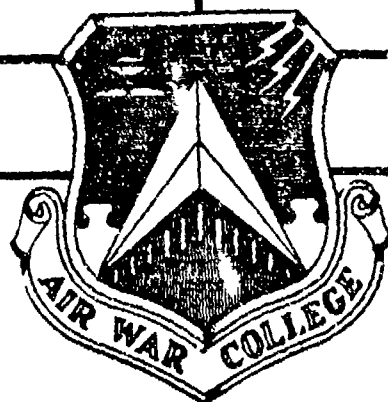




AIR WAR COLLEGE

RESEARCH REPORT

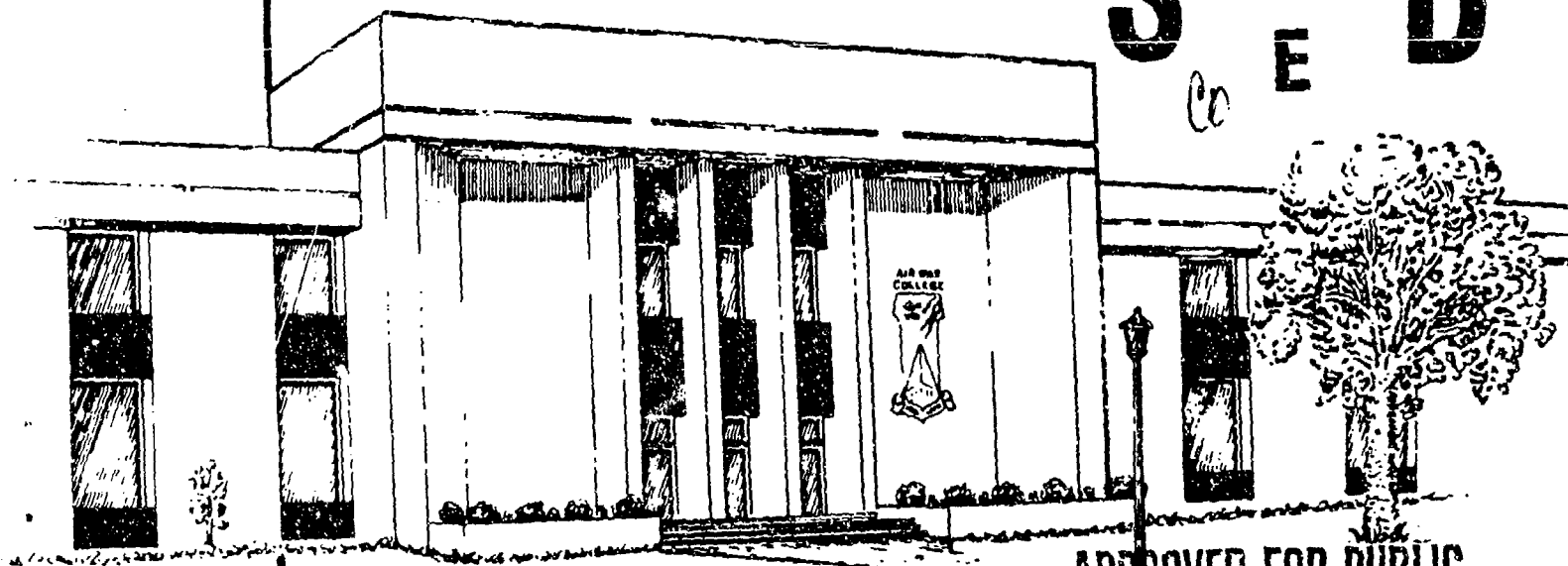
A U.S. ASAT: DO WE NEED IT?

COMMANDER JOE A. BAKER, USN

AD-A217 265

1989

DTIC
ELECTE
FEB 01 1990
S E D
Co



AIR UNIVERSITY
UNITED STATES AIR FORCE
MAXWELL AIR FORCE BASE, ALABAMA

APPROVED FOR PUBLIC
RELEASE, DISTRIBUTION
UNLIMITED

00 02 01 058

**AIR WAR COLLEGE
AIR UNIVERSITY**

A U.S. ASAT: DO WE NEED IT?

by

**Joe A. Baker
Commander, USN**

A DEFENSE ANALYTICAL STUDY SUBMITTED TO THE FACULTY

IN

FULFILLMENT OF THE CURRICULUM

REQUIREMENT

Advisor: Captain D. Glen Oakes, USN

MAXWELL AIR FORCE BASE, ALABAMA

May 1989

DISCLAIMER

This study represents the views of the author and does not necessarily reflect the official opinion of the Air War College or the Department of the Air Force. In accordance with Air Force Regulation 110-8, it is not copyrighted but is the property of the United States government.

Loan copies of this document may be obtained through the interlibrary loan desk of Air University Library, Maxwell Air Force Base, Alabama 36112-5564 (Telephone: (205) 293-7223 or AUTOVON 875-7223).

EXECUTIVE SUMMARY

TITLE: A U.S. ASAT: Do We Need It?

AUTHOR: Joe A. Baker, Commander, USN

Remarks on some historical aspects in the development of antisatellite (ASAT) weapons within the United States and the Soviet Union introduce a brief discussion of the current status of ASAT development within the U.S. The vital importance of space systems for U.S. strategic and tactical interests is described, followed by a treatment of the Soviet military space threat to those interests, setting the stage for an in-depth review of U.S. ASAT policy issues. The author addresses several of the outstanding issues, questions, and concerns about ASAT, including its appropriateness, military essentiality, impact on arms control, and its close relationship with Ballistic Missile Defense (BMD) initiatives. The purpose is to highlight the diversity and significance of the issues concerning ASAT development and to demonstrate the importance these issues have on current and future U.S. military space policy.

Handwritten notes:
 Review of the current status of defense systems
 and the Soviet military space threat

Accession For	
NTIS GRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	



BIOGRAPHICAL SKETCH

Commander Joe A. Baker received his Bachelor of Science degree from Georgia State University and a Master of Science degree from Troy State University. Commissioned in 1973 and designated a Naval Aviator in 1974, he has spent the majority of his career in aviation tours with Helicopter Combat Support Squadrons in both the Pacific and Atlantic Fleets. During the past two years, he served on the staff of the Naval Space Command headquartered in Dahlgren, Virginia. Commander Baker is a graduate of the Air War College, class of 1989.

TABLE OF CONTENTS

CHAPTER		PAGE
	DISCLAIMER.....	ii
	EXECUTIVE SUMMARY.....	iii
	BIOGRAPHICAL SKETCH.....	iv
	TABLE OF CONTENTS.....	v
I	INTRODUCTION.....	1
II	SPACE AND SPACE SYSTEMS:	
	THEIR GROWING MILITARY IMPORTANCE.....	5
III	THE SOVIET SPACE THREAT.....	9
	Soviet Space Doctrine and Strategy.....	9
	Space Programs and Capabilities.....	10
	Early Warning Satellites.....	11
	Electronic Intelligence Satellites.....	12
	Antisatellite and Strategic Defense Capabilities.....	13
	Co-Orbital Interceptor.....	14
	Galosh ABM System.....	16
	Ground-Based Lasers.....	17
	Electronic Warfare (EW).....	18
	Space System Augmentation/Reconstitution.....	19
IV	THE ASAT/BMD LINK.....	20
V	ARGUMENTS: PRO AND CON.....	24
	Arguments For ASAT.....	26
	Arguments Against ASAT.....	28
VI	CONCLUSIONS.....	31
	BIBLIOGRAPHY.....	33

CHAPTER I

INTRODUCTION

On 19 October 1959, a little less than two years after launching its first satellite, the United States successfully tested an aircraft-launched antisatellite (ASAT) missile against an orbiting satellite. (9:14) This early weapon would have carried a nuclear warhead as a means of satellite destruction. (22:14) Despite this and other military uses of space, the United States and the Soviet Union signed, in 1967, the Outer Space Treaty which focused on the peaceful uses of space. (16:79; 9:17) Almost a year later, the Soviet Union began testing its first ASAT weapon, which could destroy a satellite using a conventional explosive or by direct impact. (22:15) Thus began the development of space weapons and a new arms race.

Today, the United States has no operational ASAT, while the USSR possesses the only specifically designed antisatellite weapon system in operational service. In addition, the Soviets have at their disposal a range of nondedicated ASAT capabilities that could be used against U.S. space systems.

Whether the United States should proceed with the development and deployment of antisatellite weapons is the subject of this paper. The implications of going ahead are enormous and complex. At stake is not only the security of each side's space systems in wartime, but the possibility that the threat of their loss would inject dangerous uncertainties into each superpower's calculations during a severe crisis.

EVOLUTION OF THE ASAT ISSUE

The fact that the Soviet Union possesses an operational, if limited, ASAT capability while the United States does not, has been the subject of heated

and continuing debate. The long-running argument over whether the United States should develop and deploy its own ASAT as a counter to the Soviet ASAT has been a hotly contested issue within such diverse circles as national policymaking and scientific groups, the U.S. Congress, and international space organizations.

For the past 13 years the United States has had no consistent policy regarding U.S. ASAT's. During the late 60's and early 70's the issue was hardly cause for concern because both U.S. and Soviet ASAT programs were roughly equal, neither side possessing a reliable or sophisticated weapon and neither side seeming quite willing to devote extensive effort into their further development. Though tests of the Soviet system were carried out intermittently between 1968 and 1971, it was their resumption in 1976 that led President Ford in the last days of his administration to authorize a reinvigoration of the U.S. antisatellite program. (48:2) That the United States had fully decommissioned its last remaining nuclear-armed antisatellite system in 1975 made the Soviet action appear even more threatening.

Upon his assumption to office, President Carter believed that it was in the interests of both countries to avoid an antisatellite arms competition and proposed bilateral negotiations with the Soviet Union to prohibit these weapons. As part of a two-track strategy to provide bargaining leverage at the talks and to hedge against their failure, the U.S. ASAT program was allowed to continue. (14:45) Though talks eventually were held, they proved fruitless and ceased altogether after the Soviet invasion of Afghanistan.

Although the Soviet Union's unwillingness to dismantle its existing ASAT system was the main reason for the failure to reach an agreement, by the early 1980's the U.S. and Soviet positions on ASAT arms control had essentially

become reversed. Instead of being the reluctant partner, the Soviet Union became the champion of strict limits on space weapons. In 1981 the Soviets proposed a draft treaty to the UN General Assembly calling for a ban on weapons in outer space. (16:86) In August 1983, the Soviet leader Yuri Andropov, declared during a meeting with nine U.S. Democratic Senators that "the USSR commits itself not to be the first to put into outer space any type of antisatellite weapon, that is, imposes a unilateral moratorium. . . ." (22:19; 40:83) Later in 1983, the Soviet Union submitted a more inclusive draft treaty to the UN where they finally admitted the existence of their co-orbital ASAT system and indicated a willingness to dismantle the system provided the United States discontinued its ASAT program. (12:220-221)

The Reagan administration steadfastly rejected these initiatives. Arguing that the dismantlement of the Soviet ASAT system would be impossible to verify and that the presence of residual Soviet ASAT weapons make specific limits of dubious worth, the administration proposed that a U.S. antisatellite capability was both essential as a deterrence against attacks on U.S. and allied space systems and to negate the threat from Soviet space systems. (13:897; 12:221)

In addition to ushering in a plethora of arms-control policy questions, President Reagan's Strategic Defense Initiative (SDI) has arguably made the strongest impact on the U.S. ASAT policy debate. Critics of SDI have written persuasively about the destabilizing effect of the proposed antiballistic missile system and their arguments have not fallen on deaf ears. In 1986, Congress placed a moratorium on further testing of the Air Force's "direct ascent" ASAT, and in 1988 the Air Force formally disbanded the project. (41:3) Still, the Reagan administration continued to argue for a U.S. ASAT, and in his

1990 budget submission, President Reagan requested \$412.5 million for the Department of Defense to build and deploy land-based and sea-based kinetic energy and directed energy ASAT's. (7:22)

The remainder of this paper examines the military strategic and tactical importance of current U.S. and Soviet space systems and the arguments for and against development of a U.S. ASAT, with a brief look at ASAT implications resulting from SDI.

CHAPTER II

SPACE AND SPACE SYSTEMS--THEIR GROWING MILITARY IMPORTANCE

In addition to the many and varied services provided to commercial users, space systems are becoming more and more necessary for enhancing the war-fighting effectiveness of armed forces--in essence, they have become valuable force multipliers. Virtually every type of military scenario, from small conventional conflict to global nuclear exchange, is now likely to heavily involve satellites. The United States and the Soviet Union operate on a daily basis close to 150 satellites for such military support missions as intelligence gathering, early attack warning, arms control verification, communication, navigation, weather forecasting, and mapping. (48:15) Reconnaissance satellites are increasingly used to locate, track, and target mobile military forces. Communications satellites have improved substantially the command, control, and communications (C³) functions associated with military forces, and they carry more than 70% of all long-haul U.S. military communications. (10:87; 14:51) Navigation satellites may soon make it possible for extremely accurate targeting resolutions for both strategic and tactical weapons. (48:16)

To determine whether it is desirable or feasible to constrain the evolution of antisatellite technology, the roles of existing military satellites and their vulnerability to antisatellite weapons must be assessed. To do this it is important to distinguish among the different types of satellites and among the ways in which the U.S. and USSR are dependent on them.

The orbits of most satellites fall into four broad categories: (1) low orbits, which have a period of about 100 minutes and altitudes ranging from

around 120 kilometers up to several thousand kilometers; (2) geosynchronous orbits, in which the satellite circles the earth at the same rate as the earth's rotation and thereby remains above a fixed point on the Equator at an altitude of about 36,000 kilometers; (3) highly elliptical orbits, which descend to an altitude of several hundred kilometers at their perigee (lowest point) over the Southern Hemisphere and rise to an apogee (highest point) of around 40,000 kilometers over the Northern Hemisphere; and (4) semisynchronous orbits, which are roughly circular in an inclined plane at an altitude of about 20,000 kilometers.

The altitude of a satellite is important to its mission. A satellite in a low earth orbit has the most detailed view of the earth's surface and can also detect weak electronic signals from sources on the ground, at sea, or in the air. Accordingly photoreconnaissance, surveillance, and most electronic intelligence satellites are in low orbit. When the mission is to continuously survey large areas, to communicate with large areas, or to communicate with fixed ground sites, a geosynchronous orbit is preferred. U.S. satellites whose infrared sensors are designed to provide early warning of a Soviet missile firing are in such orbits, as are virtually all communications satellites.

Because the USSR has important facilities in the arctic region, where it is difficult to have a clear line of sight to a geosynchronous satellite above the Equator, the Soviets have introduced highly elliptical orbits known as Molniya orbits for many of their communications and early warning satellites. A satellite in such an orbit, with its apogee high over the Northern Hemisphere, remains visible to its ground station for eight hours or more of its 12-hour period.

Precise global navigation is another important military task that is being assisted by satellites. The earliest navigation satellites were in low orbits, but the improved U.S. Navstar Global Positioning System (GPS) satellites are now being deployed at an altitude of about 20,000 kilometers where comparatively few (18 to 24) satellites are required to have at least four in view simultaneously from any point on the earth. (24:48; 14:46) By having four satellites in view at any given time, the user will be able to obtain navigation fixes of unprecedented accuracy in three dimensions (position, velocity, altitude). The Soviet Union has likewise introduced a sophisticated global navigation satellite system called GLONASS which will be able to provide two-dimensional fixes for its ground customers. (16:33-34)

Although the military satellites of the United States and the Soviet Union have similar missions, they also have characteristic differences that affect their eventual vulnerability to antisatellite weapons. The persistent U.S. lead in microelectronics and other advanced technologies has led to U.S. reliance on a small number of highly sophisticated, reliable, and long-lasting satellites that often perform more than one function. Longevity is particularly important to the U.S. because of the high cost of launching such a satellite. As a result the United States has had to sustain a variety of satellite functions with fewer satellite networks, and it has had to operate them with less frequent replacements. (14:46)

The military satellites of the Soviet Union, on the other hand, are predominantly in low orbits, and they also have much shorter lifetimes. (24:1) This circumstance presumably reflects both operational choices and technological weaknesses. Soviet satellites are usually dedicated to a single mission. Moreover, they are generally deployed in larger constellations, and

because they are shorter lived than their U.S. counterparts, they must be replaced much more frequently.

Military satellites have quite different roles in peacetime, in a low-level conflict and in a strategic nuclear exchange. In peacetime low-orbit photoreconnaissance, surveillance, and electronic intelligence satellites provide information essential to arms control verification and routine military intelligence. In a crisis these satellites become particularly valuable to crisis management, and as soon as non-nuclear hostilities begin they would assume a dual role because they would also enhance the effectiveness of the combatants. Once a political crisis or a low-level armed conflict threatened escalation to a strategic nuclear exchange, the high altitude early warning and communications satellites would display the same duality: they would be significant factors in the attempt to prevent the exchange, and yet they would be important assets to the strategic forces if the attempt at prevention were to fail. (14:47)

The number of military satellites in use by the superpowers will probably not change dramatically before the mid-1990's. Beyond the mid-1990's new military applications of satellites could add significantly to the number of operational space systems. These include strategic and tactical surveillance, ballistic missile defense, air defense surveillance, satellite tracking, and submarine tracking and detection. (48:39) Manned space activities may also become more common.

CHAPTER III

THE SOVIET SPACE THREAT

SOVIET SPACE DOCTRINE AND STRATEGY

Soviet military writings suggest that leaders of the USSR expect any future war involving the superpowers to be a short and decisive clash between diametrically opposed capitalist and socialist worlds; hence global in scope. They therefore intend to use all available resources in a combined and integrated fashion to overwhelm the enemy and achieve a quick victory. (44:vii) A protracted conflict is to be avoided. Consequently, emphasis probably will be placed on mass, surprise, and mobility; every effort would be made to seize and maintain the initiative in the early phases of a war. (43:12)

Contrasting earlier Soviet views, recent trends in Soviet thought reflect a somewhat modified perspective concerning the inevitability of strategic nuclear war between the superpowers. Apparently Soviet leaders and strategists now believe that with their more technologically sophisticated military capabilities, a conventional war with the U.S. and its allies could be fought and won. Accordingly, Soviet grand strategy today places a greater premium on escalation control as a means of avoiding a devastating and potentially unnecessary strategic nuclear exchange.

With regard to space warfare, Soviet doctrine evidently emphasizes space as a warfighting medium. (46:--) DIA analyses of the known organization and capabilities of the Soviet space program arrived at the following probable military space doctrine:

The Soviet Armed Forces shall be provided with all resources necessary to attain and maintain military superiority in outer

space sufficient both to deny the use of outer space to other nations and to support Soviet offensive and defensive combat operations on land, at sea, in air, and in outer space. (44:vii)

The Soviet view of space as a medium for warfare can be traced to the earliest days of space activity. Once SPUTNIK was launched in 1957 and space exploration became a reality, the first indicators of a military space doctrine began to appear in Soviet military literature. In the early 1960's Marshal Vassily Sokolovsky, author of Soviet Military Strategy, wrote of a need for space support to strategic operations, and of a future need for space-based weapons. (46:3) By 1965 the statement "mastery of space is an important prerequisite for achieving victory in war," appeared in the Soviet Dictionary of Basic Military Terms as well as in Soviet military texts. (46:3) In 1972, references to combat zones in space, new technology for the development of lasers, heavy lift boosters, and space-to-space weapons were appearing in Soviet military publications. (46:4) The U.S. Department of Defense assesses that the key elements in Soviet military doctrine are the overwhelming offensive application of superior military force to further Soviet interests and a combined arms approach to combat operations and that these elements are equally important in Soviet military space doctrine. (46:5) To a large degree this assessment of Soviet military space doctrine does parallel the actual design, development, and deployment of the USSR's military space systems.

SPACE PROGRAMS AND CAPABILITIES

The Soviet space program is a dynamic and expanding effort, resulting in approximately 100 launches per year from any of three multi-pad launch sites--Tyuratam, Plesetsk, and Kapustin Yar. (46:6) Some 85-90% of these launches are estimated to be exclusively for military or joint military and civilian missions. (10:85; 24:68; 46:6) While the classification of an individual

satellite or satellite system by Western analysts as "military" or "civilian" is often difficult or misleading, some satellite objectives by their very nature are purely military both in design and in practice. This section describes those Soviet satellite missions which have direct military application and which serve as the most notable Soviet threats to the United States and its allies: ballistic missile early warning, electronic intelligence, and antisatellite and strategic defense capabilities. While other satellite systems—photoreconnaissance, communications, navigation, and meteorological, which are advertised by the Soviets as having only civilian applications—are not assessed, they would most certainly be put to military use in the event of conflict situations.

Early Warning Satellites. During 1987 the Soviet Union apparently reached full operational capability for the first time with their trouble-plagued, 15-year-old early warning program. (24:66) With a 9-satellite constellation, the USSR presently maintains the 24-hour-a-day coverage required by this vital mission. The satellites, circling the earth in highly elliptical, 12-hour Molniya orbits, guarantee at least one satellite will be in position to observe the central and western United States, home of the U.S. ICBM forces. (24:68) A geosynchronous network capable of detecting submarine-launched ballistic missiles (SLBMs) is expected "in the next several years." (46:7)

After a test period from 1972 to 1975 and a period of limited operational capability from 1976 to 1980, the Soviets in late 1980 began an expansion of the early warning network aimed at bringing the system to full operational capability. According to a U.S. Department of Defense assessment, the network now provides the Soviet Union with half an hour's warning of any American ICBM attack and with information concerning the site of origin of the missiles. (45:9)

Electronic Intelligence Satellites. Electronic intelligence (ELINT) satellites represent a subset of the general class of military surveillance satellites, commonly referred to as spy satellites. While photoreconnaissance satellites collect strategic and tactical data in the visible portion of the electromagnetic spectrum, ELINT satellites concentrate on the longer wavelengths in the radio and radar regions. If photoreconnaissance satellites represent the eyes of military intelligence satellites, ELINT satellites are the ears.

Soviet ELINT satellites normally orbit the earth at altitudes of 400 to 850 kilometers, patiently listening to the tell-tale electromagnetic emanations of ground-based radars and communications traffic. (24:68) Detections by several ELINT satellites can be combined to pinpoint the location and identify the signal source. In a tactical environment the movement of mobile air defense radars or communications posts might signal imminent enemy activity. Special classes of Soviet ELINT satellites use active and passive techniques in an attempt to detect and monitor U.S. and Allied naval forces. These satellites collectively make up the Soviet tactical ocean surveillance program. (46:6)

The objectives of the Soviet ocean reconnaissance network are to detect, identify, and track U.S. and Allied naval forces and to relay this information in real time directly to Soviet naval and air elements for targeting purposes. (43:63) In peacetime and periods of world tension, this information enables Soviet military leaders to monitor the movements of Western naval forces and to warn of unusual or threatening formations. In wartime, ocean reconnaissance data will help direct Soviet weapons platforms or the munitions themselves against enemy vessels. (58:17; 39:31)

The Soviet ocean reconnaissance program is comprised of two complementary satellite systems: radar ocean reconnaissance satellites

(RORSATs) which use active radar to detect and track surface targets, and passive electronic ocean reconnaissance satellites (EORSATs) which listen for and intercept radio and radar transmissions. Both systems are launched by the SL-11 launch vehicle from Tyuratam. (24:69) Historically, the EORSATs have flown at altitudes between 400 and 445 km while the RORSATs have maintained a mean altitude of only 255 kilometers. (24:69) According to one report, EORSATs are capable of providing target data of about 2-kilometer accuracy to antiship missile platforms. (3:C12) The RORSATs can probably detect destroyer-size ships in good weather and carrier-size ships in rough seas. (24:69) Collectively, these RORSATs and EORSATs represent the greatest potential threat to the operations of our navy in time of conflict. (12:126;16:26)

The Soviets are also apparently conducting basic research into the detection and tracking of submarines. (42:33) In December 1987 Soviet General Secretary Gorbachev revealed that his country had just developed the ability to detect and characterize nuclear weapons on naval vessels either on or below the surface of the oceans. (47:18) While U.S. observers cannot verify the General Secretary's statement, it is largely assumed that if the Soviets do possess this capability, it is provided by the latest version of the EORSAT (Kosmos 1818) or possibly by a large remote sensing satellite launched in July 1987 (Kosmos 1870). (24:56,71) Although a boon for arms control, this ability would allow the Soviet Union to monitor the location of every ballistic missile and attack submarine, dramatically affecting the effectiveness of what to date has been the most survivable arm of the U.S. triad and the linchpin of strategic deterrence.

ANTISATELLITE AND STRATEGIC DEFENSE CAPABILITIES

The Soviet military space systems described thus far are categorized under the heading of "space support." They are designed to provide

essential strategic and tactical support to elements of the Soviet armed forces through all levels of conflict: peacetime, crisis, theater conventional warfare, theater nuclear warfare, and global nuclear warfare. To protect these as well as terrestrial assets in wartime, the Soviets could well establish a "space control" environment which implies projecting and employing offensive and defensive military power through space while simultaneously denying their enemy similar capabilities. (24:78)

A major function of space control is the ability to negate enemy space systems. To this end the Soviet Union now possesses several different antisatellite (ASAT) systems which may be effective in destroying or neutralizing U.S. and allied satellites by employing both "hard kill" and "soft kill" methods. Included in the current antisatellite weapons inventory are: co-orbital interceptors (conventional warhead), Galosh anti-ballistic missiles (ABM) (with nuclear warhead), ground-based lasers, and electronic warfare (EW) systems.

Co-Orbital Interceptor. The Soviet co-orbital ASAT is a rocket-propelled kinetic energy weapon designed to destroy a target from shrapnel impact by exploding nearby. This Soviet ASAT was first flown on 17 October 1967 and since that time more than 20 in-space intercepts against special satellite targets have taken place. (22:19; 6:179) It has not been observed undergoing further tests since August 1983, and the Soviets since that time have implemented a self-imposed moratorium on ASAT testing.

Based upon Western observations, the interceptor apparently can intercept and destroy satellites in low-Earth orbits, reaching a maximum altitude of 4000-5000 kilometers depending upon orbital inclination. However, the interceptor has not been tested against targets much above 1500 km. and

the highest altitude ever reached by an interceptor was 2600 km. (48:86) Some analysts contend that use of a larger booster could technically provide a capability for attacks on satellites in higher altitude orbits; however, this capability is not known to have been demonstrated. To date all interceptors have been launched from Tyuratam, and only one missile has been launched at a time, although there are two pads at the complex configured for use by the interceptor. (24:79) This suggests that Tyuratam may be the only site where interceptors are stored and readily available for launch; however compatible launch facilities at Plesetsk might also be used to support the mission. (24:79)

Employment of the ASAT interceptor is subject to other operational constraints. The Soviet ASAT must be launched into the same orbital plane as the target—thus it must wait for the earth's rotation to bring the launch site under the orbital path of the target satellite. After launching the interceptor into a co-planar orbit with the target satellite, it takes one or two orbits (1.5 - 3 hours) for the interceptor to catch up with its target. Given that an opportunity for launch against an intended target must be available, and since most satellites in low-Earth orbit pass over Tyuratam only twice a day, the average wait to intercept a specific satellite would be six hours. (48:88)

The demonstrated success rate or probability of kill (P_k) for the interceptor has been slightly greater than 60 percent against non-evasive targets. Although General John L. Piotrowski, Commander-in-Chief of U.S. Space Command, considers the system operational with a P_k of 70-75 percent (32:A1), it would still probably require two or more launches to ensure successful destruction of a target satellite. Furthermore, if the target satellite is maneuverable and there is advance warning of impending ASAT attack, the

target satellite could be maneuvered to avoid destruction, thus further lowering the probability of interception and destruction.

Even with the lower reliability estimate, however, the large number of Soviet co-orbital interceptors poses a credible threat against a rather small contingent of high value U.S. satellites within their range. In the event of hostilities and in the absence of any further ASAT developments on the part of the Soviets, they presently have the potential with their co-orbital interceptor to destroy somewhere in the neighborhood of 20 U.S. satellites in low orbit. (48:90) These satellites include photoreconnaissance, ocean reconnaissance, navigation, and meteorological satellites which are essential to the U.S. prosecution of war.

Galosh ABM System. The oldest, but limited, Soviet ASAT capability remains the anti-ballistic missile (ABM) complex around Moscow. Since 1964, nuclear-tipped Galosh ABM interceptors with an estimated vertical range in excess of 300 kilometers have been operational both near Moscow and at the Sary Shagan testing grounds in south-central USSR. (24:79) The Moscow system is nearing the completion of a major upgrade which will retain an improved Galosh exoatmospheric interceptor capable of reaching satellites in very low earth orbits. (46:11; 43:65)

The Galosh ABM employs a nuclear detonation in space to either destroy or disable a satellite target by the effects of electromagnetic pulse (EMP) and/or radiation. The utility of this system as an ASAT weapon is hampered by the consequences of collateral effects produced from the nuclear warhead, by the possible reluctance to expend ABM's for an offensive rather than their primary defensive role, by the limited opportunities presented

against Western satellites, and by the escalatory nature of nuclear weapon use. (24:79; 37:58)

Ground-Based Lasers. The most recent and perhaps most rapidly evolving Soviet ASAT capability is the ground-based laser. Two experimental sites located in Sary Shagan and capable of ASAT activities have been acknowledged by the Department of Defense. (45:13) In October 1987, General Piotrowski provided additional characteristics of these lasers, claiming potential lethal capability up to 400 kilometers, general damage to satellites as high as 1200 kilometers, and possible in-band damage to special components in orbits out to geosynchronous altitudes. (34:27)

High energy laser (HEL) ASAT weapons potentially can be used for either "hard kill" or "soft kill" attacks on target satellites. To actually destroy a target, however, involves a very complex process of extremely accurate pointing and controlling of the narrow laser beam. Furthermore the beam must dwell steadily on its moving target for several seconds since beam "jitter" effectively spreads the energy in the beam over a larger spot size thereby dissipating the effect. (4:122-123)

Notwithstanding its great potential for use as a space weapon, the HEL suffers from other inherent system limitations, particularly when employed as a ground-based ASAT weapon. High energy laser weapons work most optimally when based in space, which is where they may ultimately be employed. A ground-based laser cannot penetrate cloud cover because of beam adsorption, thus laser use is restricted on earth by weather conditions. Furthermore, they require tremendous power, and it is estimated that only a limited number of laser "shots" could be fired during any period of time that a low-orbiting target satellite would be in view. (4:124)

It should be worth noting here that the inherent limitations of both the interceptor and ground-based laser systems effectively preclude any desired Soviet surprise attack which might seek to eliminate or neutralize a significant number of U.S. satellites in a short timeframe. Prevailing constraints such as the necessity to wait for satellite targeting opportunities, launch pad turnover time requirements, limited numbers of ASAT interceptor launchers, the single ground-based laser site, questionable effectiveness of the ASAT interceptor, and the interceptor's required intercept time (up to 3 hours) all combine to mitigate against rapid destruction of U.S. spaceborne assets in low-Earth orbit.

Electronic Warfare (EW). The final ASAT capability currently possessed by the Soviet Union is that of electronic warfare, called Radio Electronic Combat (REC) by the Soviets. Although not technically considered weapons in the classical sense nor uniquely designed for the ASAT role, the U.S. Department of Defense considers the Soviet EW capability extremely useful as an ASAT. (45:15)

There is little unclassified literature available to confirm the existence of current Soviet EW capabilities which might be effective against U.S. satellite systems. Nevertheless, Radio Electronic Combat is emphasized in Soviet military doctrine, and EW jamming and intrusion objectives no doubt include U.S. satellites and their associated ground stations as potential targets. This presumption is supported generally by the views of electronic warfare analysts and technical experts who credit the Soviets with a substantial capability to jam "virtually every frequency band our critical command communications systems use." (31:84) It is therefore considered highly likely that whenever required by Soviet military objectives, REC forces will use high-powered radio jammers to

saturate satellite transponder and ground station receivers to block out normal communications receiver functions.

Most U.S. communications satellites employ UHF frequencies which are relatively susceptible to jamming and intrusion. Newer satellites use SHF and higher frequencies which provide for a broader frequency spectrum, greater capacity, and increased anti-jam protection, albeit at considerably higher cost.

SPACE SYSTEM AUGMENTATION/RECONSTITUTION

While the Soviet space program may not be characterized as having the same sophistication as the United States, it can be characterized as extremely robust. There appears to be little question that the Soviets possess an impressive inventory of expendable launch vehicles and replacement satellites for those now in orbit. The Soviets currently can employ eight different boosters to place objects in orbits ranging from low-Earth to geosynchronous and beyond. (46:6) Thus they possess a superior capability to reconstitute their military satellite network in a relatively short time should their spacecraft become inoperative or disabled. This situation represents a "surge capability" which would similarly enable the Soviets to substantially expand or replace their satellite network in time of crisis or war.

CHAPTER IV

THE ASAT/BMD LINK

Questions concerning ballistic missile defense (BMD) have received increased attention since President Reagan proposed the Strategic Defense Initiative in 1983. Should the United States develop a multi-layered, ground- and space-based defensive shield which would significantly reduce the offensive nuclear threat to this country, or should the U.S. continue with the enduring strategic doctrine of Mutual Assured Destruction? Today this is one of the foremost questions in the nuclear weapon relationship between the United States and the Soviet Union, and it is an issue about which proposed arms reduction talks with the Soviets seem to hinge. A corollary to the BMD issue is that BMD holds many implications with respect to the development of ASAT weapons.

ASAT weapons, though originally developed in order to attack threatening space-based force-multiplier systems (such as photoreconnaissance, ELINT, navigation, and meteorology satellites), are now becoming indispensable as necessary precursors and adjuncts to the space-based BMD system. Robert Bowman essentially conveys the heart of the linkage between ASATs and BMD when he states:

It is no longer possible to deal with either ASATs or BMD alone—because of the technology overlap between ASAT and BMD, because of the vital role of ASATs in countering BMD systems, because of the need to have anti-ASAT (AASAT) systems to protect the enormous investment represented by space-based BMD, and because of the latent ASAT capabilities of even primitive BMD systems. (9:12)

The preceding statement summarizes the significant and complex relationship between ASAT and BMD. While certain types of ASAT systems possess BMD capability, many more types of BMD systems would have ASAT applications. Moreover, while ASATs may someday threaten BMD space systems, they also provide an avenue for the initial development of BMD. Prohibitions to BMD testing and development can be circumvented with ASAT testing and development. Additionally, proponents of SDI might vehemently oppose any restrictions to ASAT development, while critics of SDI could use ASAT arms control to suppress BMD.

This symbiotic yet antithetical relationship between ASAT and BMD has been labeled by some as a "lethal paradox". To them, "the continuously evolving ASAT capability will loom as a greater threat to the boost-phase and midcourse elements of SDI." (49:109) "Not only do antisatellite weapons, those of today and those that will be created within the SDI, fatally threaten the Star Wars armada of the twenty-first century, but they will threaten the vital military satellites of the twentieth." (49:128)

According to Paul Stares, a research associate for the Brookings Institute, the U.S. commitment to BMD—in the form of the Strategic Defense Initiative—"represents both an obstacle and a threat to ASAT limitations." "It is an obstacle in that the United States is clearly reluctant to agree to ASAT limits that might constrain its freedom of action to pursue antimissile research." And, it is a "threat to meaningful ASAT limitations because the techniques for intercepting satellites and ballistic missiles are so similar." But, he continues, it is ironic that "strategic defense may not be feasible unless constraints are placed on antisatellite weapons." (48:182)

Neither the ABM Treaty of 1972 nor the Outer Space Treaty of 1967 prohibit the development or deployment of ASAT weapons. Yet, opponents of ASAT weapons stress that their development threatens the viability of these treaties. In view of the constraints these treaties place on the weaponization of space and the restrictions they place on the numbers and locations of ABM systems within both the United States and the Soviet Union, it is not surprising that the ASAT/BMD kinship creates some troubling issues for proponents of arms control.

As presently envisioned, the SDI program involves the development of technologies which would allow the U.S. to deploy a system capable of detecting, tracking, targeting, and destroying ICBM's launched at the United States from the Soviet Union. The only way to perform all these functions before impact is to deploy a space-based surveillance system linked to space- and ground-based antiballistic missile systems. These antiballistic missile systems may come in a variety of forms, but the most prevalent involve directed energy weapons (such as space-based lasers) and kinetic energy weapons (ground- and space-launched missiles), both systems designed to destroy the incoming missiles before they impact upon the United States.

The most obvious link between current ASAT and BMD technology lay in the area of space-based kinetic-kill vehicles and ground-launched antiballistic missiles. The extremely complex homing technologies used to destroy incoming ICBMs could be readily adapted for use in the simpler ASAT role. Phase one of SDI includes the use of this homing technology in the Exoatmospheric Reentry-vehicle Interceptor Subsystem (ERIS) rockets that would engage enemy reentry vehicles at altitudes between about 100 and 160 kilometers. (2:42; 4:238; 22:23) Subsequent phases of SDI propose the

deployment of an integrated system of space-based lasers and space-based antiballistic missiles. (2:42)

To protect the enormously expensive space-based BMD satellites, it will be necessary to have anti-ASAT (AASAT) systems or Defensive Satellites (DSAT). (17:134) It must be assumed that space-borne U.S. BMD systems will be extremely important targets for Soviet ASAT attacks. Because a space-based BMD system would have inherent ASAT capabilities, the Soviets would consider the system threatening to their ability to launch satellites into space unimpeded. The United States would possess a space denial capability that would be totally unacceptable to the USSR. The Soviet Union would therefore be forced expand their own ASAT capability as a counter to the U.S. system. Consequently any BMD system will need to protect its space-based components against potential ASAT attack and will almost certainly require DSAT capability to defend itself. (4:165)

CHAPTER V

ARGUMENTS: PRO AND CON

On 29 September 1986, the U.S. Air Force conducted its fifth in a series of 12 planned tests of the developmental Air-Launched-Miniature-Vehicle (ALMV) direct ascent ASAT. Like three of the four preceding tests, this one was a success and showed that the U.S. was well on its way toward developing an ASAT weapon which by many accounts was far superior to the Soviet co-orbital ASAT. (48:102) Unfortunately for the U.S. ASAT program, the U.S. Congress, responding to its concern over the potential for an ASAT arms race, prohibited all further testing of the ALMV or any ASAT weapon against space-based targets. Because of the congressionally mandated moratorium on ASAT testing and the constraints on defense dollars, the Air Force terminated its air-launched ASAT program in 1988. (41:3)

Despite this setback the administration and the Department of Defense continue to lobby for the development of a dedicated U.S. ASAT capability. Under the heading of "Space Control," the President's 1988 National Space Policy states: "The DOD will develop and deploy a robust and comprehensive ASAT capability with programs as required and with initial operational capability at the earliest possible date." (57:11) In furtherance of this policy statement, President Reagan's budget submission for fiscal year 1990 requested \$184 million in 1990 and \$228.5 million in 1991 for the U.S. Army as lead agency to develop and "... deploy either a mobile land-based or sea-based ASAT kinetic energy program on SDI-developed technology, particularly the ERIS subsystem, and to continue parallel development efforts by the Army and Air Force related to directed energy weapons." (7:22) At this time it is

unknown whether Congress will support continued ASAT development, although Congress did, in 1988, lift the ban on testing a space control system. (38:28)

The reason for the uncertainty and ambivalence in Congress over whether the United States should or should not proceed with a dedicated ASAT system is that opinions concerning results of this action are extremely divided. And this divided opinion is not restricted just to our congressional leaders. In his book, Space and National Security, Paul Stares points to the existence of two "schools of thought" over how the U.S. military space policy should proceed (48:5), and most writings on U.S. ASAT deployment seem to split cleanly between these two distinct philosophies. Both schools present persuasive arguments.

One school, which supports ASAT, believes that space is just another military arena, much like the land or the sea. Followers of this view believe that the United States can stay ahead in the militarization of space and deny the Soviet Union the use of its space assets in time of war while simultaneously preserving the security of U.S. space systems. This school argues against attempts to constrain the development of ASATs, insisting instead that ASATs are needed to counterbalance the Soviet ASAT capability, to deter Soviet attacks on valuable U.S. satellites, and to counter the threat posed by Soviet military space systems. (48:174-75; 12:55)

The second school of thought considers ASAT development "dangerously shortsighted" because the U.S. is more dependent on space systems than the Soviets and would, therefore, stand to lose more in an ASAT exchange. This school believes ASAT development would result in an expensive and fruitless ASAT arms race which would be destabilizing during crisis

situations. They maintain that ASAT development and space weaponization could and should be constrained through arms control regimes. (48:5; 12:266))

ARGUMENTS FOR ASAT

Proponents of ASAT argue that there is a legitimate Soviet space threat reflected in Soviet behavior and doctrine that justifies ASAT. As mentioned previously, a Soviet intent to militarily exploit space is evident in their doctrinal writings which espouse concepts such as "... the mastery of space is a prerequisite for achieving victory in war." (46:3) General John Piotrowski, USCINCSpace, postulates that Soviet military space policy includes provisions for "... denying space support to the forces of the United States and its allies." (37:56)

Colin Gray, a strong advocate of U.S. ASAT development, cites the potential threat of Soviet ASATs this way:

As can best be predicted, looking out over the next two decades, the Soviet military establishment would prefer to destroy, or degrade severely, U.S. military assets in space, at the risk of losing its own, rather than treat space as a sanctuary for mutual exploitation. (16:38)

He carries this through a step further in postulating a rationale for Soviet pre-emptive use of ASATs:

Soviet military doctrine lays heavy stress upon the value and feasibility of pre-emptive action. In Soviet perspective, there is good reason to anticipate that ASAT capabilities of several kinds may be able to achieve successful pre-emptive destruction or degradation of both certain U.S. space weapons and the U.S. spacecraft those weapons are meant to defend. (16:39)

Proponents contend, too, that a U.S. ASAT capability is critical because the United States is more dependent on satellites to perform vital military functions. They point out that the United States has global security

commitments and force deployments worldwide, while the Soviet Union has few forces committed outside the Warsaw Pact and Cuba; the United States must provide C³ for global and oceanic command while the Soviet Union can rely more on landlines and over the horizon radar links; the United States does not have the launch capability to reconstitute satellites like the Soviet Union and is more critically reliant upon individual satellites; and, the United States must rely on space surveillance to gather information on the "closed society" of the Soviet Union, while the Soviets can take advantage of the United States' "open society." (4:232-237)

ASAT supporters assert that a viable U.S. ASAT capability is needed for deterrence. They contend that the only way the Soviets could be deterred from attacking U.S. satellites is if the United States has the capability and willingness to retaliate for attacks on its space assets. In fact, the 1982 U.S. Space Policy asserts: "The primary purposes of a United States ASAT capability are to deter threats to space systems of the United States and its allies and, within such tenets imposed by international law, to deny any adversary the use of space-based systems that provide support to hostile military forces." (16:112) Moreover, the 1988 U.S. Space Policy reiterates the former position by declaring that "space activities will contribute to national security objectives by 1) deterring, or if necessary, defending against enemy attack, . . ." (57:3) General John Piotrowski, Commander-in-Chief of USSPACECOM, writes: ". . . the Soviets will not be deterred from using antisatellite weapons in a crisis, and the use of these weapons will not be in any way moderate unless there is a United States-Soviet balance in antisatellite capability." (39:30)

Finally, supporters of ASAT development generally take positions against ASAT arms control. They hold that significant obstacles must be

overcome in any quest for a viable ASAT arms control agreement, and the obstacles may be insurmountable. Among the leading problems with an ASAT arms control regime are the difficulties in precisely defining ASAT weapons, and in negotiating adequate verification provisions; the potential for covert ASAT development that would have disproportionately large strategic consequences; the existence of a Soviet capability which would not likely be given up; and the fact that restrictions on ASAT may also restrict BMD development. Colin Gray is especially outspoken in his skepticism of any effective space arms control agreement. Besides addressing the "trivial" and "harmful" long term historical record of arms control agreements, he characterizes the Soviet attitude towards arms agreements as "caveat emptor" and sees the arms control process in a democracy as serving too easily as an "alibi for laxness in defense preparation." (16:75-77; 17:135-139)

ARGUMENTS AGAINST ASAT

Opponents of a U.S. ASAT admit that the Soviets do possess the world's only deployed ASAT system. But they argue that the Soviet interceptor suffers from significant operational constraints that currently limit its effectiveness in wartime. Although important U.S. satellites are within its reach, their vulnerability can to a large extent be reduced by such protective measures as attack warning sensors, emergency maneuvering capability, and decoys. Finally they contend that if the Soviets continue to observe their unilateral moratorium on ASAT testing, there is no valid reason to believe the operational effectiveness of the Soviet co-orbital system would improve. (6:179)

ASAT opponents seriously question whether the United States could deter Soviet attacks on U.S. satellites by threatening a retaliation in kind.

A necessary precondition for successful deterrence is that the Soviets value the services of their satellites more than denying the same benefits to the United States. Otherwise, the threatened loss of Soviet space systems from U.S. ASAT retaliation may not be a compelling sanction. (48:175)

To the anti-ASAT school, existing asymmetries of dependency indicate that of the many factors that would contribute to deterring the Soviet Union from attacking U.S. satellites, the threat of reciprocal ASAT attack on Soviet satellites by the U.S. would be one of the least important. Hence, to opponents, the idea of "tit for tat" with satellites is illogical, and the United States will not be able to deter Soviet ASAT attacks by posing an analogous threat. (12:83) Further, the Soviet space launch capability has attained such a high level of robustness that they could rapidly reconstitute and replace whatever losses they might incur. For this reason, opponents do not consider a U.S. ASAT to be a valid deterrent against Soviet ASAT attacks, especially in those conflict spectrums above limited war. Should the Soviet Union continue to observe its testing moratorium or dismantle its ASAT interceptors, as it offered to do in exchange for a similar U.S. concession, then the requirement for a U.S. ASAT deterrent, in their view, becomes virtually nonexistent. (48:176)

Opponents of ASAT further insist that the likely use and effectiveness of ASATs are remote and suspect when considering the spectrum of potential conflicts. In regional conflicts, for example, ASAT use seems implausible because of the risk of escalation and the existence of less provocative alternatives to demonstrate commitment (e.g., advisors, logistic support, aircraft surveillance). For global conventional warfare ASATs would provide no significant advantage: any ASAT attack would raise the nuclear alert level and provoke retaliation in kind; ASATs alone could not totally destroy or impede intelligence, communications, or surveillance; and there are

less provocative methods to counter satellites, such as jamming or spoofing. (4:161; 12:75) For any nuclear confrontation ASATs might impair the other side's ability to launch a coordinated counter strike, but they would not significantly alter the course of the war; ASATs could not provide total surprise since any extensive loss of one's early warning system would be considered a pre-emptive attack; ASATs could prolong nuclear war since destroying communications capabilities would make it difficult to restore forces or order cease fire; and ASATs could complicate war termination by negating those surveillance satellites essential to monitor enemy activities.

ASAT opponents argue that "the most important concern for the United States is to ensure that its satellites can carry out their assigned tasks even in crises and conflict. Using an ASAT to shoot down Soviet satellites would not protect or restore U.S. satellites." (50:181) Overall, ASAT opponents contend that ASAT weapons produce no net military utility; they contribute nothing to deterrence; nor do they eliminate or alleviate enemy ASAT threats. In general, the large number of satellites used in the Soviet constellations and the high launch rates used to maintain them make them fairly insensitive to discrete kills by limited ASAT attacks. Consequently, active disruption by jamming, spoofing, and other forms of countermeasures may be more efficient, effective, and timely. (12:76)

CHAPTER VI

CONCLUSIONS

The United States currently faces difficult and complex decisions regarding the development and eventual deployment of a dedicated land-based or sea-based ASAT weapon, not to mention the potential problems associated with space-based ASATs that would be adjuncts of an SDI umbrella. In addition to the implications presented by the ASAT/BMD relationship, serious questions arise about the ASAT mission, development and deployment costs, U.S. military space doctrine and strategy, bi-lateral treaty obligations, and the potential Soviet response to the threat posed by U.S. ASATs.

Does the United States need a dedicated antisatellite system? This is a question that is not so easily answered. The arguments are persuasive on both sides of the issue, and perhaps the answer lies somewhere between the two distinct viewpoints presented thus far. Then again, the answer may depend on future technologies.

In 1987, Paul Stares, who maintains a position which calls for the United States to pursue a military space policy which does not resort to ASAT deployment, wrote:

In the future the Soviets may develop more threatening surveillance satellites that can continuously track mobile U.S. strategic forces both under water and on land. *In that event the United States would almost certainly need to have a dedicated ASAT system at its disposal.* Yet all indications are that the technology for such an omniscient surveillance will not be available in the foreseeable future. (48:177) (Italics mine.)

Yet, in the 14 December 1987 issue of Aviation Week and Space Technology, Soviet General Secretary Gorbachev is reported to have indicated the . . .

. . . existence of apparently new Soviet intelligence capacity—the ability to detect, by national technical means, submerged U.S. submarines, which are a key element of the U.S. strategic triad. Gorbachev said his nation's technological advancements in national technical means (remote surveillance from space) had provided the *capability to verify the presence of nuclear SLCMs, both on surface ships and submarines, "without any actual inspection on the vessels."* (47:18) (Italics mine)

If the Soviets indeed possess this capacity, they would have the technical means to target every single U.S. and NATO nuclear ballistic missile and attack submarine as well as mobile land-based nuclear weapons. Additionally, they could conceivably be able to discriminate between hot and decoy reentry vehicles used in a nuclear exchange. It is easy to see that this capability, if real, would dramatically affect U.S. strategic planning, and would be an incontestable argument for U.S. ASAT deployment. Perhaps this argument is the loudest of all.

BIBLIOGRAPHY

1. Ackerman, Robert K., "Soviet Military Space Programs." Signal. May 1988, pp. 61-67.
2. Adams, Peter. "Warhead Interceptor Will Undergo 'Eye' Checkup in 1990 Test." Defense News. November, 28, 1988, p. 42.
3. Anderson, J. "GAO Audits Soviet Spy Satellites." Washington Post. 11 February 1985, p. C12.
4. Anti-Missile and Anti-Satellite Technologies and Programs: SDI and ASAT. Park Ridge, NJ: Noyes Publications, 1986.
5. "Appropriations." Congressional Quarterly Weekly Report. Vol 43, no. 51, December 21, 1985, pp. 2665-2666.
6. "ASAT Weapons: Arms Race or Arms Control?" Defense Science 2002+. August, 1984, reprinted in Space: The 4th Military Arena. Air Command and Staff College, Maxwell AFB, AL, January 1988, pp. 178-180.
7. Baker, Caleb. "Navy May Lose Grip on Antisatellite Program." Navy Times. 30 January 1989, p. 22.
8. Bowman, Robert M. "Arms Control in Space: Preserving Critical Strategic Space Systems Without Weapons in Space." America Plans for Space. Washington: National Defense University Press, 1984, pp. 111-132.
9. ———. Star Wars. Los Angeles: Jeremy P. Tarcher, Inc., 1986.
10. Brandt, Thomas C. "The Military Uses of Space." America Plans for Space. Washington: National Defense University Press, 1984, pp. 81-91.
11. "DOD FY89 Budget." Signal. May 1988, p. 25.
12. Durch, William J., ed. National Interests and the Military Use of Space. Cambridge: Ballinger Publishing Company, 1984.

13. "Fact Sheet Outlining United States Space Policy, July 4, 1982." Public Papers of the Presidents of the United States: Ronald Reagan, 1982. Washington DC: U.S. Government Printing Office, 1983, bk. 2, p. 897.
14. Garwin, Richard L.; Gottfried, Kurt; and Hafner, Donald L. "Antisatellite Weapons." Scientific American. June 1984, pp. 45-55.
15. Gilmartin, Trish. "U.S. Works to Resuscitate Antisatellite Program." Defense News, October 17, 1988, p. 5.
16. Gray, Colin S. American Military Space Policy. Cambridge: Abt Associates, Inc., 1982.
17. _____. "Space and Arms Control: A Skeptical View." America Plans for Space. Washington DC: National Defense University Press, 1984, pp. 133-156.
18. _____. "Space Warfare: The Need for Doctrine." National Defense January 1988, pp. 25-28.
19. _____. "Space Warfare: Principles, Weapons, and Tactics." Pt 2. National Defense. February 1988, pp. 39-43.
20. Hendrickson, Walter B., Jr. "Space Wars...Today." National Defense. February 1984, pp. 36-41.
21. "HOE Experiment—Further Details." Interavia Newsletter. No. 10523, June 13, 1984, p. 1.
22. Jasani, Bhupendra., ed. Space Weapons and International Security. Oxford: Oxford University Press, 1987.
23. _____. "Space Weapons." Space Policy. May 1985, pp. 164-178.
24. Johnson, Nicholas L. The Soviet Year in Space: 1987. Colorado Springs: Teledyne Brown Engineering, 1988.
25. Karas, Thomas The New High Ground. New York: Simon and Schuster, 1983.

26. Library of Congress, Congressional Research Service, Space Policy and Funding: Military Uses of Space. Washington DC, July 1985.
27. Lupton, David E., LtCol, USAF (ret). On Space Warfare. Maxwell AFB, AL: Air University Press, 1988.
28. Manfredi, Dr. Arthur F., Jr. "U.S. Space Systems Survivability." National Defense, September 1988, pp. 44-47.
29. Mark, Hans. "Warfare in Space." America Plans for Space. Washington DC: National Defense University Press, 1984, pp. 13-32.
30. Matthews, William. "Budget Asks Navy Lead in Anti-satellite System." Navy Times, 23 January 1989, p. 25.
31. McMillan, Raymond V., Brig.Gen., USAF, and Johnson, Dennis P., Lt.Col., USAF. "Integrating C3I, NORAD's Number One Challenge." Defense Electronics, January 1986, p. 84.
32. McMillan, S. "U.S. Must Plan for Space War, General Says." Colorado Springs Gazette Telegraph, 8 July 1987, pp. A1, A8.
33. Morrison, David C. "New ASAT Weapons, Old Worries." National Journal, 21 March 1987, p. 707.
34. Morrocco, J.D. "Soviet Ground Lasers Threaten U.S. Geosynchronous Satellites." Aviation Week and Space Technology, 2 November 1987, p. 27.
35. Oberg, J. E. "A Dozen Anti-ASAT Fallacies." Air Force Magazine, July 1985, pp. 79-81.
36. Perry, W. J. and Scowcroft, LtGen B. Anti-Satellite Weapons and U.S. Military Space Policy. Lanham, MD: The Aspen Strategy Group, The Aspen Institute for Humanistic Studies, University Press of America, 1986.
37. Piotrowski, Gen John L. "A Soviet Space Strategy." Strategic Review, Fall 1987, pp. 55-62.
38. ———. "Space Evolution." Signal, September 1988, pp. 27-28.

39. _____. "Soviet Space Doctrine for Warfighting." Signal. December 1988, pp. 29-33.
40. Radabaugh, Gregory C., Capt, USAF. "Soviet Antisatellite Capabilities." Signal. December 1988, pp. 81-84.
41. "Reluctant Air Force Scrubs its ASAT Missile Program." Washington Times. 10 February 1988, p. 3.
42. "Satellite ASW." Aerospace Daily. 7 April 1986, p. 33.
43. Soviet Military Power, 1988. Washington DC: U.S. Department of Defense, U.S. Government Printing Office, 1988.
44. Soviet Military Space Doctrine. Washington DC: U.S. Defense Intelligence Agency, U.S. Government Printing Office, 1984.
45. Soviet Strategic Defense Programs. Washington DC: U.S. Departments of Defense and State, U.S. Government Printing Office, October 1985.
46. The Soviet Space Challenge. Washington DC: U.S. Department of Defense, U.S. Government Printing Office, November 1987.
47. "Soviets Retreat on START/SDI Link, Reveal New Arms Surveillance Capacity." Aviation Week and Space Technology. 14 December 1987, p. 18.
48. Stares, Paul B. Space and National Security. Washington, DC: The Brookings Institute, 1987.
49. Tirman, John and Didisheim, Peter. "Lethal Paradox: The SDI-ASAT Link." Empty Promise: The Growing Case Against Star Wars. Boston: Beacon Press, 1986.
50. Tirman, John, ed. The Fallacy of Star Wars. New York: Vantage Books, 1984.
51. U.S. Congress. House. Hearings on Military Posture. 90th Cong., 1st sess., 1967, Committee on Armed Services, Government Printing Office, p. 874.
52. U.S. Congress. Congressional Record. Washington, DC, 19 May 1987.

53. U.S. Congress. Congressional Record. Washington, DC, 10 March 1987.
54. U.S. Congress. Congressional Record. Washington, DC, 8 August 1986.
55. The White House. "Report to Congress on U.S. Policy on ASAT." Washington, DC, 31 March 1984.
56. The White House. "The U.S. ASAT Program: A Key Element in the National Strategy of Deterrence." Washington, DC, May 1987.
57. The White House. Office of the Press Secretary, Fact Sheet, "National Space Policy." Washington, DC, 11 February 1988.
58. Wilson, G. C. "Antisatellite Effort Needed, Senate Is Told." Washington Post. 24 April 1987, p. 17.