS and MSS. The trend toward digital convergence may also undercut the current rationale for auctioning some portions of the spectrum but not others. *Telecommunications: Glossary of Telecommunications Terms*, Federal Standard 1037C, 7 August 1996, available from http://www.its.bldrdoc.gov/pub/fs-1037/ defines the terms FSS and MSS as follows: "**Fixed-satellite service**: A radiocommunication service between Earth stations at given positions when one or more satellites are used; the given position may be a specified fixed point or any fixed point within specified areas; in some cases this service includes satellite-to-satellite links, which may also be effected in the inter-satellite service, the fixed-satellite service may also include feeder links for other space radiocommunication services. **Mobile-satellite service:** A radiocommunication service: between mobile earth stations and one or more space stations, or between space stations used by this service; or between mobile earth stations by means of one or more space stations. This service may also include feeder links necessary for its operation." Hughes Network Service's DirecPC system is an example of a FSS; the Iridium system is an example of a MSS.

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[39] Nunno, CRS-4, provides the following definitions for DBS and DARS: "*Direct broadcast satellite (DBS)* is a new high powered satellite television delivery system operating using small receiving antennas in the 12.2-12.7 GHz band. It is related to direct-to-home (DTH) satellite television services that use large receiving antennas that have been offered for over a decade and operate in several other frequency bands. *Digital Audio Radio Services (DARS)* is a new high-fidelity radio service planned by several companies to be delivered by geostationary satellite. A single DARS transmission will cover the entire nation." Hughes Electronics Corporation's DirecTV is an example of a DBS system; the Sirius system is an example of a satellite DARS.
[40] See, for example, Harvey J. Levin, "Emerging Markets for Obit Spectrum Assignments," Telecommunications Policy 12, no.1 (March 1988): 57-76. Factors that favor of ITU auctions for comsats include the tendency of many states to overestimate their comsat requirements and thereby clog the coordination and registration process with "paper satellites" that hold spectrum allocations but may never be used. In a notorious case that goes well beyond simple overestimates, the tiny island state of Tonga successfully registered for six highly lucrative trans-Pacific orbital slots in 1991 and subsequently licensed their slots to other comsat companies (e.g. the APSTAR 1A satellite of APT Satellite Holdings Limited). See Edmund L. Andrews, "Tiny Tonga Seeks Satellite Empire in Space," *New York Times*, 28 August 1990, 1; and Rick Mendosa, "Tongasat's Flawed Genius," on-line, Internet, 24 August 2001, available from http://www.mendosa.com/tongasat.html. On the other hand, if the ITU moved to an auction system for allocating spectrum slots that approach could undercut the equitable access compromise in the Allotment Plan negotiated at the 1988 WRC.
[41] According to the NTIA, WRC-1992 identified 1885 to 2025 and 2110 to 2200 Megahertz (MHz) and WRC-2000 identified 806-960, 1710-1885, and 2500-2690 MHz for 3G applications. GAO, "Defense Spectrum Management," 6-7. Major 3G applications include mobile voice, high-speed data, and Internet capabilities.
[42] Ibid., 2. In a 27 August 2001 letter to Senate leaders Defense Secretary Donald Rumsfeld and Joint Chiefs Chairman (CJCS) General Henry Shelton expressed their concerns about DOD losing the 1755 to 1850 MHz band. "We depend on this band for, among other things, satellite telemetry; tracking and commanding critical satellite systems; precision guided munitions; Army, Navy, and Marine Corps tactical radio relay systems; air combat training systems; targeting; intelligence; and the real-time delivery of voice, video and data information to warfighters and their commanders." They added that while the department is open to a "win-win" solution that would provide benefits to both commercial and military users, "no solution is feasible until comparable spectrum has been identified for the displaced DOD functions." *Defense Daily*, 30 August 2001, 7.
[43] GAO, "Defense Spectrum Management," 3-24. The DOD report estimated that it would cost at least $2.8 billion to relocate some of the major communications from this bandwidth, that it would be more than $4.3 billion for DOD to vacate the band completely, and that DOD currently planed to use this band through 2017. Industry

estimates showed that auctioning the 1755-1850 MHz band could generate up to $40 billion.
[44] Ibid., 23-24.
[45] Karen Robb, "U.S. Rethinks Commercial Use of Radio Spectrum," *Space News* 15 October 2001, 10.
[46] Increasing pressure on the spectrum both domestically and internationally as well as the need for top-level national spectrum policy are among the top findings of the Defense Science Board's Task Force on DOD Frequency Spectrum Issues, "Coping with Change: Managing RF Spectrum to Meet DoD Needs," (Washington, D.C.: Office of the Under Secretary of Defense for Acquisition and Technology, November 2000).
[47] For background on U.S. plans for doomsday Moon bases see William E. Burrows, "Securing the High Ground," *Air & Space Smithsonian* 8 (December 1993/January 1994): 64-69; Jeffrey T. Richelson, "Shootin' for the Moon," *Bulletin of the Atomic Scientists* (September/October 2000); and Lieutenant Colonel S. E. Singer, "The Military Potential of the Moon," *Air University Quarterly Review* 11 (Summer 1959): 31-53. The most extreme and explicit initial public statement on the military potential of the Moon came from Air Force Brigadier General Homer A. Boushey in a speech to the National Press Club on 28 January 1958. Boushey described the physical characteristics of the Moon that he considered conducive to military operations and posited an "environmental doctrine" for the Moon. These characteristics included: the Moon's orbital position as "high ground" in relation to the earth, its low gravity and the low escape velocity required for launches from the lunar surface or subsurface, the ability to constantly monitor the Earth from the non-rotating Moon, the warning time any station on the Moon would have of an attack from Earth, and the protection and secrecy offered by the far side of the Moon. Based upon these lunar characteristics, Boushey concluded: ". . . the moon provides a retaliation base of unequalled advantage. If we had a base on the moon, either the Soviets must launch an overwhelming nuclear attack towards the moon from Russia two or two-and-one-half days prior to attacking the continental United States (and such launchings could not escape detection), or Russia could attack the continental U.S. first, only and inevitably to receive, from the moon some forty-eight hours later, sure and massive destruction. It has been said that 'He who controls the moon, controls the earth.' Our planners must carefully evaluate this statement, for, if true (and I for one think it is), then the United States must control the moon." Boushey's speech is reprinted in Eugene M. Emme, *The Impact of Air Power: National Security and World Politics* (Princeton, NJ: D. Van Nostrand, 1959), 872.
[48] Stares, *Militarization of Space*, 82.
[49] Ibid., 67-69. See also Raymond L. Garthoff, "Banning the Bomb in Outer Space," *International Security* 5 (Winter 1980/81): 25-40. A sanitized version of NSAM 156 is available in the NSC box at the National Archives in Washington.
[50] Stares, *Militarization of Space*, 82-86; and Garthoff, " Banning the Bomb," 27-31.
[51] Stares, *Militarization of Space*, 83-87; and Garthoff, "Banning the Bomb," 27-31. Sanitized versions of these two NSAMs are available in the NSC box at the National

Archives in Washington. NSAM 183 requested the development of a coordinated U.S. government position so that the U.S. space program could be "forcefully explained and defended at the forthcoming sessions of the UN Outer Space Committee [COPUOS] and the General Assembly." McGeorge Bundy, NSAM 183, 27 August 1962, 1, NSC box, National Archives, Washington. NSAM 192 indicated the president's approval of the recommendations in the ACDA memorandum "A Separate Arms Control Measure for Outer Space," which was the product of the Committee of Principals meeting on 19 September.

[52] For analysis on the negotiation history and impact of the OST that emphasizes how the Treaty has stunted growth in the uses of space, see Everett C. Dolman, *Astropolitik: Classic Geopolitics in the Space Age* (London: Frank Cass, 2002), 123-141.

[53] Stares, *Militarization of Space*, 86-90; and Garthoff, "Banning the Bomb," 31-36. UNGA Resolution 1884 (XVIII), in turn, became the basis for the OST of 1967. The process of achieving this ban was at first derailed by and then substantially accelerated by the fallout from the Cuban Missile Crisis.

[54] Stares, *Militarization of Space*, 86-87.

[55] McDougall, 274. This resolution is officially titled "Declaration of Legal Principles Governing Activities in the Exploration and Use of Outer Space." According to McDougall, UNGA 1962 "ratified the role of the COPUOS as the formative body for space law" and represented a Soviet retreat towards the space law principles advanced by the U.S.

[56] Ibid. McDougall's quotations are from the resolution.

[57] Ibid., 415.

[58] Quoted in Stares, *Militarization of Space*, 101. This JCS memorandum to Secretary McNamara was dated 23 November 1965.

[59] McDougall, *Heavens and Earth*, 416.

[60] Stares, *Militarization of Space*, 101-2.

[61] McDougall, *Heavens and Earth*, 416-17. Until October, the Soviets insisted on equal rights to foreign soil for space tracking sites, by essentially stating that if a state allowed a NASA tracking site it must also allow equal access for a Soviet tracking site within its territory.

[62] U.S. Arms Control and Disarmament Agency, *Arms Control and Disarmament Agreements: Texts and Histories of Negotiations*, 1982 Edition (Washington: GPO), 51. This quotation is from the preamble to the treaty. "Peaceful purposes" are not further defined in the OST.

[63] The quotes are from Article I in ibid., 51.

[64] All major space law and policy documents can be found at the Archimedes Institute Library available at http://www.permanent.com/archimedes/LawLibrary.html.

[65] *Arms Control and Disarmament Agreements*, 52.

[66] Ibid.

[67] On this issue see, for example, the prepared statement of Deputy Secretary of Defense Cyrus Vance in U.S. Congress, Senate, Committee on Foreign Relations,

Treaty on Outer Space: Hearing before the Committee on Foreign Relations, 90th Cong, 1st sess., 1967, 80-81, 94. (Hereinafter SFRC, "OST Hearings"). When pressed further on this issue, Vance indicated that he would find ten or more unidentified and potentially harmful space objects as a cause for concern.

[68] See, for example, the statement of CJCS General Wheeler in ibid., 84.

[69] See Wheeler testimony in ibid., 91-92, 97-98. Although not discussed in open session, this preference for NTMV rather than an international on-site inspection regime for space presumably was due to U.S. concerns with the possibility of Soviet close inspection of U.S. spy satellites. Note also that the terms of the OST draw a distinction between the inspection provisions for facilities on the Moon or other celestial bodies ("open to representatives of other States Parties to the Treaty on the basis of reciprocity") and the inspection provisions for objects in space (none specified).

[70] Ibid., 26.

[71] Ibid., 100.

[72] Ibid., 84-85.

[73] David M. Lupton, in *On Space Warfare: A Space Power Doctrine* (Maxwell AFB, AL: Air University Press, June 1988), develops a typology of four doctrines on the use of space: Sanctuary, Survivability, Control, and High Ground. The **sanctuary** doctrine builds on President Dwight Eisenhower's concepts of "open skies" and space for peaceful purposes by emphasizing that space systems are ideal for monitoring military activity, providing early warning to reduce the likelihood of surprise attack, and serving as NTM to enable and enforce strategic arms control. The basic tenet of the sanctuary doctrine is that space surveillance systems make nuclear wars less likely. Sanctuary doctrine is closely linked to deterrence theory and the assumption that no meaningful defense against nuclear attack by ballistic missiles is possible. Sanctuary doctrine advocates believe that overflight and remote sensing enhance stability and that space must be kept a weapons-free zone to protect the critical contributions of space surveillance systems to global security. **Survivability**, Lupton's second space doctrine, emphasizes broad utility for military space systems, not only at the strategic level emphasized in the sanctuary doctrine, but also at the tactical level of space support to the warfighter that has emerged as the most important force enhancement mission since the end of the Cold War. The survivability doctrine also differs from the sanctuary doctrine because it highlights space system vulnerabilities and questions whether space can be maintained as a sanctuary due to ongoing technological improvements in systems such as ASAT weapons. Lupton's **control** doctrine is analogous to military thinking about sea or air control and asserts the need for control of space in order to apply spacepower most effectively. Thus, the control doctrine sees space as similar to other military environments and argues that both commercial activities and military requirements dictate the need for space surveillance, as well as offensive and defensive counterspace capabilities. Lupton's final doctrine, **high ground**, argues that space is the dominant theater of military operations and is capable of affecting terrestrial conflict in decisive ways. As a primary example of such capability, the high-ground

doctrine points to the potential of space-based ballistic missile defense (BMD) to overturn the dominance of offensive strategic nuclear forces.

[74] Stares, *Militarization of Space*, 99-100.

[75] Gerald T. Cantwell, "The Air Force in Space, Fiscal Year 1968, Part II," Secret History, Office of Air Force History, October 1970, 2-6; microfiche document 00337 in *U.S. Military Uses of Space, 1945-1991: Index and Guide* (Washington: The National Security Archive and Alexandria, VA: Chadwyck-Healey, Inc., 1991). Many sections of this report remain classified but the sanitized version still conveys the general concern of the Air Force with the potential of the FOBS and reveals Air Force plans to counter the FOBS with improvements in early warning systems such as 440L forward scatter over-the-horizon (OTH) radars and Program 949 (Defense Support Program) infrared launch detection satellites.

[76] The standard work on thinking about the unthinkable is Lawrence Friedman, *The Evolution of Nuclear Strategy* (New York: St. Martin's Press, 1983). John Newhouse, *Cold Dawn: The Story of SALT* (New York: Holt, Rinehart & Winston, 1973) describes MAD and the SALT I negotiations in detail.

[77] Donald R. Baucom, *The Origins of SDI: 1944-1983*, (Lawrence: University Press of Kansas, 1992), 11-24. Nike-X consisted of a large phased array guidance system together with two nuclear-armed missiles, a modified Zeus renamed Spartan and a high-acceleration, short-range missile known as Sprint. The Spartan was designed to intercept incoming reentry vehicles (RVs) at an altitude of 70 to 100 miles and the Sprint would provide a second layer of defense at 20 to 30 miles altitude after atmospheric sorting of decoys from warheads. Under ARPA's Project Defender, fairly small-scale conceptual studies of space-based BMD systems were undertaken during the late 1950s and early 1960s. One type of BMD system under study within Project Defender was the ballistic missile boost intercept (BAMBI) project. One BAMBI concept called for high-speed ground based interceptor missiles with nuclear warheads; another, known as space patrol active defense, called for space-based kinetic energy weapons (KEW) housed in "garage" satellites.

[78] Safeguard was widely seen as ineffective against a large-scale attack. DOD had independently initiated plans to deactivate the system by 1 July 1976. See Baucom, *Origins of SDI*, 96-97.

[79] Baucom, *Origins of SDI*, 108-27; Michael A. G. Michaud, *Reaching for the High Frontier: The American Pro-Space Movement 1972-84* (New York: Praeger, 1986), 222-25; and Angelo Codevilla, *While Others Build: The Commonsense Approach to the Strategic Defense Initiative* (New York: Free Press, 1988), 59-92.

[80] Baucom, *Origins of SDI*, 119. This study analyzed the costs and operational parameters of space-based laser systems with varying numbers of laser battle stations and different capabilities. Hunter's study was the anonymous source behind Robinson's 16 October 1978 *Aviation Week & Space Technology* article, "Army Pushes New Weapons Effort." Robinson anonymously gave Hunter's study wide circulation as a part of an influential series of articles on emerging BMD technologies. This initial circle was completed after Hunter met Codevilla at a symposium organized by the

Institute for Foreign Policy Analysis in Washington and Codevilla later introduced Hunter to his boss.

[81] Ibid., 126-27; and Codevilla, *While Others Build*, 68-73. Hunter's briefing team was known as the gang of four and included laser expert Dr. Joseph Miller of TRW, optical expert Dr. Norbert Schnog from Perkin-Elmer, and Dr. Gerald Ouellette, an expert in pointing and tracking technologies from the Draper Laboratory. Codevilla reports that 15 Senators attended the informal briefing on 12 December 1979. This group included: Howell Heflin (D.-AL), Ernest Hollings (D.-SC), John Tower (R.-TX), Henry Jackson (D.-WA), Daniel Moynihan (D.-NY), Harrison Schmitt (R.-MN), and Jake Garn (R.-UT).

[82] "Defense Dept. Experts Confirm Efficacy of Space-Based Lasers," *Aviation Week & Space Technology*, 28 July 1980. Cited in Baucom, *Origins of SDI*, 127.

[83] Baucom, *Origins of SDI*, 137. As suggested by his title, Codevilla is very critical of what he perceives to be the Pentagon's slow response to the military potential of space-based lasers. He particularly emphasizes Air Force opposition to Wallop's initiatives by noting its foot-dragging in establishing the laser program office and bureaucratic maneuvering such as staffing this office with underachievers. See *While Others Build*, 77-92. Other important outputs of this group included Robinson's continuing series of articles on strategic defense technologies and Wallop's influential article, "Opportunities and Imperatives of Ballistic Missile Defense," *Strategic Review* 7 (Fall 1979): 13-21.

[84] On the military potential of space-based lasers see, for example, Colin S. Gray, *American Military Space Policy: Information Systems, Weapons Systems, and Arms Control* (Cambridge, MA: Abt Books, 1982), 45-74; Keith B. Payne, *Laser Weapons in Space: Policy and Doctrine* (Boulder: Westview Press, 1983); and one of the best brief treatments of the basic strategic implications of space and the military potential of space-based weaponry—Simon P. Worden and Bruce P. Jackson, "Space, Power, and Strategy," *The National Interest* (Fall 1988): 43-52. A major conclusion of the last piece is that "[*n*]*on-nuclear weapons based in space are potentially more effective militarily than nuclear weapons*." Page 45; emphasis in original.

[85] For a review of the factors which motivated Reagan's 23 March 1983 SDI speech which emphasizes the role of Dr. Edward Teller, see Philip M. Boffey, William J. Broad, Leslie H. Gelb, Charles Mohr, and Holcomb B. Noble, *Claiming the Heavens: The New York Times Complete Guide to the Star Wars Debate* (New York: Times Books, 1988), 3-25.

[86] Note, especially, that the words "space" and "shield" do not even appear in Reagan's 23 March 1983 speech and that Reagan did *not* insist that only a "leak-proof" defense would have strategic value. The material in the following paragraphs is drawn primarily from Baucom, *Origins of SDI*, 171-96.

[87] The story behind Watkins' conversion to strong support for strategic defenses within the JCS is unconventional and is also illustrative of the limited military support for strategic defenses at the beginning of 1983. Watkins is a devout Catholic and was eventually drawn towards the concept of strategic defenses on a personal level due to his feelings toward the anti-nuclear positions of the U.S. Catholic Church in the early 1980s. This anti-nuclear stance was evident in the positions

taken at National Conference of Catholic Bishops meetings and culminated in the 1983 pastoral letter, "The Challenge of Peace: God's Promise and Our Response." Watkins strongly believed that nuclear deterrence was moral and compatible with Catholicism. But he was very upset to learn "from the navy's chief of chaplains that news of the bishops' work was causing sailors and officers to leave because they believed that service in the navy was no longer compatible with a moral life." In 1982-83, he undertook a series of presentations to counter the bishops' positions. The depth of Watkins's feelings on this issue was evident to Baucom during their interview because Watkins retained an extensive grasp of the details concerning various draft versions of the pastoral letter more than five years after the event. On a professional level, Watkins believed that the December 1982 JCS split vote 3-2 against MX deployment pending resolution of the basing mode was symptomatic of America's strategic quandary. Thus, beginning at the very end of 1982, he was both personally and professionally drawn towards strategic defenses as the best way out of America's worsening strategic situation, a quagmire he described in biblical terms as "a strategic valley of death." Between the summer of 1982 and February 1983, the JCS met over forty times in executive session to discuss the issues raised by the growing vulnerability of U.S. ICBM forces. Baucom, *Origins of SDI*, 184-87.

[88] Quoted from McFarlane interview in ibid., 182.

[89] Quote from McFarlane interview in ibid., 191.

[90] All of these studies remain classified. In October 1983, an unclassified summary of the Hoffman study was released. This summary: stressed previous and ongoing U.S.S.R. strategic defense efforts and the U.S. strategic need for BMD, emphasized that any BMD systems must be designed to be highly survivable, and recommended that the U.S. embark on a building-block approach towards BMD by noting that even "intermediate" BMD systems could significantly enhance deterrence. In April 1984, an unclassified summary of the eight volume Fletcher study was made public. The conclusions of the Fletcher study included that "powerful new technologies are becoming available that justify a major technology development effort"; "the most effective systems have multiple layers, or tiers"; and "significant demonstrations of developing technologies for critical ballistic missile defense functions can be performed over the next ten years". These unclassified summaries are reprinted in Steven E. Miller and Stephen Van Evera, eds., *The Star Wars Controversy* (Princeton: Princeton University Press, 1986), 273-327.

[91] U.S. Department of Defense, Strategic Defense Initiative Organization, *Report to the Congress on the Strategic Defense Initiative*, (Washington: GPO, 1985), 3.

[92] The HOE program was begun under Army auspices in 1980. This was the fourth and final test in this series and the only successful intercept. The results from this test were widely touted at the time as being equivalent to "hitting a bullet with a bullet." On 18 August 1993, the *New York Times* charged that this test was rigged as a part of a larger U.S. deception campaign designed to deceive the Soviets about the efficacy of U.S. BMD efforts. See Tim Weiner, "Lies and Rigged 'Star Wars' Test Fooled the Kremlin, and Congress," *New York Times*, 18 August 1993, p. A1. An investigation by DOD and GAO investigators confirmed that there had been a deception campaign underway at

this time but that this effort was halted prior to the 10 June HOE test. See "Washington Outlook: Deception Confirmed, Test Exonerated," *Aviation Week & Space Technology*, 13 September 1993.

[93] Service, and especially Air Force, opposition to space-based lasers and other possible components of strategic defense systems is a major theme in Codevilla, *While Others Build*, especially 218-22; see also Bill Rusher, "Why brass fights SDI," *Colorado Springs Gazette Telegraph*, 13 August 1989, p. 11. Rusher is the former publisher of *National Review*. A primary fear of the Services regarding SDI was that the funding for a large-scale BMD deployment would come out of their budgets and strip funds from their preferred, core missions.

[94] Ambassador Paul H. Nitze, "On the Road to a More Stable Peace," Bureau of Public Affairs, Department of State, Current Policy No. 657, 20 February 1985, 2.

[95] "Chronology" in *Military Uses of Space*, 59. The Delta 181 test took place on 8 February 1988 and tested more advanced sensing and tracking technologies.

[96] U.S. Department of Defense, Strategic Defense Initiative Organization, *Report to the Congress on the Strategic Defense Initiative*, (Washington: GPO, April 1988), 1-9.

[97] U.S. Department of Defense, Office of Assistant Secretary of Defense (Public Affairs), "News Release: SDI Gains Milestone I Approval," 18 September 1987. The six elements selected for the Milestone I dem/val review were the ground-based surveillance and tracking system (GSTS); the boost surveillance and tracking system (BSTS); the space-based surveillance and tracking system (SSTS); battle management/command, control, and communications (BM/C^3); the space-based interceptor (SBI); and the exoatmospheric reentry vehicle interceptor subsystem (ERIS).

[98] Michael R. Gordon, "General Quitting as Project Chief for Missile Shield," *New York Times*, 28 September 1988, p. A1. Abrahamson was an energetic, positive, and sales-oriented advocate for Reagan's original comprehensive vision of SDI in his appearances before Congress and the public. Despite a long string of successful assignments and being perceived as a rising star within the Air Force prior to becoming director of SDIO, Abrahamson's nomination by President Reagan for full general was blocked by forces within DOD and the Senate "in part because of concern that a promotion of that sort would increase the influence of the Strategic Defense Initiative office in Pentagon decision-making." Abrahamson's replacement, Air Force Lieutenant General George L. Monahan, Jr., entered office only one year prior to reaching his mandatory retirement after 35 years of service—another data point that seemed to indicate the military's true feelings towards SDI. Andrew Rosenthal, "Pentagon: The New 'Star Wars' Chief Brings a Soft-Sell Approach to his Mission," *New York Times*, 18 May 1989, p. A15.

[99] U.S. Department of Defense, Strategic Defense Initiative Organization, *1989 Report to the Congress on the Strategic Defense Initiative*, (Washington: GPO, 13 March 1989), 5.3-1 through 5.3-3. Wood is a protegee of Teller who was heavily involved in the X-Ray laser program prior to developing the Brilliant Pebbles concept.

[100] Ibid., 140. Emphasis added.

[101] The ABMT interpretation dispute in the 1980s generated a large volume of literature and was clearly one of the most important and contentious strategic issues near the end of the Cold War. Some of the best and most important sources on this

debate and its impact include: U.S. Department of State, Bureau of Public Affairs, Statements by Special Advisor to the President and Secretary of State on Arms Control Matters Ambassador Paul H. Nitze and Legal Advisor Abraham D. Soafer, "The ABM Treaty and the SDI Program," Current Policy No. 755, October 1985; Abram Chayes and Antonia Handler Chayes, "Testing and Development of 'Exotic' Systems under the ABM Treaty: The Great Reinterpretation Debate," and Abraham D. Soafer, "The ABM Treaty and the Strategic Defense Initiative," *Harvard Law Review* 99 (June 1986): 1956-1985; Adam M. Garfinkle, "ABM-The Wrong Debate," *The National Interest*, Spring 1988, 76-84; Mark T. Clark, "The ABM Treaty Interpretation Dispute: Partial Analyses and the Forgotten Context," *Global Affairs* 2 (Summer 1987): 58-79; Strategic Defense Initiative Organization, *Report to the Congress on the Strategic Defense Initiative* (Washington, GPO, April 1987), Appendix D; and Senator Sam Nunn in the *Congressional Record*, Daily ed., (11-13 March 1987), S2967-S2986, S3090-S3095, and S3171-S3173.

[102] *Arms Control and Disarmament Agreements*, 139-40.

[103] The provisions in Article III of the ABMT allowed each party two 100 launcher declared ABM sites. This provision was amended to allow each party only one declared ABM site by the Protocol to the ABMT signed on 3 July 1974. Ibid., 162-63.

[104] Ibid., 143. Article XIII establishes and outlines the duties of the Standing Consultative Committee (SCC). Article XIV discusses the provisions for reviewing and amending the treaty.

[105] On this issue, see, for example, Stares, *Militarization of Space*, 166-67. OPP are never defined in the treaty.

[106] For a discussion of these issues, see, for example, Clark, "The ABM Treaty Interpretation Dispute."

[107] National Security Advisor Robert C. McFarlane first publicly revealed the Reagan Administration's LCI on the "Meet the Press" television show on 6 October 1985. Note also that the Clinton Administration officially rejected the LCI, see, for example, Thomas L. Friedman, "U.S. Formally Rejects 'Star Wars' in ABM Treaty," *New York Times*, 15 July 1993, p. A6.

[108] The BMDO website shows $58.1 billion in SDIO and BMDO then-year dollar expenditures from fiscal year 1985 to 2001 (http://www.acq.osd.mil/bmdo/bmdolink/pdf/1529-00.pdf).

[109] Shortly after taking office, the Clinton Administration decided not to resume the Ross-Mamedov talks on a cooperative transition to strategic defenses. See Curt Weldon, "Charting a New Course on Missile Defense," in Peter L. Hays, James M. Smith, Alan R. Van Tassel, and Guy M. Walsh, eds., *Spacepower for a New Millennium: Space and U.S. National Security* (New York: McGraw-Hill, 2000), 141-164; and Henry F. Cooper, "Active Defenses to Help Counter Proliferation," in Peter L. Hays, Vincent J. Jodoin, and Alan R. Van Tassel, eds., *Countering the Proliferation and Use of Weapons of Mass Destruction* (New York: McGraw-Hill, 1998), 193-215. Representative Weldon (R.-PA) is a leading advocate for BMD in the House of Representatives and Ambassador Cooper was the last Director of SDIO.

110 Dennis Ward, "Helsinki, Demarcation, and the Prospects for U.S.-Russian Accommodation on the Anti-Ballistic Missile Treaty," *Comparative Security* 16 (1997): 377-384. Ward was a BMDO representative at the SCC during the demarcation negotiations. In this article he argues that the demarcation agreement announced at Helsinki "fails at its only purpose—to draw a clear demarcation line that provides unambiguous guidance for compliance determinations" because there was never disagreement that the lower velocity interceptors were compliant but the demarcation agreement does not set a standard for testing compliance of higher velocity systems.

111 Ibid., 380-81.

112 Jesse Helms (R.-NC) was Chairman of the Senate Foreign Relations Committee and is a leading opponent of the ABM Treaty. Helms argued that the Constitution requires submitting treaty protocols to the Senate for advice and consent prior to ratification. In May 1997, he made the requirement to submit the ABM Treaty protocols a legally binding precondition for ratification of the Conventional Forces in Europe Flank Document. The Clinton Administration missed Helms' deadline of 1 June 1999 for the administration to submit the ABM Treaty protocols to the Senate for approval. For its part, the Clinton Administration's Cologne Joint Statement with President Yeltsin called for the United States and Russia to move ahead on START III and ABM Treaty modification negotiations while continuing to link the ABM Treaty protocols (and several other arms control issues) to ratification of START II by the Russian Duma. The U.S. Senate provided its advice and consent to ratification of START II 26 January 1996 and the Russian Duma ratified START II with conditions on 14 April 2000. The Clinton Administration had previously indicated that it would submit the ABM Treaty protocols to the Senate after the Duma ratified START II but it did not submit the protocols to the Senate prior to leaving office. See Jesse Helms, "Amend the ABM Treaty? No, Scrap It," *Wall Street Journal*, 22 January 1999.

113 1998 appears to be a landmark year in terms of changing perceptions of the ballistic missile threat and the utility of missile defenses. At the risk of oversimplification, it is fair to characterize the beginning of the year as dominated by traditional thinking concerning the expense and difficulty of defense and the lack of a near-term threat. A continuing series of General Accounting Office (GAO) reports or the Welch Report's finding that BMDO was "rushing to failure" are representative of the first half of the year. Perceptions of the potential threat and proper response changed quite radically, however, following the Indian and Pakistani nuclear tests in May, the 15 July release of the Report of the Commission to Assess the Ballistic Missile Threat to the United States (usually referred to as the Rumsfeld Report after its chairman, former and future Secretary of Defense Donald H. Rumsfeld), and the 31 August North Korean Taepo Dong I launch. According to Rumsfeld, the report found "an environment of little or no warning of ballistic missile threats to the United States from several emerging powers," a finding that was made to appear prescient by the Korean launch six weeks later. The Rumsfeld Commission's charter was characterized as a "Team B" approach to reexamine the data that led to the

December 1995 National Intelligence Estimate (NIE 95-19) finding that the continental United States would not be likely to face a ballistic missile threat until 2010. See Bill Gertz, "Missile Threats and Defenses," *Air Force Magazine* 81 (October 1998) online at http://www.afa.org/magazine1098missile.html.

[114] "Special Defense Department Briefing with Defense Secretary William Cohen," Federal News Service, 20 Jan 1999. Available online at http://ebwest.dtic.mil/Jan1999/s19990121cohen.htm.

[115] Bush's most comprehensive statement on the ABMT and nuclear deterrence to date was his 1 May 2001 speech at National Defense University (available from http://www.whitehouse.gov/news/releases/2001/05/20010501-10.html). Bush called for "a new framework that allows us to build missile defenses to counter the different threats of today's world. To do so we must move beyond the constraints of the 30-year-old ABM Treaty. This treaty does not recognize the present or point us to the future. It enshrines the past." He also specifically linked together building defenses with offensive strategic nuclear force reductions as part of the new framework. Most significantly for our focus, President Bush noted some of the potential advantages of boost phase intercepts but carefully avoided even mentioning space-based BMD systems: "[Secretary Rumsfeld] has identified near-term options that could allow us to deploy an initial capability against limited threats. In some cases, we can draw on already established technologies that might involve land- based and sea-based capabilities to intercept missiles in mid-course or after they re-enter the atmosphere. We also recognize the substantial advantages of intercepting missiles early in their flight, especially in the boost phase. The preliminary work has produced some promising options for advanced sensors and interceptors that may provide this capability. If based at sea or on aircraft, such approaches could provide limited but effective defenses." Presidents Bush and Putin met on 16 June in Slovenia, on 22 July in Italy, and on 13-15 November 2001 in Washington and Crawford, Texas. At the November summit President Bush promised to cut the U.S. nuclear arsenal by two-thirds, down to 1,700 to 2,200 warheads, in the next 10 years and President Putin pledged to make similar reductions in the total number of Russian warheads. According to the *New York Times*, National Security Advisor Condoleezza Rice summarized the outcome of the summit on the ABMT as follows: "'The president has made clear that one way or another the U.S. will have to get out of the constraints of the missile defense treaty.' She set no deadlines and insisted that the relationship between the two men was so good that their differences over the treaty were less important than they were earlier this year. 'This is a smaller element of the U.S.-Russia relationship than it was several months ago and certainly than it was before Sept. 11,' Ms. Rice said." David E. Sanger, "Before and After Bush and Putin's Banter, No Agreement on Missile Defense," *New York Times*, 16 November 2001. For discussion on the administration's rationale for withdrawing from the ABMT see Jane Perlez, "Rice on Front Lines as Adviser to Bush," *New York Times*, 19 August 2001; and Patrick E. Tyler, "U.S. Sets Deadline for Settlement of ABM Argument," *New York Times*, 22 August 2001. On 13 December 2001, the Bush Administration provided formal notification of its withdrawal from the ABM Treaty.

In accordance with Article XV of the Treaty, the effective date of withdrawal will be six months from the formal notification. "ABM Treaty Fact Sheet," (Washington, D.C.: The White House, Office of the Press Secretary, 13 December 2001). Available from http://www.whitehouse.gov/news/releases/2001/12/20011213-2.html.

[116] "ABM Treaty Fact Sheet," (Washington, D.C.: The White House, Office of the Press Secretary, 13 December 2001). Available from http://www.whitehouse.gov/news/releases/2001/12/print/20011213-2.html.

[117] Thomas Duffy, "Missile Defense Overhaul Complete; BMDO Made a Defense Agency," *Inside the Army*, 7 January 2002, 1; see also Secretary of Defense Donald H. Rumsfeld's seven-page memo, "Missile Defense Program Direction," (Washington, D.C.: Office of the Secretary of Defense, Department of Defense, 2 January 2002).

[118] Stares, *Militarization of Space*, 49. Stares provides the most detailed account of the development of U.S. ASAT programs and is the primary source for the following section.

[119] Ibid.; and Major General John B. Medaris, USA, (Ret.), *Countdown for Decision* (New York: G.P. Putnam's Sons, 1962), 162.

[120] Stares, *Militarization of Space*, 49-50.

[121] Ibid.

[122] According to Stares, there were four primary reasons why the Eisenhower Administration chose to take a very slow and studied approach to the development of ASAT or other space weapons during the remainder of its tenure: 1) The current and projected Soviet space threat from reconnaissance satellites or possible orbital bombardment systems was not considered grave enough to require a U.S. ASAT system. 2) Orbital bombardment systems and other possible space-to-earth weapons systems were not judged to be the most rational allocation of defense efforts. 3) Space-based systems with a demonstrated military rationale such as a space-based ballistic missile defense system faced prohibitive technical and cost hurdles. And, 4) most importantly, because of the administration's overriding concern with the development of spy satellites, it had an equal desire to protect these systems from the impact of a possible U.S.-U.S.S.R. "ASAT race." Stares, *Militarization of Space*, 50-52. According to York, "[t]he President himself, in recognition of the fact that we didn't want anybody else interfering with our satellites, limited this program [the SAINT ASAT] to 'study only' status and ordered that no publicity be given either the idea or the study of it." Herbert F. York, *Race to Oblivion: A Participant's View of the Arms Race* (New York: Simon & Schuster, 1970), 131. Thus, once again the secret but all-powerful influence of spysat requirements fundamentally shaped another initial military space application.

[123] Stares, *Militarization of Space*, 112.

[124] Ibid., 112-13. Stares notes that the discovery of an unidentified satellite in December 1959 strengthened the Air Force's case to go ahead with SAINT. On the impact of this unidentified satellite see also George Kistiakowsky, *A Scientist at the White House: The*

Private Diary of President Eisenhower's Special Assistant for Science and Technology, (Cambridge: Harvard University Press, 1976), 245.

[125] Stares, *Militarization of Space*, 112-13; and Kistiakowsky, *Private Diary*, 229-30. As an indication of the perception that Kistiakowsky was at this time the key administration decision-maker on space and missile issues consider the following remark from General Bernard Schriever to Kistiakowsky as recorded in the latter's diary for 16 December 1959 (page 200): "everybody in the Air Force from the secretary down now thinks that you control the entire military R & D program."

[126] Stares, *Militarization of Space*, 115-16. See also Steinberg, *Satellite Reconnaissance*, 83-85. The reoriented SAINT program (program 706) was a study program only. The Air Force, noting that ASAT requirements were increasing, planned to use the Blue Gemini and the Manned Orbital Development Station (MODS) programs to test manned ASAT techniques. Steinberg's interviews with former Deputy Secretary of Defense Roswell L. Gilpatric, former Air Force Secretary Eugene M. Zuckert, and retired General Schriever indicate that McNamara personally canceled the SAINT program, primarily due to his fears of an action-reaction space-based ASAT race.

[127] Stares, *Militarization of Space*, 109. See also "Chronology" in *Military Uses of Space*, 30; and "Space Systems Glossary," in ibid., 154. Project Bold Orion was designed primarily to test the feasibility of air-launched ballistic missiles. The missile apparently passed with four miles of its target, certainly a lethal range for a nuclear warhead.

[128] Stares, *Militarization of Space*, 109-11. The smaller ASAT missiles used in these tests were launched from F-4s.

[129] Ibid., 74.

[130] Ibid., 76.

[131] Ibid., 118-19. Stares questions whether the system was truly operational as of this date. Program 505 was deactivated by 1967.

[132] Ibid., 121.

[133] Ibid., 123. The modified Thor missiles used in Project 437 apparently had a somewhat longer range (approximately 700 miles) than the modified Nike Zeus missiles in the Project 505 ASAT system. See Cantwell, "AF in Space, FY 64," 61; microfiche document 00330 in *Military Uses of Space*. As requested by DOD, Program 437 was granted highest national priority for research and development by NSAM 258 on 6 August 1963. See McGeorge Bundy, "National Security Action Memorandum No. 258, Subject: Assignment of Highest National Priority to Program 437," 6 August 1963; microfiche document 00542 in *Military Uses of Space*.

[134] "News Conference of Honorable Robert S. McNamara, Secretary of Defense, The Pentagon, Friday, September 18, 1964, 0900;" microfiche document 00018 in *Military Uses of Space*.

[135] On these operational deficiencies see Stares, *Militarization of Space*, 117-28; Steinberg, *Satellite Reconnaissance*, 85; Cantwell, "AF in Space, FY 64," 61; microfiche document 00330 in *Military Uses of Space*; and Henry F. Cooper, "Anti-Satellite Systems and Arms Control: Lessons From the Past," *Strategic Review* 17

(Spring 1989): 40-48. Cantwell stated that the limiting factor on the Program 437 system reaction time was "the target tracking time [between 24 and 36 hours] needed to acquire sufficiently accurate satellite position data." Steinberg notes that some of these operational deficiencies were explicitly highlighted by top U.S. officials including President Johnson; he believes these statements on the deficiencies of the Program 437 ASAT system were a part of the larger "informal bargaining" campaign between the superpowers on space that is the focus of his study. On the limitations of ASATs more generally see Ashton B. Carter, "Satellites and Anti-Satellites: The Limits of the Possible," *International Security* 10 (Spring 1986): 46-98.

[136] The limited and temporary nature of the ASAT systems authorized by Secretary McNamara is well illustrated by the history of these systems once deployed. The Army's Program 505 was declared operational on 1 August 1963 but the system was dismantled less than four years later. The Nike Zeus missiles in this system were apparently only tested seven times between 1964 and 1966. Program 505 was terminated by 1967. Apparently, McNamara's decision was motivated primarily by a desire to avoid duplication of the more capable Program 437 ASAT system. The Air Force's Program 437 ASAT system fared little better. Program 437 became operational on 10 June 1964. Between 1964 and 1970, sixteen Thor missiles were launched from Johnson Island in support of this program but only six were "combat test launches" or actual Air Defense Command tests of the alert Program 437 ASAT system while the remaining launches tested various different related systems. On 4 May 1970 Deputy Secretary of Defense David Packard indicated that the Air Force "should phase down the [437] system by the end of FY '70 or as soon thereafter as possible." Although Program 437 remained nominally operational until 1 April 1975, Packard's decision in 1970 marked the effective end of this program and of the United States' only operational ASAT systems. Stares, *Militarization of Space*, 119-127.

[137] Stares, *Militarization of Space*, 136. Emphasis in original.

[138] Ibid.; and William E. Burrows, *Deep Black: Space Espionage and National Security* (New York: Berkley Books, 1986), 268-69. The Soviet co-orbital system is normally launched into an orbit with the same inclination as the target satellite at a slightly higher or lower altitude (known as a grazing orbit). The ASAT vehicle then uses radar tracking to maneuver itself within close range of the target satellite over the course of one or two orbits around the earth. The Soviet system apparently employs metal pellets propelled by an explosive warhead as its kill mechanism. An artist's rendering of the Soviet ASAT system attacking a satellite is reprinted in U.S. Department of Defense and U.S. Department of State, *Soviet Strategic Defense Programs* (Washington: GPO, October 1985), 15. In 1964, the Soviets created the PKO (anti-space defense) section of the PVO Strany Air Defense Forces; PKO is apparently responsible for both the Soviet ABM and ASAT systems. Note also that *dedicated* ASAT systems such as the Soviet co-orbital system or the U.S. miniature homing vehicle (MHV) receive a great deal of attention but are only one of at least four broad categories of potential ASAT weapons. The other categories include: 1) systems with residual ASAT capabilities such as ABM systems or possibly modified

nuclear-armed ballistic missiles; 2) ground-based lasers; and 3) electronic warfare. On the complete Soviet strategic defense network and the place of ASAT within this system, see *Soviet Strategic Defense Programs*, 7-16. On the particular strengths and weaknesses of different types of ASAT approaches see, for example, Nicholas L. Johnson, *The Soviet Year in Space, 1987* (Colorado Springs: Teledyne Brown Engineering, 1988), 78-81.

[139] There is a great deal of disagreement over what constitutes a "successful" ASAT test and this disagreement illustrates both the difficulties in performing and monitoring these type of operations and, more importantly, reflects differing perceptions on the military utility of ASAT within the differing schools of thought on space. See Stares, *Militarization of Space*, 136-40; and Burrows, *Deep Black*, 268-69.

[140] Stares, *Militarization of Space*, 162. The Soviet tests were the object of a good deal of speculation within the aerospace press throughout this time.

[141] Ibid., 155. See Stares, 146-155 for a discussion on the general motives behind the Soviet ASAT system.

[142] Burrows, *Deep Black*, 268.

[143] The vulnerability of U.S. DSP satellites in GSO to being "blinded" by Soviet ground-based lasers was apparently first demonstrated in September and October 1975, adding to U.S. concerns about the survivability and utility of its military space assets. See Stares, *Militarization of Space*, 169; and "Chronology," 41 in *Military Uses of Space*.

[144] Ibid., 168-70. These studies included: a 1975 panel headed by Charles Slichter from the University of Chicago which studied "ways of improving and safeguarding the flow of information to and from commanders in the field"; and another panel chaired by Solomon Buchsbaum which specifically studied the problem of satellite vulnerability during 1976. Deputy National Security Advisor Lieutenant General Brent Scowcroft briefed the results of these panels to President Ford who became "very concerned" with this issue and "asked the DOD for their own analysis."

[145] Ibid., 170, 176-78. NSDM-333 was not available in the NSC box at the National Archives.

[146] Ibid., 170.

[147] Ibid. Stares' analysis of these developments during the Ford Administration seems to be based almost completely upon interviews with former "senior" officials who wished to remain anonymous rather than upon harder documentary evidence. The primary Soviet space-based targeting systems which concerned the U.S. at this time were the nuclear powered Radar Ocean Reconnaissance (RORSAT) and the ELINT Ocean Reconnaissance (EORSAT) systems first deployed in 1974.

[148] Ibid., 171. Ford apparently was "very upset and concerned about the relaxed approach of the Defense Department" towards developing a new ASAT system and felt "the only thing to do was to issue a formal directive." According to Donald Hafner, an analyst with the NSC ASAT Working Group during 1977-78,: "Secretary of State Kissinger argued that the U.S. should redress any asymmetry in ASAT capabilities between the two sides before any arms control restraints were considered. The directive [NSDM-345] by the Ford Administration to go ahead with

the MHV system did call for a study of arms control options, but it did not include any concrete proposal for inviting the Soviets to ASAT talks. Kissinger may have felt it was premature to make such a proposal; or indeed, he may not have favored negotiations at all." See Donald L. Hafner, "Averting a Brobdingnagian Skeet Shoot: Arms Control Measures for Anti-Satellite Weapons," *International Security* 5 (Winter 1980/81): 50-51. NSDM-345 was not available in the NSC box at the National Archives.

[149] Stares, *Militarization of Space*, 181-82. The quote is from White House Fact Sheet, "U.S. National Space Policy," 20 June 1978, reprinted in *President's Space Report, 1978*, 98-100.

[150] Stares, *Militarization of Space*, 182.

[151] Ibid., 184.

[152] Cited in ibid.

[153] Stares, *Militarization of Space*, 194-95; and John Wertheimer, "The Antisatellite Negotiations," in *Superpower Arms Control: Setting the Record Straight*, eds. Albert Carnesale and Richard N. Haass (Cambridge, MA: Ballinger Publishers, 1987), 142-43.

[154] Stares, *Militarization of Space*, 195.

[155] Ibid., 196.

[156] Ibid., 197; and Wertheimer, "Antisatellite Negotiations," 145-46.

[157] Stares, *Militarization of Space*, 198-99.

[158] Ashton B. Carter, "Satellites and Anti-Satellites: The Limits of the Possible," *International Security* 10 (Spring 1986): 68.

[159] Reprinted in *President's Space Report, 1982*, 99.

[160] Information in this paragraph is drawn from the following sources: Stares, *Militarization of Space*, 206-9, 220-22; Craig Covault, "Antisatellite Weapon Design Advances," *Aviation Week & Space Technology*, 16 June 1980, 243-47; and House, "Defense Appropriations, 84," 498-501. The complete MHV ASAT weapon weighed about 2600 pounds and was approximately 17 feet long and 18 inches in diameter. In 1981, the official name of this program was changed to the prototype miniature air-launched system (PMALS), but the MHV, MV, or air-launched MV (ALMV) terminology is still used most often. A GAO report critical of the MHV ASAT system was completed in January 1983 and estimated that the total procurement costs would total at least $3.6 billion versus the $3.45 billion estimated by the Air Force. The Air Force planned to station one squadron (20 aircraft) of F-15s modified for the ASAT mission at McChord AFB, WA, and another squadron at Langley AFB, VA.

[161] An air-launched, direct-assent ASAT system has significantly greater operational flexibility in rapidly attacking many types of LEO than does a ground-launched system with a limited number of fixed launch points. With air-refueling, an F-15 has a range of approximately 5000 nautical miles and can attack satellites from virtually an unlimited number of locations whereas a ground-launched system must wait for the target satellite to pass within range overhead. The drawbacks of an air-launched system include the significant difficulties in command and control for this type of operation and the weight

(and therefore range) limitations imposed by the payload capability of the aircraft launch platform. "Space Systems Glossary" in *Military Uses of Space*, 165.

[162] Stares, *Militarization of Space*, 222-23.

[163] Ibid., 223; and "Soviets Stage Integrated Test of Weapons," *Aviation Week & Space Technology*, 28 June 1982, 21. This final Soviet ASAT test was only a small part of a coordinated strategic exercise which included test launches of two ICBMs, two ABMs, one SLBM, and one SS-20 IRBM, as well as the launch of a navigation and photoreconnaissance satellite which may have simulated the reconstitution of "Soviet satellites negated by Allied forces during the war scenario." This test was similar to but more comprehensive than an earlier Soviet strategic forces test on 16 February 1976. The U.S. has never conducted a similar comprehensive test of its strategic forces involving actual test firings. On this test see also Nicholas L. Johnson, *The Soviet Year in Space, 1982* (Colorado Springs: Teledyne Brown Engineering, 1983), 25. Johnson is the source of the quote above.

[164] See Rebecca V. Strode, "Commentary on the Soviet Draft Space Treaty of 1981," in Gray, *American Military Space Policy*, 85-91; and Stares, *Militarization of Space*, 229-30. Strode concludes that "[t]he Soviet Union may have presented the Draft Treaty merely for propaganda benefit." According to Stares, "[t]he Reagan Administration dismissed the Soviet draft treaty as a hypocritical propaganda ploy." One of the few specific prohibitions in this draft treaty was against carrying weapons "on reusable manned space vehicles," an obvious reference to the Space Shuttle. The Soviet 1981 draft treaty is reprinted in Gray, 115-17.

[165] Quoted in Stares, *Militarization of Space*, 231.

[166] The divergent responses to this Soviet ASAT arms control initiative provide an excellent example of the generally polarized and contentious broad strategic setting for arms control during this period. The ASAT issue was a relatively minor element of the overall strategic setting but was largely shaped by perceptions related to this overall situation. The group who saw considerable utility in general arms control efforts and the use of arms control to curtail U.S. military space efforts was spearheaded by individuals such as Senators Larry Pressler (D.-SD) and Paul E. Tsongas (D.-MA); Representatives Norman D. Dicks (D.-WA), Les AuCoin (D.-OR), and George E. Brown, Jr. (D.-CA); space policy analyst Paul B. Stares; and Federation of American Scientists Spokesman John E. Pike and was willing to overlook the potential problems in this second draft treaty in order to get space-related arms control efforts restarted. By contrast, many top members of Reagan's Administration in arms control-related positions such as Under Secretary of Defense for Policy Fred C. Iklé, Assistant Secretary of Defense for International Security Policy Richard N. Perle, and ACDA Director Kenneth L. Adelman were skeptical of arms control in general and of space-related arms control in particular due to the asymmetries caused by the Soviet lead in ASAT weapons, the difficulties in crafting and verifying any ASAT arms control agreement, and the U.S. lead in most areas of space-related technology.

[167] Bilateral arms control negotiations had been suspended in December 1983 following the Soviet walkout from the INF negotiations in response to the first NATO deployments of these systems. Following the signing of the INF Treaty in December

1987 and START I in July 1991, the Defense and Space Talks remain the only one of the three negotiations begun in March 1985 in which a major agreement has not been reached—another illustration of the extremely difficult technical, political, and conceptual challenges facing arms control in this area.

[168] U.S. Congress, Senate, Committee on Foreign Relations, Subcommittee on Arms Control, Oceans, International Operations and Environment, *Arms Control and the Militarization of Space: Hearing before the Subcommittee on Arms Control, Oceans, International Operations and Environment*, 97th Cong., 2nd sess., 20 September 1982. (Hereinafter SFRC, "Arms Control and Militarization of Space").

[169] SFRC, "Arms Control and Militarization of Space," 11-12.

[170] SFRC, "Controlling Space Weapons." The principle administration witnesses at these hearings were ACDA Director Adelman and Under Secretary of Defense for Policy Iklé.

[171] Ibid., 8.

[172] Stares, *Militarization of Space*, 232.

[173] Ibid., 232-33. This withholding of the $19.4 million in advanced procurement funding for the MHV ASAT in FY 1984 until 45 days after the administration's report was submitted to Congress was also known as the McHugh amendment. See Under Secretary Aldridge testimony in U.S. Congress, House, Committee on Armed Services, *Defense Department Authorization and Oversight for Fiscal Year 1985: Hearings before the Committee on Armed Services, Part 2*, 98th Cong., 2nd sess., 1984, 30. (Hereinafter HASC, "DOD Authorization, FY 85").

[174] Executive Office of the President, "Report to Congress: U.S. Policy on ASAT Arms Control," 31 March 1984; microfiche document 00075 in *Military Uses of Space*. (Hereinafter "ASAT AC Policy Report to Congress, 84"). This is the unclassified version of the report; a more detailed classified version was also delivered to Congress at the same time.

[175] Ibid., 9. The ASAT arms control problem areas listed included: verification, breakout, disclosure of information, definitions, vulnerability of satellite support systems, and the Soviet non-weapon military space threat. Assistant Director of ACDA, Dr. Henry F. Cooper, and Deputy Under Secretary of Defense for Strategic and Theater Nuclear Forces, T.K. Jones, did most of the drafting of the report. The Services were not principle participants in any of the discussions leading to this report but they did, along with the CIA, draft the appendices in the classified version of the report.

[176] HASC, "DOD Authorization, FY 85," 9. At these hearings, Representative Kramer indicated "I think the decision was made internally, as I understand it, within the Department or within the Air Force not to engage in a floor fight on this [the Tsongas and McHugh amendments]." Aldridge basically agreed that this had been the approach of the DOD but added that DOD had "attempted to try to provide —I guess you would call it limit the amount of restraint of the amendment." Moreover, Aldridge indicated that the Air Force was interpreting the Tsongas amendment "as a permanent law" and later added "we believe we can live with it in spite of those conditions." Quotes from pages 29-32.

[177] Stares, *Militarization of Space*, 233.

[178] The Air Force Space Test Program satellite P78-1 was an experimental system launched in February 1979 that was designed to study the sun's corona. P78-1 was still operational in a LEO between 319 to 335 nautical miles in altitude when it was destroyed by the MHV.

[179] On 12 December, immediately prior to this new and much more serious restriction, the Air Force had placed two instrumented target vehicle (ITV) satellites into LEO of approximately 200 by 480 nautical mile orbits. See "Launch Listing" in *Military Uses of Space*, 118-19. These ITVs cost $20 million, had a limited lifetime, and were specifically designed to provide data on MHV intercepts, see Michael R. Gordon, "Air Force to Test a Weapon in Space," *New York Times*, 20 February 1986, p. A18. For a discussion of a possible Soviet violation of their self-imposed moratorium that took place on 21 June 1985, see James E. Oberg, "A Mysterious Soviet Space Launch," *Wall Street Journal*, 21 January 1986, p. 16. Oberg is the author of several major books on the Soviet space program including *Red Star in Orbit* (New York: Random House, 1981).

[180] Gordon, "Air Force to Test Weapon in Space."

[181] "Chronology" in *Military Uses of Space*, 59; and "Anti-Satellite System Tested Successfully," *Los Angeles Times*, 23 August 1986, p. 24. The 30 September 1986 test marked the fifth and final test of the MHV system in space. Of course, since this system was not designed to lock onto the infrared energy of stars it is difficult to determine from open sources just how useful or "successful" such tests might have been.

[182] Representatives AuCoin, Brown, and Dicks continued to spearhead the restrictive amendments for FYs 87 and 88.

[183] Colonel Charles E. Heimack, Department of the Air Force, HQ USAF, "Point Paper on Antisatellite (ASAT) Study," 27 October 1986; microfiche document 00081 in *Military Uses of Space*, lists specific congressional restrictions on MHV development and testing for FY 87. Total expenditures were limited to $200 million versus the $324 million requested and funds for long lead missile components and the mission control center were completely eliminated. Additionally, this point paper indicated that NSSD 4-86 called for a thorough exploration of U.S. ASAT options and was signed by President Reagan on 20 October 1986. Heimack is apparently quoting from study directive 4-86 when he indicates that the air-launched ASAT is "a good first step[.]" but notes that "[s]upport has eroded due to high costs, limited capability." Finally, this point paper also indicates that a report from Secretary Weinberger to the president on "Air-Launched ASAT continuation/alternative program options" was due no later than 12 December 1986.

[184] "Defense Department Unveils $1.2-Billion ASAT Restructuring Plan," *Aviation Week & Space Technology*, 16 March 1987, 19-21; Rudy Abramson, "New Space Satellite-Killer Tests Planned," *Los Angeles Times*, 11 March 1987, p. 11. Although not specifically stated, this restructured ASAT program was apparently the result of the ASAT report submitted by Weinberger in December 1986.

[185] "$1.2 Billion ASAT Restructuring Plan," 20. These plans called for a study to compare using a more powerful first stage booster on the air-launched MHV system with switching to a much larger ground-launched system using a modified Pershing 2

booster. Rankine indicated that doubling the range of the MHV would give the U.S. the about same ASAT range capability already demonstrated by the Soviets (approximately 700 miles). The third part of the overall ASAT restructuring plan called for a joint project with SDIO "to develop an excimer laser system for use against satellites."

[186] Abramson, "New Satellite-Killer Tests Planned," the interior quote is from Rankine.

[187] "Chronology" in *Military Uses of Space*, 60. A 1990 DOD report to Congress listed three "key negative factors [which] culminated in a decision to terminate the F-15 ALMV program in March 1988: (1) severe Congressional funding reductions in the program over a 3 year period; (2) continuing Congressional testing prohibitions on the ALMV that would not permit confidence for an effective operational system, and diminished prospects for future support; and (3) limited capability for system growth to meet expanded threats at higher altitudes." See U.S. Department of Defense, "Anti-Satellite: A Report to Congress," February 1990, 2-4. (Hereinafter "ASAT Report to Congress, 90").

[188] "Chronology" in *Military Uses of Space*, 61. Following the Air Force's cancellation of the MHV, both the Army and the Navy expressed considerable interest in developing ground- or sea-launched ASAT systems. According to "Navy space officials," the Navy "is the only service that has a defined mission for the ASAT—the requirement of fleet commanders to be able to eliminate low-orbiting Soviet satellites used to target U.S. ships," see "Pentagon Preparing to Restart Antisatellite Program in January," *Aviation Week & Space Technology*, 14 November 1988, 33-34. On 13 December 1989 the Defense Acquisition Board (DAB) selected four candidate KEW ASAT system designs from which Under Secretary of Defense for Acquisition (USD(A)) Robert B. Costello selected "a land-based system with the minimum scope to meet USCINCSPACE's highest priority ASAT mission needs." See "ASAT Report to Congress, 90," vi. The initial Army ASAT system proposed for this program was canceled in December 1990, see "Chronology" in *Military Uses of Space*, 62

CRS Space Analyst Marcia S. Smith provides the best short description of other U.S. ASAT activity following the cancellation of the MHV (Smith, "U.S. Space Programs: Civilian, Military, and Commercial, CRS-11 and 12): "As for ASAT development, the Clinton Administration terminated a program to develop a ground-based kinetic-energy ASAT ("KEAsat") interceptor in 1993, permitting only technology studies. Congress revived the program in FY1996, however, adding $30 million that year, $50 million in FY1997, and $37.5 million in FY1998. President Clinton line-item vetoed the $37.5 million on the basis that DOD has other ASAT options and did not need the KEAsat program. After the Supreme Court rejected the line-item veto that money was restored to DOD, and the conference report on the FY1999 DOD authorization bill (H.R. 3616, H.Rept. 105-736) directed DOD to obligate the funds promptly. However, Congress apparently was persuaded that there are other methods for achieving the objective of space control, and stated that DOD could use some of that money for other space control technologies and added $15 million for space control technologies for FY1999. For FY2000, the administration requested no funding for KEAsat, and $9.8 million for Air Force space control technologies. Congress added $7.5 million for KEAsat (in the defense-wide [research, development, testing, and engineering] RDT&E budget), and $3 million for Air Force space control technology. For FY2001, Congress approved the $9.7 million requested for Air Force space control technology, and added $3 million for Army space control technology development (none was requested). The FY2001 DOD authorization act (P.L. 106-398) specifies that the $3 million is to be allocated to KEAsat. In a December 5, 2000 letter report (GAO-01-228R) to Senator Smith, GAO stated that the program was in disarray, and the $7.5 million in FY2000 funding had not been released because there was no agreement on a spending plan for the program. *Defense Daily* reported on February 7, 2001 (page 4) that Senator Smith and the Army had reached agreement and the Army would complete the manufacture of three KEAsat kill vehicles. The April 6, 2001 edition of *Aerospace Dail*y, however, reports that Senator Smith remains dissatisfied with the Army's management of the program. Meanwhile, General Eberhart, Commander in Chief of U.S. Space Command, expressed reservations about using KEAsats because of the collateral damage that could be inflicted on U.S. government and commercial satellites, describing KEAsats as a "last ditch option" *(Aerospace Dail*y, March 29, 2001). Among the alternatives to the KEAsat is a ground-based laser called MIRACL (Mid-Infrared Advanced Chemical Laser) in New Mexico. A long-standing congressional restriction in DOD authorization bills prohibiting the use of MIRACL against targets in space expired in FY1996. On October 2, 1997, DOD Secretary William Cohen approved a test use of MIRACL against an Air Force satellite (MSTI-3). The test was conducted on October 17, 1997. DOD insists it was a defensive test designed to assess the satellite's vulnerability to laser attack. Others view it as a test of an offensive antisatellite capability."

[189] For example, Secretary Weinberger's Annual Report for FY 1986 did not even mention the congressional restrictions placed on the MHV thus far. The Annual Report for FY 1988 unrealistically did its best to try to ignore the deleterious effects which the congressional restrictions had already caused for the MHV program: "In FY 1988, building on the results from our successful test program, we will begin producing the [MHV] missiles. Further congressional restrictions on ASAT testing will, however, needlessly delay attaining an operational capability with the system." See U.S. Department of Defense, *Annual Report to the Congress, Fiscal Year 1986* (Washington: GPO, 1985), 60-61, 215; and *Annual Report to the Congress, Fiscal Year 1988* (Washington: GPO, 1987), 214.

[190] In an extensive interview in July 1986, Aldridge discussed several space issues in considerable depth, but did not even mention the MHV ASAT program. See Edgar Ulsamer, "Aldridge on the Issues," *Air Force Magazine* 69 (July 1986): 84-89. Note also that the Air Force Association (AFA) also did not even mention the MHV ASAT it its 1986-87 Statement of Policy adopted on 15 September 1986. This policy statement is reprinted as "Government's First Responsibility," in *Air Force Magazine* 69 (November 1986): 6-9.

[191] Treaty Between The United States Of America And The Union Of Soviet Socialist Republics On The Reduction And Limitation Of Strategic Offensive Arms (START I), signed 31 July 1991, entered into force 5 December 1994. Most of the

discussion and analysis on START I and II below is drawn directly from Billick, "Arms Control Implications for Military Operations in Space," 24-30. Lt Col Billick developed his outstanding analysis after working START I and II issues while serving at the Nuclear and Counterproliferation Directorate on the Air Staff.

[192] "Paragraph 2 of Article IX in START I is adopted verbatim from paragraph 2 of Article XII of the ABM Treaty and is essentially identical to subparagraph 2(a) of Article XII of the INF Treaty. It prohibits each Party from interfering with the national technical means of verification of the other Party operating in accordance with paragraph 1 of Article IX. This means, for example, that a Party cannot destroy, blind, jam, or otherwise interfere with the national technical means of verification of the other Party that are used in a manner consistent with generally recognized principles of international law. Note that while paragraph 2 of Article IX prohibits interference with national technical means, the prohibition on interference with inspectors during inspections is in the Inspection Protocol." See "Article-by-Article Analysis of Treaty Text" available at http://www.state.gov/www/global/arms/starthtm/start/abatext.html# IX.

[193] Ibid.

[194] See the discussion of FOBS in the OST Regime section above.

[195] START I, Paragraph 4 of Article IV provides limits on ICBMs and SLBMs used for delivering objects into the upper atmosphere or space. The Parties recognized that such use of ICBMs and SLBMs is valid and economical, but they also recognized that such use must be limited because such missiles could also be used for their original purpose of weapons delivery. In order to limit the potential for breakout, paragraph 4 limits each Party to no more than five space launch facilities, which are defined as specified facilities from which objects are delivered into the upper atmosphere or space using ICBMs or SLBMs. Paragraph 4 also provides that these facilities may not overlap ICBM bases; limits each Party to a total of no more than 20 ICBM or SLBM launchers at those facilities, of which no more than ten may be silo and mobile launchers, unless otherwise agreed; and limits the number of ICBMs or SLBMs at a given space launch facility to no more than the number of launchers at that facility. Space launch facilities are not subject to inspection. The number of space launch facilities and the number of launchers at those facilities may be increased or decreased if the Parties agree. Such changes would not require an amendment to the Treaty. These treaty provisions also affect tensions in the commercial space sector between launch service users such as satellite builders and launch service providers. In general, the former have advocated greater use of deactivated ballistic missiles for space launch while the latter do not support such use because it has the potential to flood the market with deactivated ballistic missiles used as space launchers.

[196] START I, Article X and the Telemetry Protocol. During the Cold War, the United States invested billions of dollars in intelligence gathering equipment designed primarily to obtain telemetry data on Soviet ballistic missiles. Gathering and analyzing this information was among the most difficult intelligence challenges of the Cold War.

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[197] Agreement Between The United States Of America And The Union Of Soviet Socialist Republics On Notifications Of Launches Of Intercontinental Ballistic Missiles And Submarine-Launched Ballistic Missiles (Ballistic Missile Launch Notification Agreement), signed at Moscow 31 May 1988, entered into force 31 May 1988.

[198] START I Article by Article legal analysis makes specific reference to the National Aerospace Plane in describing the Treaty definition of "airplane" and the Treaty prohibition against flight-testing, equipping, and deploying nuclear armaments on an airplane that was not initially constructed as a bomber but has a range of 8000 km or more or an integrated planform area over 310 square meters. However, the Parties did not reach agreement on the applicability of the Treaty to future non-nuclear systems. During the negotiations, the United States stated its view that a future non-nuclear system could not be considered a new kind of strategic offensive arm and, thus, would not be subject to the Treaty. The Soviet Union did not accept this view. The Parties agreed, in the Second Agreed Statement, that, if "new kinds" of arms emerge in the future and if the Parties disagree about whether they are strategic offensive arms, then such arms would be subject to discussion in the Joint Compliance and Inspection Commission. Of course, if one Party deploys a new kind of arm that it asserts is not subject to the Treaty, and the other Party challenges this assertion, the deploying Party would be obligated to attempt to resolve the issue. There is, however, no obligation to delay deployment pending such resolution.

[199] Treaty Between the United States of America and the Russian Federation on Further Reduction and Limitation of Strategic Offensive Arms (START II), signed 3 January 1993. The U.S. Senate provided its advice and consent to ratification of START II on 26 January 1996. The Russian Duma completed ratification on 14 April 2000 with conditions. U.S. Senate review of the modified treaty is pending.

[200] Memorandum of Agreement Between the United States of America and the Russian Federation on the Establishment of a Joint Center for the Exchange of Data from Early Warning Systems and Notifications of Missile Launches (JDEC MOA), signed in Moscow and entered into force on 4 June 2000. According to the fact sheet released about the MOA: "This agreement—which is the first time the United States and Russia have agreed to a permanent joint operation involving U.S. and Russian military personnel—is a significant milestone in ensuring strategic stability between the United States and Russia. It establishes a Joint Data Exchange Center (JDEC) in Moscow for the exchange of information derived from each side's missile launch warning systems on the launches of ballistic missiles and space launch vehicles. The exchange of this data will strengthen strategic stability by further reducing the danger that ballistic missiles might be launched on the basis of false warning of attack. It will also promote increased mutual confidence in the capabilities of the ballistic missile early warning systems of both sides. The JDEC will build upon the successful establishment and operation during the millennium rollover of the temporary joint center for Y2K Strategic Stability in Colorado Springs. The JDEC will be staffed 24 hours a day, seven days a week, with American and Russian

personnel. The JDEC is also intended to serve as the repository for the notifications to be provided as part of an agreed system for exchanging pre-launch notifications on the launches of ballistic missiles and space launch vehicles. This agreement is currently being negotiated separately." Available from http://www.clw.org/coalition/summit060400launch.htm.

At least implicitly, the JDEC is one response to the potentially dangerous weaknesses the United States perceives in the post-Cold War Russian Federation strategic early warning system. The most chilling example of this took place on 25 January 1995 when the Russian strategic command and control system was activated after computers mistakenly identified a Norwegian research rocket launch as an attacking U.S. Trident II SLBM. Reportedly, the Russians raised their nuclear alert status and President Boris Yeltsin was prepared to activate his nuclear launch codes out of the Russian version of the "football" before the situation was reassessed and the alert status decreased back to normal several minutes later. See Nikolai Sokov, "Could Norway Trigger a Nuclear War? Notes on the Russian Command and Control System," Program on New Approaches to Russian Security Policy Memo Series, Memo Number 24, available from http://www.fas.harvard.edu/~ ponars/POLICY%20MEMOS/Sokovmemo2.html; and Center for Security Policy Decision Brief, 21 November 2000, "Clinton Legacy Watch # 50: Stealthy Accord With Russia Threatens to Foreclose U.S. Space Power," available from http://www.security-policy.org/papers/2000/00-D91.html.

[201] Memorandum of Understanding on Notifications of Missile Launches (PLNS MOU), signed 16 December 2000.

[202] On the spectrum of opinion concerning the JDEC and PLNS see, for example, John Steinbruner, "Sharing Missile Launch Data," Pugwash Online, available from http://www.pugwash.org/publication/nl/nlv38n1/essay-steinbruner.htm; and "National Security Alert," Center for Security Policy, 8 December 2000, available from http://www.security-policy.org/papers/2000/00-A44.html.

[203] There are, of course, a virtually unlimited number of ways in which space viewpoints can be delineated and grouped together. These four camps are presented from a U.S. national security perspective; they could also be used for analysis at the global security level. There are also many strands of thought within any of these camps and some of them might even be contradictory. The four camps presented here are similar to Lupton's four space doctrines discussed above and are derived from the schools of thought about space weaponization discussed in Hays and Mueller, "Going Boldly—Where?" Moreover, the growing importance of commercial space activity adds a new dimension to this analysis that few of the traditional approaches seem well prepared to incorporate or even address. For a groundbreaking analysis that advocates using economic criteria to separate traditional military space functions from more regulatory functions that would be performed by a new United States Space Guard (modeled after the Coast Guard), see Lt Col Cynthia A.S. McKinley, "The Guardians of Space: Organizing America's Space Assets for the Twenty-First Century," *Aerospace Power Journal* 14, no. 1 (Spring 2000): 37-45.

[204] Senator Bob Smith, "The Challenge of Space Power," *Airpower Journal* 13, no. 1 (Spring 1999): 33. Prominent space hawk groups include High Frontier, the Heritage Foundation, and the Center for Security Policy.
[205] Space Commission Report, x. Most U.S. space policy, military space doctrine, and military officers probably fall into this camp.
[206] Maj William L. Spacy II, USAF, "Does the United States Need Space-Based Weapons?" *Cadre Paper 4* (Maxwell AFB, AL: Air University Press, September 1999), 109. Emphasis in original. See also Maj David W. Zeigler, "Safe Heavens: Military Strategy and Space Sanctuary," in Col Bruce M. DeBlois, ed., *Beyond the Paths of Heaven: The Emergence of Space Power Thought* (Maxwell AFB, AL: Air University Press, September 1999), 185-245.
[207] Lt Col Bruce M DeBlois, "Space Sanctuary: A Viable National Strategy," *Airpower Journal* 12, no. 4 (Winter 1998): 41-57. This article is one of the most comprehensive and persuasive expositions of the space dove camp.
[208] Model I (rational actor), Model II (organizational process), and Model III (bureaucratic politics) are commonly used lenses for examining governmental decision-making that were developed by Graham T. Allison in *Essence of Decision: Explaining the Cuban Missile Crisis* (Boston: Little, Brown and Company, 1971).
[209] See, in particular, the outstanding analysis of trigger events for space weaponization in Barry D. Watts, *The Military Use of Space: A Diagnostic Assessment* (Washington, D.C.: Center for Strategic and Budgetary Assessments, February 2001), 97-106. Watts argues that: "There are at least two paths by which orbital space might become a battleground for human conflict. One consists of dramatic, hard-to-miss trigger events such as the use of nuclear weapons to attack orbital assets. The other class involves more gradual changes such as a series of small, seemingly innocuous steps over a period of years that would, only in hindsight, be recognized as having crossed the boundary from force enhancement to force application. For reasons stemming from the railroad analogy . . . the slippery slope of halting, incremental steps toward force application may be the most likely path of the two." Watts discusses high-altitude nuclear detonations (discussed in the next section of this essay), failure of nuclear deterrence, and threats to use nuclear ballistic missiles during a crisis as the most likely of the dramatic trigger events. For Watts, the most likely of the gradual paths to weaponization is illustrated by using the development and military implications of railroads as an analogy for space: "first, orbital mechanics makes satellites more like railroads than aircraft or capital ships; second, the main function of these orbital railroads is to collect and transport information to users on earth, particularly information about enemy forces and capabilities. If this information collection-and-transport use is the main value of satellite systems, then it follows immediately that there are a lot more ways to interrupt space-based or space-dependent information flows than physically destroying satellites. For instance, if an enemy happened to be deriving military information about American force deployments from commercial satellites, an entirely non-lethal solution would be to use diplomatic pressure to cut off the opponent from further information. Other approaches could range from jamming

vulnerable segments of the information chain to using terrestrial forces to interdict the satellite ground stations or other nodes through which the information was being routed.

These possibilities have an important implication for our understanding of space warfare. If a terrestrial attack on an adversary's satellite ground station can deny use of certain space-dependent information, then it is plausible to argue that capabilities for space warfare exist today, even though lethal weapons are not currently deployed in orbital space.

It is not difficult to foresee, then, how nations could begin gradually sliding down a slippery slope toward the weaponization of near-earth space without being fully cognizant of the eventual end state. Over a period of years nations could engage in numerous activities short of outright weaponization that, in the long run, could lead to an environment in which the deployment and use of weapons in or from space would emerge as a logical and natural next step. Consider the following activities:

- using earth-based lasers to dazzle the optical arrays of electro-optical imaging reconnaissance satellites whenever they appear above the horizon;
- active jamming of imaging radar satellites;
- widespread jamming of GPS location and timing information;
- positioning satellites in orbit in close proximity with the satellites of one's military, economic or political competitors;
- the use of satellites with active, high-power radars to degrade the electronics of adversary satellites; and
- capturing or corrupting the data streams to or from competitors' satellites."

[210] The single best and most up to date source on this threat are the "High Altitude Nuclear Detonations (HAND) Against Low Earth Orbit Satellites ('HALEOS')" Slides, Advanced Systems and Concepts Office, Defense Threat Reduction Agency, April 2001, available from http://www.dtra.mil/about/organization/haleos.ppt. (Hereinafter HALEOS Slides). One of the key findings of this study is: "One low-yield (10-20 kt), high-altitude (125-300 km) nuclear explosion could disable—in weeks to months—**all** LEO satellites not specifically hardened to withstand radiation generated by that explosion." Slide 4, emphasis in original. This study estimated replacement costs in excess of $50 billion for all the systems potentially disabled by a HAND (Globalstar, OrbComm, Iridium, Teledesic, Skybridge, Weather Satellites, Commercial imaging and mapping satellites, and research systems such as the International Space Station and the Hubble Space Telescope). Slides 17-22. Other detailed open source discussions of these phenomena are found in Samuel Glasstone and Philip J. Dolan, *The Effects of Nuclear Weapons*, Third Edition, (Washington, D.C.: Department of Defense and Department of Energy, 1977), 350-353, 383-385, 474-478, and 514-540; Lupton, *On Space Warfare*, 71-75; Bruce G. Blair, *Strategic Command and Control: Redefining the Nuclear Threat* (Washington, D.C.: Brookings Institution, 1985), Appendix C, "Electromagnetic Pulse," and Appendix D, "Satellite Vulnerability to System-Generated EMP," 321-331; Ashton B. Carter, "Communication Technologies and Vulnerabilities," in Ashton B. Carter, John D. Steinbruner, and

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Charles A. Zraket, eds., *Managing Nuclear Operations* (Washington, D.C.: Brookings Institution, 1987), 217-281; Watts, *Military Use of Space*, 19, 98-102; and Tom Wilson, Threats to United States Space Capabilities," Staff Paper for the Commission to Assess United States National Security Space Management and Organization, available from https://www.space.gov/commission/support-docs/article05/article05.html.

[211] Kenneth F. McKenzie, Jr., "The Revenge of the Melians: Asymmetric Threats and the Next QDR," *McNair Paper 62* (Washington, D.C.: Institute for National Strategic Studies, National Defense University, 2000), 38. One factor that might devalue HAND in the minds of terrorists is the fact that such an attack would lack the type of powerful visual imagery produced by the 11 September 2001 terrorist attacks on the World Trade Center and the Pentagon.

[212] The damage caused to satellites in line of sight by prompt X-rays decreases with the inverse square of the distance between the satellite and the explosion ($1/R^2$). HALEOS Slide 9.

[213] The cumulative effects are caused when unstable nuclear fission fragments decay, emitting electrons that are trapped in the Earth's magnetic field and increase the peak radiation flux in parts of LEO by 3-4 orders of magnitude. The predicted lifetime of LEO satellites drops precipitously following a HAND; for example, an Iridium satellite would go from having a 72-month normal lifetime to about one month. The lower Van Allen radiation belt would remain "excited" for six months to two years. See Watts, *Military Use of Space*, 99; and HALEOS Slides 9-12.

[214] Although not directly analogous, consider the range of predictions concerning the Y2K computer software problem. Different initial assumptions can drive even the best models to widely divergent results; this is especially true when attempting to model systemic effects for complex, interdependent systems. Wilson lists "Reliable Threat Analyses" as his first strategy for enhancing satellite survivability, 41.

[215] Glasstone and Dolan, *The Effects of Nuclear Weapons*, 45; and Stares, *Militarization of Space*, 107-8. The major tests and series included: The HARDTACK Series above Johnson Island in the Pacific consisting of TEAK (1 August 1958, 48 miles altitude), and ORANGE (12 August 1958, 27 miles); the ARGUS Operation in the South Atlantic in September 1958 consisting of three 1-2 kiloton bursts from 125-300 miles altitude; and the FISHBOWL Series above Johnson Island consisting of STARFISH PRIME (9 July 1962, 248 miles, 1.4 megatons) and three subsequent submegaton devices in October and November of 1962. Significant ground communication disruptions were recorded in Hawaii (700 miles away) following the STARFISH PRIME detonation and this explosion also eventually caused the failure of seven satellites in LEO at the time of the test.

[216] Stares, *Militarization of Space*, 107.

[217] HALEOS Slide 31, emphasis in original.

[218] Watts, Military Uses of Space, 101.

[219] This escalatory ladder is imbedded in Office of the Secretary of Defense, *Proliferation: Threat and Response* (Washington, D.C.: Department of Defense, November 1997); and is fleshed out in Hays, Jodoin, and Van Tassel, *Countering*

WMD. The latest version of *Proliferation: Threat and Response* was published in January 2001.

[220] Anti-western groups or states might view the destruction of the global information infrastructure as a desirable outcome regardless of (or perhaps because of) their level of connectivity with this infrastructure. Positive security assurances are commitments to come to the aid of states that have forsworn WMD but are being threatened with their use. Negative security assurances are commitments not to use WMD against states that do not have them. See Ronald F. Lehman, "Reassurance and Dissuasion: Countering the Motivation to Acquire WMD," in Hays, Jodoin, and Van Tassel, *Countering WMD*, 89-120.

[221] At a minimum, it would seem prudent for the United States to specify both the types of "purposeful interference" that would trigger an automatic response and to spell out what the response options might include in order to strengthen the rather milk-toast statement in its current space policy: "Purposeful interference with space systems shall be viewed as an infringement on sovereign rights." National Science and Technology Council, "Fact Sheet: National Space Policy," (Washington, D.C.: The White House, 19 September 1996).

[222] Wilson, "Threats to U.S. Space Capabilities," 43.

[223] HALEOS Slide 30.

[224] Three U.S. firms—Space Imaging, EarthWatch, and OrbImage—are developing high-resolution commercial remote sensing systems (Ikonos, QuickBird, and OrbView, respectively) and they face significant foreign competition from systems such as SPOT, the Indian Remote Sensing (IRS) satellites (marketed by Space Imaging), and EROS (an Israeli-U.S. joint venture). Ikonos 1 failed to reach orbit following its launch from Vandenberg AFB on 27 April 1999. The first commercial one-meter resolution remote sensing system became operational following the successful launch of the Ikonos 2 satellite aboard a Lockheed-Martin Athena II booster from Vandenberg AFB on 24 September 1999. See Vernon Loeb, "Spy Satellite Will Take Photos for Public Sale," *Washington Post*, 25 September 1999, 3. The Ikonos system can provide resolutions of 0.82 meters ground sample distance per pixel for digitized panchromatic images and four meters for multispectral images. EarthWatch's QuickBird 1 was launched aboard a Cosmos 3M expendable launch vehicle (ELV) from Plesetsk on 21 November 2000 but failed to reach the proper orbit and was presumed destroyed. Jason Bates, "QuickBird Loss Hits Firm, Remote Sensing Industry," *Space News*, 4 December 2000, 3. ImageSat (formerly West Indian Space)—a joint venture between two Israeli companies (Israel Aircraft Industries and Electro-Optics Industries) and Core Software of Pasadena, California—successfully launched its EROS A1 0.82-meter resolution system (that is derived from Israel's Ofeq 3 spysat) aboard a Start 1 ELV from Svobodni, Siberia on 5 December 2000. ImageSat "does not believe it is subject to U.S. jurisdiction regarding export licenses." See "West Indian Space Changes Name to ImageSat, Announces Product Offerings," *SPACEandTECH Digest*, on-line, Internet, 23 January 2001, available from http://www.spaceandtech.com/digest/sd2000-22/sd2000-22-007.shtml; and ImageSat's website, http://www.imagesatintl.com. In

December 2000, the National Oceanic and Atmospheric Administration (NOAA) awarded the first two half-meter resolution licenses to Space Imaging and EarthWatch. The half-meter licenses "contain a provision that calls for a 24-hour delay from collection of an image to distribution to a customer." See Jason Bates, "U.S. approves Licenses for Two Imaging Satellites with Half-Meter Resolution," *Space.com*, 18 December 2000, on-line, Internet, 19 December 2000, available from http://www.space.com/businesstechnology/business/satellite_licenses_001212.html.

EarthWatch's corporate roots go back to WorldView Imaging (the first licensee for a high-resolution commercial system) and Ball Aerospace. Space Imaging's lineage includes the Eosat, Lockheed-Martin, and Raytheon corporations. In addition, from the 1950s until losing a $4.5 billion NRO Future Imagery Architecture (FIA) contract to Boeing in 1999, Lockheed had been the NRO's primary spysat contractor. See Tim Smart, "Lockheed Loses Big U.S. Contract," *Washington Post*, 8 September 1999, E1. OrbImage is a corporate affiliate of the Orbital Sciences Corporation. According to the *Commercial Space Opportunities Study* (CSOS), the Air Force spends $10 million annually on commercial imagery (this includes the innovative Eagle Vision activities); the report recommends that spending be increased to $80 million annually for each year in the Future Years Defense Program (FYDP). Headquarters Space and Missile System Center, Developmental Planning Directorate and Headquarters Air Force Space Command, Directorate for Plans and Programs, *Final Report: Commercial Space Opportunities Study* (Los Angeles AFB, CA: Commercial Exploitation Planning Office, 16 February 2000), 3-13.

On the security implications of high-resolution commercial remote sensing see Yahya A. Dehqanzada and Ann M. Florini, *Secrets for Sale: How Commercial Satellite Imagery Will Change the World* (Washington, D.C.: Carnegie Endowment for International Peace, 2000); Gerald M. Steinberg, "Dual Use Aspects of Commercial High-Resolution Imaging Satellites," Security and Policy Studies No. 37, (Bar-Ilan University, Israel: Begin-Sadat Center for Strategic Studies, February 1998); and Vipin Gupta, "New Satellite Images for Sale," *International Security* 20 (Summer 1995): 94-125.

[225] "Pursuant to the 1992 Land Remote Sensing Policy Act and Administration policy on foreign access to remote sensing space capabilities, responsibilities have been delegated from the Secretary of Commerce to the Assistant Administrator of NOAA's National Environmental Satellite, Data, and Information Service (NOAA/NESDIS) for the licensing of companies to operate private space-based remote sensing systems." See NOAA Commercial Remote Sensing Satellite Systems website at http://www.licensing.noaa.gov/. As of January 2001, NOAA had granted a total of 17 licenses. The text of PDD-23 remains classified but a press release and fact sheet accompanied the directive. The press release quoted Vice President Al Gore on the many advantages of improved resolution for benign civil applications and environmental monitoring and the importance of the $15 billion total annual worldwide market for remote sensing data and applications that was expected to develop by the year 2000. The fact sheet covers the specifics of PDD-23

in considerable detail and is available on-line from http://www.fas.org/irp/offdocs/pdd23-2.htm. For detailed background and analysis on this issue see, Lt Col Peter L. Hays and Lt Col Roy F. Houchin, II, "Commercial Spysats and Shutter Control: The Military Implications of U.S. Policy on Selling and Restricting Commercial Remote Sensing Data," paper prepared for the USAF Institute for National Security Studies, 1 October 1999; and Lt Col Peter L. Hays, "Transparency, Stability, and Deception: Military Implications of Commercial High Resolution Remote Sensing Satellites in Theory and Practice," Paper Presented at the International Studies Association Annual Convention, Chicago, 21-24 February 2001..

[226] Report of the National Commission for the Review of the National Reconnaissance Office, *The NRO at the Crossroads* (Washington, D.C.: National Commission for the Review of the National Reconnaissance Office, 1 November 2000), quotations from pages 67, 74, and 71.

[227] Report of the Independent Commission on the National Imagery and Mapping Agency, *The Information Edge: Imagery Intelligence and Geospatial Information in an Evolving National Security Environment* (Washington, D.C.: Independent Commission on the National Imagery and Mapping Agency, December 2000), quotations from pages viii, 60, and 33.

[228] Ibid., 56.

[229] Ibid., 16. On DOD's pledge to buy $1 billion worth of commercial imagery over the FYDP see, for example, Warren Ferster, "U.S. to Buy Private Imagery for Intelligence," *Space News*, 12 April 1999, 1 and 34.

[230] *The Information Edge*, 89.

[231] Ibid., 90.

[232] Steven Livingston, "Transparency or Opacity? Information Technology and Deception Operations," paper presented at the International Studies Association Annual Convention, Chicago, 21-24 Feb 2001. Livingston's quotation is from Don E. Tomlinson, "Computer Manipulation and Creation of Images and Sounds: Assessing the Impact," Washington, D.C.: The Annenberg Washington Program, 1993). See also Ivan Amato, "Lying with Pixels," *Technology Review* (July/August 2000).

[233] Kimberly Amaral, "The Digital Imaging Revolution: Legal Implications and Possible Solutions," available from http://www.umassd.edu/Public/People/KAmaral/Thesis/digitalimaging.html.

[234] Dehqanzada and Florini, *No More Secrets*, viii.

[235] On 9 June 1999, the Canadian Ministries of Foreign Affairs and Defense announced that they had formed an interdepartmental team of experts who are charged with developing new "access control" legislation to control Canadian commercial remote sensing satellites. The principles guiding the interdepartmental team are very similar to PDD-23 and the process of drafting and implementing the policy is expected to take up to two years. The News Release and a Backgrounder are available at http://198.103.104.118/minpub/Publication.asp?FileSpec= / Min_Pub_Docs/101271.htm. Unlike many other dual-use technologies

(pharmaceutical plants, for instance), high-resolution remote sensing systems are limited in number, expensive to build, and very difficult to launch or operate covertly. They could, therefore, be more easily controlled than many other types of dual-use technology.

236 Kerry Gildea, "NIMA Extends Deal with Space Imaging for Exclusive Imagery Over Afghanistan," *Defense Daily*, 7 November 2001, 2; "Eye Spy," *The Economist*, 10-16 November 2001; and Pamela Hess, "DOD Won't Release Pix Until 5 Jan," *Washington Times*, 7 November 2001. In addition, the French Ministry of Defense barred SPOT Image from selling or distributing images of Afghanistan and the surrounding regions to anyone except that ministry. "Shutter Control for SPOT Over Afghanistan," *Space Newsfeed*, 28 October 2001, available from http://www.spacenewsfeed.co.uk/2001/28October2001.html. These decisions have left Cypress-based ImageSat International as the only company able to provide one-meter commercial imagery of Afghanistan and the surrounding region. Barbara Opall-Rome, "U.S. Data Purchase Opens Doors for ImageSat," *Space News*, 22 October 2001, 6.

237 Lt Gen Bruce Carlson, USAF, "Protecting Global Utilities: Safeguarding the Next Millennium's Space-Based Public Services," *Aerospace Power Journal* 14, no. 2 (Summer 2000): 37. For a more detailed discussion of why GPS does not fit exactly into existing categories of "natural monopoly," "public good," "utility, " or "dual-use technology" see Scott Pace, et al., *The Global Positioning System: Assessing National Policies* (Washington, D.C.: RAND Critical Technologies Institute, 1995), 184-89.

238 Carlson, "Protecting Global Utilities," 38. All modern "digital compression" telecommunication protocols such as time division multiple access (TDMA) or code division multiple access (CDMA) require highly accurate timing signals to operate.

239 Ibid., 37. Emphasis in original. The PanAmSat Corporation's *Galaxy 4* satellite failed on 19 May 1998.

240 John M. Logsdon, "Just Say Wait to Space Power," *Issues in Science and Technology* (Spring 2001), n.p.; on-line, Internet, 24 April 2001, available from http://www.nap.edu/issues/17.3/p_logsdon.htm.

241 USSPACECOM perhaps made this "Flag Follows Trade" argument most strongly in *Long Range Plan: Implementing USSPACECOM Vision for 2020* (Peterson AFB, Colo: U.S. Space Command, Director of Plans, March 1998).

242 Carlson, "Protecting Global Utilities," 41.

243 Planetary Defense or the effort to track and eventually defend against potentially life threatening near-Earth objects (NEO) that might impact Earth is another high-profile window for cooperation on a space-related issue but it does not appear to be a traditional control or regulation effort and is not discussed in this essay. For more information about Planetary Defense see, for example, "Preparing for Planetary Defense: Detection and Interception of Asteroids on Collision Course with Earth," *SPACECAST 2020* Appendix R, available from http://www.au.af.mil/Spacecast/app-r/app-r.doc; *Air Force 2025* Research Paper, "Planetary Defense: Catastrophic Health Insurance for Planet Earth," available from

http://www.au.af.mil/au/2025/volume3/chap16/v3c16-1.htm; and Brigadier General S. Pete Worden, NEOs, Planetary Defense and Government: A View from the Pentagon," available from http://www.spaceviews.com/2000/04/article2a.html.

[244] "Frequently Asked Questions about Orbital Debris," NASA-Johnson Space Center, Space Science Branch, available at http://orbitaldebris.jsc.nasa.gov/faq/faq.html.

[245] Ibid.

[246] The European Space Agency estimates that 44 percent of the catalogued orbit population (larger than 10 cm) originated from the 129 on-orbit fragmentations recorded since 1961. See European Space Agency, "Introduction to Space Debris," available from http://www.esoc.esa.de/external/mso/debris.html; and the Aerospace Corporation's "What is Orbital Debris?" website at http://www.aero.org/cords/orbdebris.html. Until fairly recently, several spacefaring states (Russia in particular) routinely blew up their satellites at the end of their useful life. Inadvertent mixing of propellant and oxidizer and over pressurization of residual fuel or batteries are the most common causes of unintentional explosions.

[247] In LEO (less than 2000 km altitude) the average relative velocity at impact is 10 km per second. At this speed: "An aluminum sphere 1.3 mm in diameter has damage potential similar to that of a .22-caliber long rifle bullet. An aluminum sphere 1 cm in diameter is comparable to a 400-lb safe traveling at 60 mph. A fragment 10 cm long is roughly comparable to 25 sticks of dynamite." In GSO, average relative velocity at impact is much lower (about 200 meters per second) because most objects in the geostationary ring move along similar orbits. See "What are the Risks of Orbital Debris?" available from http://www.aero.org/cords/debrisks.html.

[248] Aerospace Corporation, "What is the Future Trend?" available from http://www.aero.org/cords/future.html. The Space Shuttle must infrequently (every year or two) maneuver away from known orbital debris. Critical components on the International Space Station have been designed to withstand the impact of debris up to 1 cm in diameter.

[249] Historic Space Policy documents are available from the Air War College's Space Operations & Resources Gateway, available at http://www.au.af.mil/au/awc/awcgate/histpol.htm. The first emphasis on orbital debris in National Space Policy came in President Reagan's 11 February 1988 National Space Policy and by the Clinton Administration's 19 September 1996 National Space Policy, mitigation of orbital debris was a major intersector guideline:

> (7) Space Debris
>
> (a) 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.

(b) It is in the interest of the U.S. Government to ensure that space debris minimization practices are applied by other spacefaring 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.

[250] Leonard David, "Eye in the Sky to Track Space Junk," *Space.com*, 7 November 2000, available from http://www.space.com/businesstechnology/technology/space_trafficcontrol_001102.html.

[251] For a detailed discussion of STCS (especially the technical requirements for such a system) see "Space Traffic Control: The Culmination of Improved Space Traffic Operations," *SPACECAST 2020*, Appendix D, available from http://www.au.af.mil/Spacecast/app-d/app-d.html.