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Cambridge, Massachusetts H.F.

SPACE-BASED BALLISTIC MISSILE DEFENSE: A MULTIDIMENSIONAL ANALYSIS

Introduction

Because of the great technical complexity of the systems under development for space-based ballistic missile defense (BMD) and the highly politicized nature of these systems as the target technologies of President Reagan's Strategic Defense Initiative (SDI), many of the analyses of these systems and their applications have taken rather microanalytic perspectives. Such microanalytic pieces are useful for providing fuller explications of specific problems involved in the development and deployment of space-based weapons systems, but there are few published analyses that attempt to assess the breadth of issues involving the development and deployment of space-based weapons.

It is interesting to be told, for example, that there are legal problems involved with the development and deployment of directed-energy BMD or ASAT systems, or that a defense-dominant military posture provides greater or less stability than an offense-dominant posture. It is methodologically unsound, however, to make a recommendation for or against the continued development and the deployment of space-based weapons on the basis of single-issue arguments.

The breadth of issues properly considered in evaluating continued work on space-based systems would include the technology of those systems and their expected costs, the military effectiveness of these systems, their role in US military strategy, and the Soviet reaction to their deployment. Analyses of these systems would also have to consider US allies' concerns about the development and deployment of the systems, public interest aspects of their development and deployment, and the arms control implications of the systems. Some of these factors are more important than others, but a sensitive and circumspect approach to the question of space-based weapons would have to consider this broad range of topics.[1]

One of the issues of the SDI debate that receives less systematic analysis than it deserves is the connection between technologies for BMD applications and for Anti-Satellite (ASAT) systems. President Reagan's speech on March 23, 1983 did not explicitly address ASAT technologies and systems, but it is obvious that much of the research on directed energy ASAT systems will provide the basis for the BMD systems he envisions. The technological link between the two R&D efforts, however, gives rise to other important connections.[2] Foremost among these are the functional similarities in the missions these systems would perform and the implications of the possible deployment of these systems, both for strategic policy and for arms control initiatives.

Major General Donald Lamberson, head of the directed energy weapons (DEW) program at the US Department of Defense (DOD) addressed the issue of the similarities among these two R&D areas in testimony at a Senate hearing the day of the "Star Wars" speech. Although his comments reported here focus on directed-energy applications for defense of satellites as such applications related to space-based BMD, the relation of ASAT applications to space-based BMD would be similar. In his written testimony, Lamberson commented that

> a constellation of space laser platforms might by themselves defend U.S. satellites from attack and also might possess the capability to negate, say, 50% of a large-scale ICBM attack on US strategic forces by engaging several hundred missiles in boost phase as the first layer of a ballistic missile defense in depth.[3]

It is a principal thesis of this paper that these two R&D efforts must be examined in tandem to develop a thorough and integrated perspective on the technological, military, and arms control implications of space-based BMD. Accordingly, the terms in which SDI is discussed here will be applied as well to ASAT developments in order to construct an analytical perspective that integrates these two areas.

In an effort to provide a sufficiently broad evaluation of the issues of space-based BMD and ASATs, I will examine these issues in four basic steps. I will first look at the development of and current trends in American military space policy. Next, I will assess the current BMD and ASAT systems the Administration is considering with respect to the issues I posed above. I will raise questions which the Government needs to answer before full-scale system development program(s) are begun. Third, I will examine the current BMD/ASAT debate in light of the ABM controversy of the late 1960s and evaluate how the shape of the previous debate provides useful lessons for evaluating the current controversy. Finally, I will present conclusions that will draw together major points of the second and third sections.[4]

Because the analyses herein cover a broad range of topics, each individual issue will receive brief treatment in comparison with what it fully deserves. Since a White Paper on policies for space-based BMD and ASATs would probably be several hundred pages long, what I will try to do is frame and analyze the major issues rather than resolve them.

While the basic conclusions I reach reveal skepticism about the near-term likelihood of an effective space-based BMD and awareness of the strategic and legal problems involved with the SDI, this paper is not intended to serve an advocacy function. Rather, its purpose is to elaborate the critical issues for SDI in an integrated and systematic context. Considering the highly politicized nature of the debate surrounding SDI, the absence of strong partisan conclusions here may seem unusual. Since the paper is intended as an in-depth explication of the various facets of space-based BMD rather than as an argument for or against the SDI, a basically apolitical approach to the main issues has been chosen. Partisan conclusions on the basis of the discussion presented here are left to the reader.

The principal conclusions I reach are that: 1) there are significant technological constraints space-based system developers must overcome before such systems are feasible for deployment; 2) if such systems do become feasible, US policymakers must thoroughly examine the economic costs and benefits of space-based BMD and ASATs before procurement decisions are made; 3) similarly, if such systems appear technologically feasible and economically practical, US policymakers must also take a serious look at the costs and benefits of space-based BMD for the US-Soviet strategic relationship; and 4) if a decision is made to deploy space-based weapons, US policymakers should anticipate and be prepared to meet a wide range of criticism about the military, political, and legal implications of the decision.

PART I: US Military Space Policy, 1950-1985

Over the past thirty-five years, the US Government has vigorously pursued military opportunities in space while at the same time being generally mindful of arms control issues. These joint concerns have been characteristic of US military space policy in spite of the wide variety of space R&D programs the Department of Defense has investigated. Until recently, however, space arms control has not been a major issue. Such has been the case partly because of the relative newness of DEW space applications. Space arms control additionally has not been an important facet of US security concerns because US space policy has had a large civilian component and because US military space deployments have generally involved passive systems (observation satellites). One often unconsidered factor in examining US space weapons and arms control policies is the value of consistency, to the extent possible, of future policies with past policies. Therefore, in the following summary of US military space endeavors, I intend to highlight important military space programs and space arms control issues to provide a background in which to evaluate the current trends in both these areas. Assuming that basic circumstances have not changed over time, consistency is a valuable criterion for decisionmaking if past decisions have resulted in effective, workable policies. Consistency is a questionable criterion, obviously, if past policies have not been effective and have not served national security well. As will become apparent in the following discussion, US space policy since the late 1950s, as far as it has combined military program development with sensitivity to arms control issues, has proven fairly successful. I think one can argue that the superpower strategic relationship has not so fundamentally changed in the past decade that the value of consistency in US space policy can be ignored in future decisionmaking.

Although the primary focus of this paper is BMD developments, I will discuss ASAT system developments first in the various parts of this historical section. I will pursue this approach since the US Government has investigated more directed energy ASAT than BMD systems and since, in the 1970s, it was often the ASAT-related research on directed energy that spawned thinking and development of BMD applications of these systems.

The Early Development Period

During the early years after the end of World War II, Wernher Von Braun, along with about 1000 other German military scientists, helped develop boosters for the US Army. Tasked in 1949 with the development of an IRBM for nuclear warheads, they developed the Redstone booster, the first working rocket in the US arsenal. At the same time, Von Braun began marketing his ideas for a space station to provide the US a space-based ballistic missile launching platform. This permanently manned space station would be serviced by a reusable shuttle.

Walter Dornberger was another German scientist (and Von Braun's former chief under the Nazis) working in the United States on space technology. In the late 1940s, he proposed to his employers--the US Air Force--a space-based ballistic missile defense system composed of several hundred satellites armed with small missiles. These missiles, equipped with infrared homing devices, could be launched from orbit for boost-phase intercept of ICBMs.[1]

Dornberger's system, given the title Ballistic Missile Boost Intercept (BAMBI), was a variation of another Dornberger creation--Nuclear Armed Bombardment Satellites (NABS). This system comprised a regime of hundreds of nuclear-armed satellites, orbiting at different altitudes and inclinations, that could be directed to reenter the atmosphere to strike assigned targets. Dornberger also had developed a concept for a glide bomber that would head from a partial low earth orbit (LEO) to drop its bombs on targets in the USSR and glide to a landing in the ocean. In 1950, he sold this idea to the Air

Force, which let a contract to Bell Aviation to develop it. The concept later developed in the late 1950s and early 1960s as the Air Force's Dyna-Soar program for manned space reconnaisance and bombing missions. Dyna-Soar funding was dropped in the mid-1960s, but the concept behind the program, together with the thinking and R&D supporting the earlier X-15 project, was reincarnated in the Space Shuttle.[2]

In addition to these rather futuristic schemes, US scientists working with the US Air Corps' Project Research and Development (RAND) in the mid-1940s, developed space projects for potential use in conventional warfare. These projects included satellites for ocean navigation, terrain mapping, communications, and early warning.[3] In the period of military economic stringency in the post-World War II Truman Administration, most of the US military space funding was directed to projects that would have a significant payoff potential for near-term conflicts. While the Truman Administration during this period funded ballistic missile and space-related military programs, most of the monies for rockets went for air-to-air, air-to-surface, and tactical surface-to-surface missiles, rather than for ICBMs.[4]

Worried by NSC-68's evaluation of the Soviet threat, the Truman Administration more than tripled DOD's budget from FY1950 to FY1951, but the major push for an ICBM program did not develop until 1953. It was then that the Air Force's Strategic Missile Evaluation Committee determined that H-bombs could be miniaturized, housed in a protective nose cone, and mated to an intercontinental missile. Eisenhower accepted the DOD recommendations and gave the Air Force the responsibility for developing ICBMs, to which he assigned a high priority. This decision coincided with the thinking that would lead the Administration the following year to propound the policy of Massive Retaliation.[5]

While the ICBM program continued, despite the interservice rivalries for funding in this area, the Air Force let contracts to Lockheed, Eastman Kodak, and CBS to develop the reconnaissance satellites that would eventually replace the U-2. Based on a series of Air Force-RAND studies from 1946 to 1954 (Project Feed Back), this satellite program (known as WS-117L) later developed into the Discoverer program, the Satellite Missile Observation System (SAMOS), and Missile Defense Alarm System (MIDAS) program.[6] The former two were military photoreconnaisance systems (MPR), while the latter was a ballistic missile early warning system. Under the guidance of the Defense Advance Research Projects Agency (DARPA) created in 1958, scientists with all three services developed satellites for military navigation, communications, surveillance, and geodetic (gravitational anomaly measurement for space tracking) missions.[7]

Major Programs

The first ASAT and ABM programs got underway in earnest in 1958. The Army and Navy developed direct-ascent ASATs with nuclear warheads that would be launched in time to intercept a hostile satellite as its ground track (its path if charted on the ground) neared the ASAT's launch site. The Army's program, called MUDFLAP, used a Nike-Zeus missile armed with a nuclear warhead. This system was tested about eight times from its base at Kwajalein Atoll before it was retired in 1967.[8] In the Navy's program, a similar ASAT would be launched from a ship. Like the Army, the Air Force developed its own direct-ascent ASAT based on the Thor missile armed with a nuclear warhead. McNamara chose this system, based on Johnston Island in the Pacific Ocean, as the DOD's primary ASAT. Although of questionable value given the negative effects of electromagnetic pulse (EMP) from the nuclear explosion for other US satellites, it remained in service until 1975. The Air Force also developed and successfully tested in its Bold Orion program an ASAT launched from a B-47. In its SAINT program, the Air Force considered a co-orbital manned ASAT that could both inspect and destroy a hostile satellite.[9]

The primary ABM program during this period was the Army's Nike-Zeus.[10] Based on research beginning in 1954 that led to the Nike-Hercules anti-aircraft system (deployed in 1958), the Nike-Zeus ABM system was proposed in 1959. This program was rejected, primarily because of its poor discrimination and tracking capabilities. First, the reentry vehicle (RV) tracking radars had to be mechanically turned from one target to another, thus creating a great vulnerability to decoys and RV proliferation. Second, while the missile system and its guidance radar achieved a 70% success rate when tested against single (not multiple) RVs, firing the missile could not be delayed until the RVs entered the atmosphere, thus precluding RV-decoy discrimination through atmospheric filtering.

The Nike-Zeus led to the Nike-X with Perimeter Acquisition Radars that utilized electronically, rather than mechanically, pointed beams. Not only was RV tracking thus improved, but the Zeus missile was supplemented by Sprint, a high-performance, short-range missile whose firing could be delayed until RV reentry. The Nike-X, initiated in 1963, was therefore a more efficient system than Nike-Zeus, but it too was rejected, since policymakers were at the time considering primarily area defense, and Nike-X was suitable only for site defense. Area defense capability was soon improved by the advent of perimeter acquisition radars, which could track ballistic missiles at long range and extrapolate their trajectories, and of the Spartan missile, whose range and guidance capabilities were great improvements over those of the Zeus.

It was the Spartan-Sprint system for area defense of selected cities and point defense of Titan and Minuteman sites that Secretary of Defense Robert McNamara packaged and sold as the Sentinel system in 1967. Although the

Johnson Administration left office before the Sentinel system could be put into production, the Nixon Administration revised the system's deployment scheme to cover only silos, and renamed the program Safeguard. This system squeaked by Congress, after hot debate, by a very slim vote margin. After the ABM treaty had been signed and had passed the Senate, the system was phased back from its original deployment of 12-15 sites to a single deployment at the Grand Forks, N.D., ICBM field. (Congress phased out the Grand Forks site in 1975.)

As mentioned earlier, the Air Force had a boost-phase BMD research program underway in the 1950s (BAMBI). Its ground-based version, Wizard, had lost out in the late 1950s to the Army's Nike-Zeus follow-on, so in addition to its work on ballistic missile early warning radar systems, the Air Force also pursued more imaginative programs like Project LUNEX, a plan for establishing a missile base on the moon. Headed by General Homer Boushey, director of the Air Force's Office of Advanced Technology, the Air Force let contracts to a number of US firms to provide feasibility studies for transportation of materials to the moon and construction of a base there. According to Boushey, a strong advocate of militarizing the moon, there were numerous advantages to establishing a base there. Ballistic missile launch crews could guide missiles better, since they could observe trajectories without being hindered by the horizon as on earth, and space weapon tests and facility construction would be easier to conceal there. Boushey, together with DARPA's first administrator Roy Johnson, were among the most vigorous advocates of US military space programs in the late 1950s.[11]

Starting in 1958, military space weapons programs receded into the background for a while. In that year occurred two events that had important impacts upon military space developments. First was the US-Soviet decision to observe a moratorium on atmospheric testing of nuclear weapons. Primarily intended to curtail the harmful fallout that resulted from such tests, the moratorium also brought a halt to active US testing of EMP effects in the Van Allen Belt. (EMP was being investigated as a means to destroy hostile satellites and to blackout both enemy communications and ABM tracking and guidance systems.) The second major event was the US establishment of a civilian space agency--NASA. The civilian moon program began to consume a large amount of attention and funding, and, several years later, McNamara's cost-benefit analyses led to a further slowdown in military space system developments through significant military program consolidations. Major funding for surveillance satellites continued, however, as it did for ABM systems.[12]

The Air Force, after DOD policymakers cancelled its satellite interceptor program Project SAINT in 1962, turned its attention to three major non-weapons-related space programs: satellite rendezvous and inspection capabilities, a manned orbiting space station to study the feasibility of manned reconnaisance and strategic C^3 platforms, and advanced communications satellites in geostationary and polar orbits. The Air Force worked together with NASA on the Gemini project, but there were few developments in ASAT or space-based BMD programs.[13]

BAMBI, the Air Force's only significant space-based BMD project, was rejected by McNamara in 1963 because of technological problems in target acquisition, precision aiming, and interceptor missile guidance, not to mention the system's price tag. Furthermore, there had been a <u>de facto</u> international consensus developing in support of free passage over national territory by satellites. The McNamara Defense Department noted that while nations had not objected to scientific or photoreconnaisance satellites flying over their territory, there might be strong objection to armed satellites in space. US defense policymakers even by that time recognized that the US was militarily more dependent on space than the Soviets. Many also realized that in order for its satellites to operate freely in space, the US should not unnecessarily provoke world opinion against its military space programs when the deployment of those programs was not considered critically important.[14]

For the next decade or so following the cancellation of BAMBI, there was no significant funding of space-based weapons systems. Most of the funding, as mentioned earlier, went to navigation, communication, and reconnaisance satellite systems. The Air Force's Manned Orbiting Laboratory project (MOL), begun in 1965 in an effort to evaluate the feasibility of a space station as a military command post, was phased out by 1971, though some of its missions were transferred to NASA's Skylab project.

NASA too faced significant program cuts in the Nixon Administration. Nonetheless, it was eventually succdssful in keeping its Space Shuttle project alive. The Air Force was brought into their project, and largely as a result of the efforts of NASA and the US aerospace industry, President Nixon announced his support for a shuttle program in early 1972. Apart from the military aspects of the shuttle program, though, there were no major space weapons programs underway in the early 1970s until several ASAT-related projects were initiated in 1975.[15] This period of less activity on the military space frontier coincided with cutbacks in NASA funding and in space funding in general after the Apollo landing. Furthermore, SALT negotiations had begun in the late 1960s, and given the growing opposition to Sentinel/Safeguard, the Johnson and Nixon Administrations were reluctant to support funding for space-based BMD research, the feasibility and political attractiveness of which would be immensely more controversial than for Safeguard/Sentinel.

Space Arms Control Initiatives in the 1950s and 1960s

During these first twenty or so years of the Space Age, what had been the extent of US Government sensitivity to arms control in space?[16] Fueled by the concern with staying ahead of the Soviets as well as by the challenge of space exploration, the US space programs seemed to have something of a "manifest destiny" character to them, with the administrators of those programs showing little clear regard for the implications of their programs for arms control or the atmospheric environment. Much of this apparent lack of concern was probably due to the fact that the more exotic systems remained in the R&D stage.

Eisenhower's 1955 Open Skies policy was a step in the direction of recognizing that space should be treated as a common international asset and that there was value to a certain amount of US-Soviet military cooperation in space. Eisenhower proposed an ICBM ban at the same time, and although nothing came of it, it was further reflective of US sensitivity about arms control issues. US participation in the International Geophysical Year (July 1957-December 1958) and support of the policy to share all information gained from space exploration done during that year also showed increasing concern for space as an international asset.

Later, when the US sought to supplant the U-2 reconnaissance effort with the Discoverer program, concern grew for having space declared internationally as an environment to be used for peaceful or nonaggressive purposes. Accordingly, the US leaders proposed (in several NSC reports) that space would not be subject to national jurisdiction and that states should have the right to full and unhindered passage through space. This approach towards space, was developed by the Eisenhower administration in the late 1950s and continued by President Kennedy.[17]

US participation in the moratorium on nuclear weapons testing that began in 1958, as well as Eisenhower and Kennedy's efforts to negotiate a test ban treaty (in spite of some strong opposition from the Atomic Energy Commission and the Joint Chiefs of Staff) with the Soviets were probably the most significant arms control initiatives of the early 1960s that had major implications for US and Soviet military space relations. In spite of differences between the two sides on verification and on other related issues, the US and Soviet Union had negotiated and signed the Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space, and under Water by August 1963. These arms control initiatives in the early phase of space development were followed by the Outer Space Treaty in 1967, which banned "mass destruction" weapons in space, the Non-Proliferation Treaty in 1968, which encouraged the superpowers to pursue further arms control agreements to avoid a nuclear confrontation, and the ABM Treaty and Interim Agreement in 1972, which set limits on ABM systems and offensive missiles. These treaties indicated significant US commitment to resolving some of the problems directly and indirectly related to the militarization of space.

Although there was often significant domestic opposition to the limits these treaties would place on US capabilities, the administrations of the 1950s and 1960s set a fairly consistent course for US arms control and military space policy. Continued development of terrestrial and space weapons systems was supported, but the deployment of such systems was not pursued when it was determined that, because of arms control agreements or simply pure feasibility problems, such deployments would not be in the national interest.

<u>ASATs, 1975-Present</u>

ASAT research continued under the Nixon Administration, but current US ASATs stem largely from renewed momentum in the Prototype Miniature Air-Launched ASAT (PMAL), generated by the Ford Administration in 1975. The

Air Force, under the Nixon Administration, had considered a system employing an F-106 to fire an ASAT missile with a homing device. Called "Project Spike", this program was not given development funds. This system, however, was the direct predecessor of the PMAL program.[18] The PMAL system uses a Miniature Homing Vehicle (MHV) powered by a two-stage Altair/Short-Range Attack Missile booster and launched from an F-15. Unlike the co-orbiting ASAT the Soviets had been developing and testing since 1968, the MHV uses infrared sensors for its guidance system and was designed to attack its target without going into orbit. Also unlike the Soviet kinetic-kill ASAT that employs an array of pellets, the MHV destroys its target by colliding with it.[19] The US Air Force has also been conducting research on several other types of ASATs, including ones with bigger boosters for higher altitude intercepts, ground-launched ASATs, and directed-energy ASATs. The PMAL has been the primary system, however, because of its relatively low cost.[20]

President Carter continued this program, primarily because of his concern for protecting the growing US investment in its military satellite network. While Carter initially had supported the "'maximum pacification of space'", a series of Soviet ASAT tests (several of which were successful) in the first year of his administration convinced him and Secretary of Defense Harold Brown of the need for a strong US ASAT program. After a review of US space policy was completed early in his administration, Carter concluded that it was important to have a capability to counter the Soviet ASAT as well as an ability to negate other Soviet military satellites. Nevertheless, he preferred a situation in which both sides had satellites in sanctuary.[21]

Carter's concern about space arms control led him to the conclusion that a strong US ASAT program could also provide an important incentive to convince the Soviets to undertake ASAT limitation talks (Carter's ASAT limitation initiative is discussed <u>infra</u>, at 22). Accordingly in May 1978, Carter issued

Presidential Decision Memorandum (PDM) 37 that called for vigorous pursuit of space weapons in order to strengthen US defensive capabilities for national security and arms control purposes. While the initiative committed the US to continue working for the prohibition of weapons in space, it also called for an "'integrated attack, warning, notification, verification and contingency reaction capability which can effectively detect and react to threats to U.S. space systems.'" PDM 37 concluded that the US "'finds itself under increasing pressure to field an antisatellite capability of its own in response to Soviet activities in this area.'"[22]

Carter's thinking on ASAT is probably best reflected in the 1982 Senate testimony by Ambassador Robert Buchheim, Carter's principal ASAT negotiator. Buchheim commented that among the possible reasons for ASAT systems were having the capability

> 1) to destroy the space assets of another power
> 2) to retaliate if one's own space assets are attacked
> 3) to rectify any substantial asymmetry which might arise if one party's ASAT capability is superior to another's, and
> 4) to demonstrate a general R&D interest in understanding and advancing proficiency in space technology and operations as a hedge against possible future contingencies.

Although Ambassador Buchheim said he favored limitations on ASATs, he commented that the US had "clearly and "properly" pursued a vigorous approach to its military space program.[23]

Two years after the Carter Administration took office, Seymour Zeiberg, Carter's deputy undersecretary of defense for research and engineering for strategic and space systems, testified before the Senate on the expansion of DOD's ASAT program. He commented that the

> principal motivation for our anti-satellite program is to put us in the position to negate Soviet satellites that control Soviet weapons systems that could attack our fleet. Our anti-satellite program should be principally motivated by the fact that the Soviets have satellites in their force that can track, locate, and assist in the targeting of elements of our military forces.[24]

The Reagan Administration, continuing to improve the US ASAT program, has viewed an ASAT capability in much the same light. Undersecretary of Defense

Richard DeLauer, testifying before the Senate in September 1982, commented that since the Soviets have never reduced their spending for military space systems, it is important for the US to develop an ASAT capability in order to be able to target Soviet satellites, just as the Soviets have the ability to target US satellites. DeLauer added that a strong US military capability has generally proven useful in arms talks to limit activity in that particular area.[25]

The current administration has elaborated its position on the dual role of ASATs both to strengthen deterrence in space and to provide the capability to protect against threatening satellites (i.e., the opponent's ASATs and military support satellites) in the July 1982 "White House Fact Sheet on National Space Policy" and in the March 1984 White House "Report to the Congress: U.S. Policy on ASAT Arms Control." The former states that

> The United States will proceed with development of an anti-satellite (ASAT) capability, with operational deployment as a goal. 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 limits imposed by international law, to deny an adversary the use of space-based systems that provide support to hostile military forces.
>
> The United States will develop and maintain an integrated attack warning, notification, verification, and contingency reaction capability which can effectively detect and react to threats to United States space systems.[26]

The latter relates a US ASAT capability to deterrence strategy:

> For US and Allied security, the United States must continue its efforts to protect against threatening satellites. ASAT capabilities complement the other measures that must be used throughout a conflict. To do otherwise would undermine both conventional and nuclear deterrence.
>
> . . . .
>
> The U.S. ASAT program is focused explicitly on those Soviet satellites which threaten U.S. and Allied terrestrial interests in time of war. All of these threatening Soviet satellites operate at low altitude. Without low altitude satellites to confirm detections of terrestrial targets, Soviet space-based targeting data would be significantly degraded.[27]

These arguments supporting the deterrence and satellite protection role of ASATs have both strong and weak points that I will examine later. Suffice it to note here that the potential roles of ASATs have been expanded as the R&D programs have continued.

BMD, 1975-Present

What developments occurred in US BMD policy from the time of the signing of the ABM treaty? Other than as it occasionally figured into debates in US strategic nuclear policy during the 1970s, US BMD policy remained fairly constant.[28] Agreed limitations on BMD were left relatively undisturbed during the SALT II process. Sometimes during the 1970s, US (and to a lesser extent, Soviet) worries that developed about the other side's violations of the ABM Treaty led to questions about the Treaty's lasting value. US worries usually diminished, however, when the Soviets provided acceptable responses to questions that the US side had raised.

The BMD developments in the 1970s basically proceeded along two tracks: development in the early 1970s of the Site Defense system for Minuteman fields and developments in the late 1970s on the Low Altitude Defense System (LoADS and its follow-on, Sentry) for the MX. The Site Defense system basically consisted of radar and guidance system improvements to the single Safeguard deployment at Grand Forks, N.D., before the ABM site was closed in 1975. LoADS, an underground system using nuclear warheads to protect MX in the Multiple Protective Shelter (MPS) mode, was designed to move among the shelters with the MX. This concept was problematic because variants of it included mobile components. It therefore could have been cited by the Soviets as a violation of the ABM Treaty (Article V, Sec. 1, which prohibits mobile ABM components). However, because MPS was dropped, so also was mobile LoADS. Sentry, the LoADS follow-on for the Closely Spaced Basing (CSB or Dense-Pack) mode, was studied in development with both fixed and mobile components. Sentry, however, fell by the wayside along with MX-CSB.[29]

In addition to the LoADS and Sentry systems, the Army had also developed in the mid-1970s the Homing Overlay Experiment (HOE), a non-nuclear mid-course and terminal intercept BMD system consisting of two layers. The lower would use one of the site, or point, defense concepts. The upper employed pop-up long-wave infrared (LWIR) sensors for RV detection and ground-launched interceptors that would home in with infrared sensors and kill RVs either on impact or with deployed kill vehicles before the RVs re-entered the atmosphere.[30]

Needless to say, the major innovations in BMD thinking in the 1970s accompanied the developments in DEW R&D. It was these developments that first found their way into policy with the March 23 speech. Although DARPA first began investigating lasers for military applications in 1962, it began pursuing chemical laser BMD research in earnest in 1975. In addition to this research, it also began investigating BMD applications of charged and neutral particle beam systems. A vital part of these programs were not only the weapons systems themselves, but the pointing and tracking optics systems, whose precise functioning is critical to intercept.[31]

These directed energy programs found their major application in DARPA's current triad of system developments. This triad includes the Alpha program, an R&D project to build a 2-3 MW, cylindrical hydrogen flouride chemical laser for feasibility demonstrations; the Large Optics Demonstration Experiment (LODE), a project to build a 4-meter-diameter mirror for beam control experiments; and Talon Gold, a tracking and pointing system. DOD DEW programs, and the DARPA triad in particular, received their first major attention when a General Accounting Office (GAO) study, published in early 1982, questioned whether the Defense Department was giving adequate attention to space-based lasers and recommended that the programs, especially the DARPA triad, be accelerated and that DARPA attempt to provide an early feasibility demonstration with its system.[32] This demonstration, the GAO report argued, would be important in order to obtain the data to develop an integrated system of space-based laser battle stations.

The GAO noted that many of the technologies under study by DARPA, as well as by the services' technological research organizations, could be used in ASAT and BMD applications. Alleging that the Soviet high-energy laser program had been three to five times larger than the US program, the study urged that the various military laser R&D programs be funded more heavily and that Congress should consider setting up a new organization to manage the primary DARPA and Air Force programs. In addition to this new organization, the GAO report added that Congress may want to consider establishing a Space Force as a new service branch, a National Laser Institute, and/or a Strategic Defense Agency. Considering as conservative the $150 million funding for military lasers proposed as the annual authorization for the next few years, the report concurred with comments by "knowledgeable" DOD officials that a wiser approach to military laser technology would be to have programs limited by technology rather than funding.

Secretary of Defense Caspar Weinberger responded positively to the report, and by June 1982 he had approved the establishment of a Space Command in Colorado Springs, Colorado, to consolidate Air Force operation of space activities around the existing Aerospace Defense Center.[33]

In a meeting three months later with a number of DOD officials and Sen. Malcolm Wallop, Weinberger commented that he had directed the Department to pursue the technology for space-based BMD as rapidly as possible. As clarified by a DOD "Space Policy Fact Sheet" issued in August 1982, these initiatives were taken to implement President Reagan's National Space Policy Statement in July of that year. The DOD Fact Sheet also reported that a group led by Undersecretary of Defense for Policy Fred Ikle had been studying military, political, and legal aspects of DOD's military space programs since mid-1981 and that their policy recommendations for DOD cited the importance of space for peaceful purposes and self-defense as guidelines for future DOD policy.[34]

These various programs and policy recommendations came to a head in President Reagan's March 23 "Star Wars" speech. Reagan had been interested in high-tech defense systems from the years he was Governor of California. His interest in this area grew during the 1980 Presidential electoral primaries with the advice of Dr. Edward Teller (Lawrence Livermore Laboratory). In late 1981, Teller met with Lt. Gen. Daniel Graham (US Army, ret.) and Karl Bendetsen (Hoover Institution) at the Heritage Foundation, where the three formed a small group on space policy and continued to offer advice to Reagan.[35]

In early 1983 the Presidential Science Advisory Committee studied the prospects for space-based BMD and came to a less than enthusiastic conclusion. These findings were forwarded to Presidential Science Advisor George Keyworth, but the possibilities to bolster US security through space-based BMD apparently looked so promising to Reagan and to the very few of his advisors who were assisting him on the speech that Reagan decided to proceed with his speech as planned. In the speech, Reagan called for "a comprehensive and intensive effort to define a long-term research and development program," and clarified in a news conference a week later that he was not urging a "crash program", but only that a greater amount of R&D funding be allocated to space-based military systems.[36]

Reagan's proposal, formally labelled the SDI, and its implications for the ABM Treaty were then examined by an inter-agency study group that integrated the reports of two other committees, the Defensive Technologies Studies Team (headed by James Fletcher) and the Future Security Strategy Study (headed by Fred Hoffman). This inter-agency group, which forwarded its evaluation through Secretary of Defense Weinberger and then-NSC head William Clark, argued that with a vigorous development program, basic space-based BMD technologies could be demonstrated by the early 1990s. The report went on to say that while the R&D program will not impinge on the ABM treaty in the near term, strong programs in this area could serve as a "hedge" against early Soviet breakout of the ABM treaty. An effective space-based BMD system, the report added, would lead the Soviets to spend money on countermeasures rather than simply proliferating ICBMs.[37]

While this report took a rather optimistic position on the near-term feasibility of a space-based BMD system, indications from the Reagan Administration in early 1984 suggested that the key steps identifying the most promising technologies for a space-based system would take a long time and that the US would be unable to deploy any effective space-based BMD system in the short term. Even after Reagan signed PD-119, formally initiating the strengthened research program on space-based DEW BMD, signals continued from the White House that a measured approach to the SDI would be the most technologically and politically viable one. This measured approach was also reflected in the January 1985 White House pamphlet, "The President's Strategic Defense Initiative." This pamphlet repeated previous points that a wide range of potential systems are being considered and that fundamental scientific and engineering problems involving SDI are yet to be answered.[38]

ASAT and Space Arms Control Policy, 1975-Present

As previously noted, DEW ASATs and space-based BMD are closely related in the area of arms control by their technologies, and it is necessary in examining recent developments in BMD arms control to look not only at the ABM Treaty, but also at ASAT negotiation issues.

In the pursuit of ASAT limitations, President Carter initiated talks on these capabilities with the Soviet Union in 1978. These discussions were part of a two-track policy to curtail Soviet ASAT developments by building a US ASAT (the PMAL) while simultaneously pursuing negotiations. Although Carter stated that the primary US objective was a verifiable ban on ASATs, there was in actuality significant disagreement within the Carter Administration as to whether a ban was indeed verifiable. Basically the Carter negotiators, going into these talks, had four major policy guidelines:

1) the US rejects claims to space sovereignty;
2) any nations' space systems have right of passage in space without interference;
3) the US will pursue defensive R&D activities in space and make its current systems more survivable; and
4) the US feels constrained to pursue development of an ASAT capability because of Soviet activities in this area, but prefers comprehensive limits.[39]

During the three sessions in Helsinki, Bern, and Vienna from 1978-1979, the sides agreed that attacks on satellites should be considered "acts of war", as attacks on ships, planes, and other earthbound systems would be so considered. The two sides considered, but did not come to any agreement on, prohibitions of attacks on "third-party" satellites such as Chinese systems, limitations on the use of space shuttles, an ASAT testing moratorium, dismantling of existing systems, and verification of unconventional ASATs such as ground-based lasers.[40]

It is clear that even if the invasion of Afghanistan had not occurred and the ASAT talks had continued, the negotiations would have been complex and difficult. Carter's ambassador to the talks, Robert Buchheim, presented during his September 1982 Senate testimony some of the interpretative difficulties faced by the US negotiators on issues such as an ASAT treaty's relation to the Outer Space Treaty and whether limitations on ASAT systems or ASAT operations (testing, etc.) should be the primary subject of the treaty. Leslie Gelb, chief of the Bureau of Political-Military Affairs at the State Department during the Carter Administration, commented in a 1983 interview that the ASAT negotiations were ones in which there were more problems than one really knew how to solve.[41]

For better or worse, the Reagan Administration capitalized on this issue of difficulties inherent in ASAT negotiations and has, until recently, avoided reopening talks. The Administration continued to assert its interest in ASAT limitations but emphasized the necessity of developing well-defined positions on the definition and verification problems inherent in such negotiations. In 1982 Senate testimony, ACDA Director Eugene Rostow stated that the Reagan Administration is loath to move ahead with the "enormously complex" ASAT negotiations without very careful preparation. The Administration, he commented, did not want to use negotiations as a means of working out policy. The Administration, Rostow said, believed that doing so would be unwise, in spite of its interest in arms control in space.[42]

This position was basically the same one taken by current ACDA Director Kenneth Adelman, in testimony before the Senate in May 1983, and by the White House March 1984 report to the Congress, "US Policy on ASAT Arms Control." Adelman's testimony in particular, but also the White House document, mentions the Reagan Administration's significant involvement in and support of the activities of the UN Conference on Disarmament and states the Administration's preference (at that time) to pursue ASAT limitations in this UN forum instead of in bilateral talks with the Soviets. The Adelman testimony and the White House report also mention the importance of considering ASAT policy within, and not divorced from, the context of US deterrence policy and verification activities for other arms negotiations.[43]

By June 1984, apparently, this internal review had been sufficiently completed, for the Reagan Administration responded positively at that time to an offer from Soviet leader Konstantin Chernenko for bilateral ASAT talks beginning in September 1984. Critics of the Reagan Administration have charged that the decision to pursue negotiations was a cosmetic political move to demonstrate an otherwise insufficient interest in arms control as the Presidential campaign season began. Although these talks did not materialize, high-level communications between the leaderships of both countries in late fall began to lay the groundwork for negotiations on ASAT and strategic offensive systems that began in March 1985.[44]

Several problems are inherent in this endeavor. As will become more clear later, it is virtually impossible to support SDI as well as an ASAT treaty that would cover directed-energy ASATs, on account of the technological overlaps. A treaty that provided for the limitation or dismantlement of current systems is possible, but a treaty that did so without constraining or precluding development of directed-energy ASAT systems would have only limited value. Still, the Administration appears committed to the negotiations and now indicates it perceives some strategic value to pursuing ASAT limitations. Only time will tell whether the current US and Soviet negotiations will lead to serious and meaningful results.

BMD and Space Arms Control Policy, 1975-Present

Most of the BMD arms control issues in the 1970s dealt with the ABM Treaty. For example Article XIV, Paragraph Two, of the ABM treaty calls for reviews of the Treaty at five-year intervals. The parties to the agreement decided to hold these reviews within the context of the Standing Consultative Commission (SCC) meetings and did so in 1977 and 1982. Moreover, the Carter Administration in 1977 took the view that the SCC provided a continuous review function, with the result that any serious problems either side may have with the treaty could be discussed at a regular SCC meeting and did not have to be postponed until the formal review session. The two sides in 1977 and 1982 reaffirmed the treaty and, as far as is publicly known, presented no amendments.[45]

It is important to note also that in spite of the potential conflict between the Administration's BMD programs and the ABM Treaty (especially Agreed Statement D on "other physical principles") and the Outer Space Treaty (especially Article IV on placing nuclear weapons into orbit), the

Administration has shown no consistent official interest in withdrawing from those agreements. In an interview in September 1984, Secretary of Defense Weinberger commented that the ABM Treaty may need to be renegotiated or repudiated if the US can develop a thoroughly reliable BMD. He did not, however, indicate that he opposed the ABM Treaty in general terms, irrespective of current US defense capabilities.

Questions about the viability of the ABM Treaty have been raised at other times by Administration officials, but there has been no firm, single policy perspective emerging from the Administration that the ABM Treaty should be substantially modified or dropped. The January 1985 White House pamphlet states that as President Reagan "made clear at the start of this effort, the SDI research program will be consistent with all U.S. treaty obligations, including the ABM Treaty." It may be the case that Administration opponents of the ABM Treaty will eventually emerge successful as US military space policy is hammered out, but such a development is by no means certain.[46]

During the mid-1984 Soviet-US communications concerning ASAT talks, it is interesting to note that the Soviets sought negotiations toward a comprehensive ban on all types of space weapons, but the US responded that only "limitations" on ASATs would be appropriate topics for discussions on space weapons.[47] Obviously, the Administration wants to leave itself some latitude for space-based BMD R&D, given that a ban on all space weapons would naturally include DEW systems. In spite of the ties between ASAT and BMD technologies, the Reagan Administration has not explicitly stated that it wants to take a constrained approach to ASAT talks in order to leave room for BMD developments.[48] Still, ASAT-BMD ties are patent; how much latitude for BMD the Administration will seek to develop through ASAT negotiations is yet to be seen.

CONCLUSIONS

Policy and Technology

What can be said about trends in US policies regarding ASAT and BMD technologies since the 1950s? First, with increased awareness of the problems in managing crises in distant regions, US policymakers have concomitantly become more concerned with protecting the space-based communications and surveillance links with those areas. One may argue that this awareness was significantly stimulated by logistical planning to support Schlesinger's counterforce strategy (elaborated a year or so before ASAT R&D was begun again in earnest) and later PD-59. It seems more reasonable, though, to assume that the management of any type use of US forces abroad to meet conventional threats needs a well-protected communications link and that the concern for such protection preceeded the elaboration of the counterforce concepts.

Not only do US conventional forces need strong communications and navigation support, but the verification section of the ABM Treaty (Article XII) placed primary monitoring responsibilities on satellites. Having such means of verification at risk is clearly an unattractive situation. For these reasons, protection of US satellites is vital to the national interest. To achieve this objective, one might choose to negotiate some type of limitations for ASATs, to build redundancy into present National Technical Means to permit quick reconstitution, or to construct a strong ASAT force, unconstrained by negotiations, as a deterrent to the opponent's use of its ASATs. Avoiding the problems inherent in these courses by not pursuing any of them would not be wise security policy. The past several Administrations have realized they needed to grapple with these issues as the Soviets have developed their ASAT capability. The national disagreement on the best course to follow has been a major dynamic of the ASAT issue and will continue to be so until it is settled.

Next, the US ASAT was to some extent reprogrammed in the Carter Administration as an incentive to bring the Soviets to the negotiating table.

One cannot help but reflect on the criticisms of the two-track approach in the NATO INF decision two years later concerning the extent to which the negotiating and deployment policies, pursued in tandem, may have been counterproductive. The two-track approach has not appeared to be unsuccessful, however, with the ASAT issue. The Soviets did indeed agree to negotiate, and they pursued the negotiations without extensive propagandizing about the destabilizing effect of the US ASAT program, which was not the case with the INF negotiations and deployments. There were, certainly, difficulties in the negotiations, but these were as much technical as political, which was not the case with the INF negotiations. The fact that the negotiations were not accompanied by an excessive amount of propaganda suggests that the Soviets would be seriously interested in arriving at meaningful ASAT limitations through the negotiation process.

Interestingly, while it is difficult to prove that the Soviets would not have negotiated if the US had not been pursuing a strong ASAT program at the time, the Soviets did agree to negotiate before the US system had become operational. The Soviets apparently had strong enough respect for US technical capability that they realized earlier rather than later that negotiating ASAT limitations would be in their interest. Therefore, the threat of continued weapon system development may be, in the case of ASATs, a worthwhile incentive to impress upon the Soviets the value of negotiations.

To whatever extent the current Administration may perceive its ASAT programs (the PMAL in particular) as incentives to the Soviets to pursue negotiations, the question automatically arises as to how far we should pursue our programs before negotiations begin. The Soviets, as noted before, were prepared in the late 1970s to negotiate when the current US ASAT system was still in the early R&D stages. It is logical to conclude, then, that completing testing and evaluation of the system is not imperative before the

US seriously pursues whatever limitations it seeks to negotiate. Indeed, some analysts have argued that if the Soviets are convinced we have a reliable, high-quality system ready for procurement, the Soviets would contend that they should be allowed under an ASAT treaty to develop their system to the point it works approximately as well as ours. These analysts conclude that if the Administration seriously wants an ASAT treaty, it should negotiate sooner rather than later to avoid excessively intimidating the Soviets and making the negotiations more difficult than they would be anyway.[49]

Are the Soviets seriously interested in ASAT negotiations now? Initial hedging in response to the June 1984 Reagan acceptance of their negotiation offer suggests they had expected the offer to be rejected. Still, the Soviets have been seriously interested in space weapons limitations since at least the late 1970s, and twice since 1981 have presented model ASAT control treaties to the UN as negotiating tools. Commentaries in the Soviet media have remained almost exclusively in favor of negotiating limits to ASAT systems, not to mention BMD developments and deployments. It seems reasonable to assert that the current US ASAT capability, not to mention limits to the SDI developments, continues to be of sufficient concern to the Soviets that they seek to achieve ASAT limitations. This perspective is clearly evident in the Soviet willingness, expressed beginning in the late fall of 1984, to begin negotiations without preconditions (like a mutual moratorium on ASAT tests).

As noted earlier, another important advantage of ASAT and BMD systems is their alleged deterrent capability. ASAT and space-based BMD have been supported by the Reagan Administration in part because of the role these systems may be expected to play in deterring nuclear and conventional conflict. While an eventual ASAT treaty may provide for the dismantling of each side's ASAT systems, the current administration's policy signals that ASATs could eventually be regarded as an indispensable part of the nuclear and conventional deterrent. So also, therefore, could space-based BMD become. The deterrence argument needs to be examined carefully; it may not provide as much justification for ASAT and BMD systems as has been suggested. As I will discuss later, a strong US ASAT capability, even if it has geosynchronous range, will not be sufficient to deter a Soviet attack on US satellites in the event of a strategic nuclear exchange. While it would be difficult to deny categorically a deterrent role to either ASAT or BMD systems, this argument is not one of the stronger ones for supporting the development of these systems.

An important lesson related to the deterrence issue concerns US R&D resources for space-related research. US ASAT and space-based BMD R&D has continued strongly since the mid-1970s, and to the extent to which the US Government has supported advanced technology development, the US scientific community has historically responded most capably. The technical capacity of the US scientific community is significant, and while one might argue that ASAT and BMD R&D should not be supported, it would be difficult to deny the possibility that the problems involving these systems could eventually be solved, given adequate funding.

The obvious question here is how much funding how fast. This question will be more fully explored in the next section. An initial observation is that directed-energy ASAT and BMD systems are still in their infancy, and that without vital, compelling reasons for pursuing these technologies as our only alternative for protecting our national interests and avoiding conflict with the Soviets, our devoting as much funding to them as currently envisioned may not be cost-effective. DEW systems may indeed provide the answers to security issues we have long sought to resolve, but anticipating these resolutions in the very near term may be expecting too much from the defense R&D establishment.

Space Arms Control Issues

In the area of arms control, the US Covernment has consistently shown interest in developing space for peaceful purposes. While the Reagan Administration had concluded until mid-1984 that negotiations for an ASAT treaty were not in the US interest the Administration still talked positively on occasion about the value of ASAT arms control, as well as arms control treaties currently in force. It additionally showed its concern for arms control by continuing to abide by the SALT II Treaty's constraints, in spite of the Administration's opposition to parts of the Treaty.

One could argue that the Administration's approach, prior to mid-1984, to pursuing ASAT limitations in the forum of the UN Council on Disarmament did not indicate a strong interest in arms control. This point would indeed be well taken, since negotiating a treaty in the UN on ASATs, when only the US and the Soviets have such capabilities, is about as effective as trying to negotiate START in the UN. This move by the Reagan Administration made good tactical sense in light of the thinking during its first few years on space-based military systems. Negotiations in a multilateral setting were likely to go nowhere, and the US Administration did not have to take as much criticism for delaying the endeavor as it would have if talks had been bilateral.

Even though the Reagan Administration emphasized definitional and verification obstacles to negotiating an early ASAT treaty, some analysts have argued with a certain amount of weight that if the Administration had really desired an ASAT treaty, it could have devoted enough attention to these problematic issues to resolve them earlier. The fact that this resolution came in mid-1984 suggests that ASAT negotiations were not a priority issue with the Administration. While this is a fairly obvious conclusion, the more subtle point is that the US Government could probably have come up with a reasonably sound negotiating position earlier if there had been pressure from the Executive Branch to do so. That necessary amount of pressure or political will does seem to be present now. In a November 1984 press statement, NSC head Robert McFarlane said the US would enter talks "in a spirit of honest compromise and getting results," and Administration officials have maintained that line. While McFarlane asserted that the US had prepared its positions, he did not disclose what the ASAT/BMD positions were. Administration officials, including Reagan himself, have continued to assert since early 1985 that the SDI is not negotiable.[50] What this stance means for US negotiating positions is difficult to tell precisely, but since it is unlikely that SDI will prove to be a bargaining chip, so also it is unlikely that there will be any significant restraints placed on ASAT developments because of the interconnectedness of the two technologies (this point will be explored later).

Still, there has been significant debate, both within and outside the Administration as to what specific types of ASAT/BMD limitations might be advantageous to the US yet still achieveable in negotiations. Numerous model ASAT treaties have also been proposed by scholars and advocacy groups, but it is beyond the scope of this paper to examine these in detail. If seems logical though, that the US would not seek an ASAT treaty that would handicap its space-based BMD effort. Since one could strongly question the usefulness of such a treaty or the benefit of negotiating a comprehensive ASAT treaty that would have to be repudiated to deploy a space-based BMD systems, it will be interesting to follow the negotiating objectives the US side presents and to see whether or not the negotiations become primarily a PR effort.[51]

PART II: Aspects of the Current Debate

Introduction

With an understanding of the historical trends in US ASAT and BMD policy, attention may be turned to the next steps in evaluating the current administration's policy on space-based BMD. I will approach this topic in two ways. In this section of the paper, I will examine basically six broad issues that the Administration would do well to consider in developing policies on ASAT/BMD programs and related arms control issues. In the next section, I will reflect on how the issues raised in the ABM debate of 1966-1969 relate to the current issues discussed and speculate on whether the previous debate provides any lessons for the current one. Can the current debate be considered basically a rehash of the previous one, with different systems at the center of controversy but the same questions? While I think that many of the issues are the same, I would argue that there are major differences in the debates related to the IOCs of the two types of systems and related to the implications of the deployment of the two systems for US nuclear deterrence policy.

As was mentioned in the opening section of the paper, there are numerous analyses of the current debate that present positions for or against the development of space-based BMD based on one or a few arguments. Often these analyses do not ask enough questions, let alone the right questions, about how the issues should be considered. Given the complex, technical nature of these issues, as well as the fact that these issues span a broad range of disciplines, from the scientific to the legal to the political/strategic, one should indeed expect compartmentalized arguments. Nevertheless, there have been few efforts to integrate those approaches into a single, unified analysis, which is what this paper tries to do.

I will group the issues I intend to cover into the following broad categories: the technological feasibility and effectiveness of space-based BMD systems, the implications of space-based BMD for US strategic deterrence policy, the character of the transition period to a defense-dominant defense, the Soviet response to the SDI, public interest issues, and arms control concerns. What I will do with each of the categories is examine the major issues therein related and frame the questions and areas of ambiguity that still need to be addressed before a well-founded recommendation on space-based BMD can be made. Obviously, as I mentioned in the introduction of the previous section, space limitations do not allow the amount of coverage of these issues one could obtain in a White Paper. Nevertheless, the principal areas for discussion and further examination can be laid out.

The primary conclusions I reach in this section are that the SDI appears to be a fairly desirable concept in the abstract, but that there is a host of issues connected with the development and deployment of a space-based BMD system that need careful consideration and resolution before the SDI becomes a multi-billion dollar development effort. Some of these problems can and should be resolved soon. Many of these problems, however, appear intractable for the foreseeable future.

Technological Feasibility and Effectiveness

The technological question is the base upon which the superstructure of the controversy is created. While I will discuss the major DEW technologies only in terms of their BMD applications, ASAT applications will become apparent as precursors to BMD applications. I will return to the ASAT issue proper and its relation to BMD in the section on arms control implications for space-based BMD.

There are six basic technologies under consideration for space-based BMD applications (see Appendix I for a more detailed explanation). Three of these technologies employ lasers. These three include chemical lasers using hydrogen flouride or related compounds, ground-based lasers (with space-based components) using excited dimers from noble gas and halogen combinations, and nuclear bomb-pumped X-ray lasers. Systems are also being investigated that use directed kinetic energy (DKE) technologies, particle beams, and microwaves. In the recent past, chemical and X-ray lasers had an apparent lead in the perceived feasibility of their application. In Senate testimony in March 1985, Lt. General James Abrahamson, who heads the Strategic Defense Initiative Office, commented that kinetic kill technologies currently seem more promising.[1]

There are a variety of constraints each of these technologies faces, but the primary difficulties involve pointing and tracking for the beams, sufficient dwell times in order to disable intercepted missiles, and adequate numbers of stations in order that the composite kill rate is high for a massive ICBM launch. Many of the current problems are surmountable in the near future, but some of the technologies involve physics constraints that still require significant amounts of research to resolve. Careful consideration of the difficulties and potential capabilities inherent in each of these technologies would obviously be necessary in the decisions about the choice of system and deployment time frame.

In addition to the difficulties inherent in the technologies for the kill and the pointing and tracking mechanisms, there are significant technological problems, given the shortness of ICBM boost time, with effective command and control. Furthermore, considering the shortness of time from attack sensing during which the weapons must be used to be at all effective, it is easy to see that boost-phase intercept systems will have to work almost automatically, with little or no time for decisionmaker input.

There are also numerous countermeasures available to space-based BMD systems. These countermeasures include such alternatives as shortening the

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boost phase by faster burning propellants, shortening the warning time for the defense by depressing the trajectories or disrupting C^3I by damaging BMD system sensors with lasers or EMP. Shielding boosters can be accomplished by ablative coatings, which melt off under attack, absorbing a chemical laser's heat. (Shielding against X-ray and particle beams is more complicated.) Shielding can also be accomplished by spinning the booster, which can double or triple its hardness because of the increase in surface area to absorb laser heat. Offensive proliferation is possible as well, as is the less expensive alternative of building decoy boosters. Additionally, as mentioned earlier, grouping ICBMs in a single geographic region can drive up the cost to the defender because of the large number of BMD satellites needed to provide full-time coverage.[2]

Deployment, Mid-Course, and Re-Entry BMD

It is much more difficult to identify and destroy ICBMs after bussing has begun. Not only does a proliferation problem occur, increasing the number of targets by a factor of five to ten or more, but the small infrared signature of the RVs makes the RVs very difficult to locate. Space-based lasers, particle beams, or directed kinetic energy (DKE) technologies may provide possibilities for mid-course or re-entry phase intercept, but the sensing, tracking, and kill mechanism problems remain and, in fact, are aggravated at these intercept stages. The High Frontier study notes that there would be clusters of battle stations not over the Soviet Union at the time of launch that would become available in the ensuing minutes for mid-course intercept, but this possibility depends significantly on the total number of satellites in orbit and on very advanced sensing mechanisms.[3] In actuality because of the physics involved (basically the need for long-wave rather than medium- or short-wave infrared sensors), different systems are needed for mid-course as opposed to boost-phase intercept. Other than HOE, there have been few systems designed specifically for mid-course intercept; most of the attention on post-boost phase kill has been focused on re-entry and point defense technologies discussed earlier.

The principal conclusions to draw from this technical discussion is that the scope and number of technological breakthroughs required to take most of these technologies to the system or operational stage are enormous. While breakthroughs may occur in certain facets of these technologies, the likelihood of constructing reliable systems from most of these technologies is not great within the next ten to fifteen years. Such is the case especially if the goal is a perfect or very nearly perfect defense. For example, the brightness of chemical lasers (a measure of lethality) needs to be improved by several factors of ten over what is available currently.[4] One should also note that offensive technological breakthroughs, of course, are virtually as likely as defensive ones.

System management problems also comprise a major obstacle facing BMD R&D. Herbert Lin, a specialist in computer processing for defense systems, presents some significant problems that must be surmounted in the development of effective software for space-based BMD management. He notes that the Defensive Technologies Studies Team (headed by James Fletcher) suggested in its March 1984 report that the software for space-based BMD system management would require programs on the order of ten million lines. Discussing some of the problems of the AEGIS air defense system (for which the tactically significant software totals about one million lines), Lin concludes that developing and debugging a system whose complexity is an order of magnitude greater than that for AEGIS is indeed a prodigious, if not currently insoluble, task.[5]

In spite of the overall impression suggested by the foregoing discussion of relevant technologies, it is necessary to emphasize that the R&D on some of these alternatives is farther along than on others. Dr. Lowell Wood, one of the principal participants in the Lawrence Livermore Laboratory work on the X-ray laser, commented in a September 1984 interview that work on the pop-up X-ray concept would be sufficient to "support a deployment decision on the five-to-ten year time scale." The remark "support a deployment decision" is subject to some interpretive latitude, but the most likely assessment is that work on the pop-up system will have advanced far enough that a decision could be made to procure parts of a boost-phase system, though not an entire boost-phase layer.[6]

James Fletcher, chairman of the Defensive Technologies Studies Team mentioned earlier, wrote in mid-1984 that R&D on some technologies would have progressed far enough that procurement of portions of a boost-phase system could begin in the 1990s. Fletcher comments that although procurement of a four-phase defense (boost-phase, post-boost-phase, midcourse, and terminal) probably would not be feasible until after 2000, technologies for mid-course and terminal defense are already well understood. Fletcher's article also addresses some of the main countermeasures to boost-phase BMD and why they may not be as effective as some analysts expect.[7]

An additional and obvious obstacle to space-based BMD deployment is the cost. Cost estimates are currently hard to establish with confidence. However, even without factoring in the probable program cost increases, most estimates are still very high. One conservative estimate is that a layered defense, deployed by 2000, would cost about $95 billion, a figure which includes R&D and procurement but does not include operation and maintenance projections.[8] Undersecretary of Defense for Research and Engineering Richard DeLauer, testifying in November 1983 before the House Armed Services Committee, commented that pursuing the SDI would be the equivalent of pursuing several Apollo programs simultaneously, and that the Congress would be "staggered" at the cost of developing and deploying DEW BMD systems.[9]

Because most of these programs are still in their relative infancy and neither costs nor capabilities can be reasonably assessed, cost-exchange ratios are virtually impossible to construct. Given what is currently known about countermeasures, though, an early, qualitative evaluation suggests that a space-based BMD would have cost-exchange ratios that favored the offense. This evaluation would be particularly true if, again, a perfect defense were sought.

Strategic Issues

Should space-based BMD remain a priority? How does BMD fit into our nuclear deterrence strategy? The primary argument for an allegedly perfectable BMD is that it provides a conceptually simple solution (theoretically, though not scientifically, speaking) to all the problems generated by the Soviet strategic force buildup in the 1960s and 1970s as well as all the problems inherent and experienced in complicated offensive strategic arms talks. Obviously, if the US can construct a near-perfect defense, one will not have to worry about either of these sets of problems. The hope is that offensive ballistic missiles will be made obsolete through a process (i.e., building a layered BMD) that avoids the complex negotiations and difficult verification issues associated with arms control approaches in a defense-dominant strategic security environment. According to sympathetic observers, the Reagan Administration rightly perceives that "historical precedent and sound military logic" dictates that any nation that controls access to the "high ground of space" could achieve "decisive military superiority on earth."[10]

The High Frontier study captures well the argument concerning the insufficiency of the US strategic defense posture as this problem relates to BMD. Daniel Graham and his associates present the essential position of the argument when they state that the "dangerous doctrine" of Mutual Assured

Destruction (MAD) could be replaced by a strategy of assured survival. They comment that the US cannot reverse the ominous trends in the military balance simply by buying many high-tech weapons, particularly strategic offensive ones, and by relying only on an offense-dominant deterrence posture. The best hope, they contend, is to redesign US strategy and move strategic competition into an area--defense dominance--where the US has the advantage.

While Graham would agree that MAD has provided a significant deterrent capability, he would asserts that there would be greater security in a defense-dominant environment, in which a nation's survival does not depend on the forebearance of its adversaries. Graham and his associates argue that a defense does not have to be perfect to be worthwhile--that invulnerability is an unrealistic goal for a defense. Since no defense can be perfect, Graham asserts that proponents of Assured Destruction will tout this goal as an excuse to reject all types of defense. Graham states that the purpose of his defense is to save lives, first by deterring an attack, and second by offering significant protection against counterforce or countervalue strikes. In the area of deterrence, Graham states that on account of the screen BMD would provide, there would be major uncertainties in the mind of the Soviet planner about the effectiveness of his weapons against the targets he wanted to attack. Graham concludes that the strategic posture he proposes would provide far more security than MAD, both in deterrence and damage limiting capabilities.[11]

Reagan was somewhat more sanguine in his speech, holding out the prospect of making a nation's nuclear weapons "impotent and obsolete" so that "free people could live secure in the knowledge that their security did not rest upon the threat of instant retaliation to deter a Soviet attack."[12] Was Reagan really supporting a perfect defense to stop all Soviet ICBMs? It looks that way on the surface, and the point might have been framed this way to appease anticipated criticism that he was pursuing a "warfighting" approach to deterrence. Military sense, though, leads one to the conclusion that a perfect defense against a large force of ICBMs, SLBMs, and cruise missiles, a force such as the Soviets have, would be extremely difficult. Administration officials have indeed admitted that perfect defense would be an eventuality only for the distant future.[13]

It is important to note, though, that the admission that the defense actually preferred will not be perfect is not to assert that the Administration, or anyone who takes Reagan's March 23 speech at face value, is prepared to settle for a 50% or 80% effective BMD. Some BMD proponents have argued that a partially effective defense will constitute a satisfactory conclusion to the SDI, on the grounds that such a defense is "the best we can get." The analyses presented in this paper, however, are based on the position that such an approach essentially vacates the President's stated goal. Therefore, the evaluation of the President's objective presented herein focuses on a near-perfect area defense.

One might restate the thrust of the President's message with the formulation that the US should gain the capability to ensure that the survivability of the nation does not depend on the restraint and forebearance of its adversaries from lauching a ballistic missile attack on the United States.[14] Given that a superior, highly effective damage-limiting capability is the primary objective, what are the specific assumptions behind this goal that go beyond the generalities of the "Soviet military threat" discussed above and support the space-based BMD initiative?

The assumptions behind this argument are threefold.[15] First, the Soviets since SALT I have greatly increased their hard-target kill capability, so that the ratio of hard-target kill warheads now stands 2.5:1 in the Soviet favor. Second, they have also developed parts of what could constitute a traditional ground-based BMD system with, among other components, the SA-12 missile system that can intercept airplanes (ostensibly) at 100,000 ft. and a phased array radar at Abalakova.[16] Third, while the Soviets might be deterred from attacking US cities as well as missile sites since a full-scale retaliation would follow, they might not be as deterred from attacking silos and other military targets. This might be the case since, faced with a counterforce attack (and assuming the US had no launch-on-warning policy), the US would have the options to surrender or respond with a primarily countervalue attack with its SLBMs (the D-5 will make a counterforce SLBM attack possible), followed later by bombers.

Given these alternatives, the argument continues, the US would choose to surrender, as a countervalue retaliation (assuming it is against Soviet cities) would result in a Soviet attack against US cities. Such a Soviet countervalue response would drive the casualty level from the initial counterforce attack from 2-14 million to 80-170 million (DOD estimates).[17]

The argument concludes, therefore, that a defense in depth, incorporating space-based BMD that protected our missile sites as well as cities, would be a valuable asset even if it were not perfect. Not only would the Soviets have to direct missiles currently targeted on cities to counterforce targets to insure adequate penetration of the screen, the presence of an efficient defense would so drive up the number of offensive weapons needed to deliver a successful first strike, an opponent would despair early on of the ability to build enough missiles to saturate such a defense.[18]

Area defense plays a transitional role in the current strategic thinking on SDI. In the first stages of a layered defense procurement, some cities would be protected as a fringe benefit of protection of counterforce assets. As the layered defense was strengthened, cities would eventually have about the same amount of protection as the military assets did earlier.[19].

While this argument seems a reasonable one, there are several important issues it does not address. First, if the US moves to mobile Midgetman, could the Soviets count on being able to take out our land-based hard-target kill capability? Second, as the D-5 is deployed on Trident submarines, would the Soviets not be concerned that we could launch against the missiles they retained for their alleged city strikes in case of a US response against Soviet cities? Next, what about an effective defense against SLBMs and SLCMs? A layered defense would certainly attrit an SLBM attack, but it probably would not destroy as high a percentage of SLBMs as ICBMs because of possibilities such as depressed-trajectory launch. Furthermore, an effective defense against cruise missiles is a significant distance away.[20]

Fourth, if we did move to mobile ICBMs (as well as completing the deployment of the D-5), might not the Soviets be unsure enough of the effectiveness of their initial counterforce strike, even without a US BMD, that they would be sufficiently deterred from launching it? Finally, which is more stabilizing, mutual certainty of the ineffectiveness of a first strike or the mutual certainty of the success of retaliation? Has MAD really been the key to deterrence since World War II, or have there been other viable hypotheses?[21] Whatever one might label the basis of the current strategic relationship, will a move to a defense-dominant posture clearly be more stabilizing? Even if so, will this move toward greater stability be worth its economic cost and bring a net gain to national security? How would that "net gain" be most effectively evaluated? Before embarking on a major space-based BMD development program, the US defense community would have to settle some of these basic strategy issues so that the US Government was moving in as much of a single direction in this area as possible.

The US defense community would also have to assess how the Soviets would consider a move to a BMD regime, a move that would indeed be a fundamental modification in the current strategic relationship. To be sure, a BMD deployment would not necessarily entail the dismantling of the US or Soviet strategic systems, as attractive as that possiblity appeared when Reagan first presented it in his March 23 speech. Strategic systems, and the current deterrence relationship (whether one calls it Mutually Assured Destruction or Mutually Assured Restraint) would be maintained for a fairly lengthy period. As the January 1985 White House pamphlet stated, "the SDI program in no way signals a near-term shift away from the modernization of our strategic and intermediate-range nuclear systems and our conventional military forces."[22] One somewhat less problematic issue that needs resolution, then, is how SDI would entail a modification of the current deterrence strategy, even though it would not necessitate a wholesale replacement of this strategy.

The Transition

A second, though no less important strategic issue, is the question of what happens in the transition period. If a consensus develops among the President and the defense community that a defense-dominant posture is a desirable goal and that the technology is available to reach it, how would they proceed? Some observers have argued that since the US has a greater technological capability than the Soviets and would be able to deploy a space-based BMD sooner, it should pursue that deployment. The assumption here is that American superiority would again be the foundation of world security.[23] Others, like President Reagan, suggested at one time that the US could consider offering our BMD technology to the Soviets or, like Secretary of Defense Weinberger, anticipate that the Soviets will develop and prepare to deploy a similar system at approximately the same time that the US has completed the RDT&E on its own system.[24] A third alternative would be to negotiate a BMD deployment/build-down regime (Defense-Protected Build-Down--DPB) whereby the US and the Soviets would reduce their offensive arsenals as the defensive systems were established.[25]

Evaluation of these alternatives revolves around basically five questions. First, would the Soviets perceive, or could they be convinced, that a defense-dominated strategic relationship is desirable? If they did agree in principle, would they only do so in policy if there were a negotiated transition to that relationship? Next, if there were a negotiated transition, how could it be verified, given that offensive proliferation is only one of the means to defeat a space-based BMD? Likewise, if there were a negotiated transition, what would be the US position if the Soviets did not have sufficient technology for an effective defense and made US-Soviet technology transfer a sine qua non for an agreement? Finally, should the US pursue a space-based BMD if the Soviets objected strongly to its destabilizing nature or if they agreed to negotiating a transition to a defense-dominant posture but stalled the negotiations in an effort to obtain an offensive or defensive advantage?

The Soviets, understandably, considered Reagan's March 23 speech to be indicative of US intentions to renege on the ABM treaty and to gain military superiority, a move the Soviets say they will not permit. Although the Soviets probably would not be worried enough by potential US "aggressiveness" that they would strike against US territory or a US BMD system if the US were to establish such a system, this unilateral initiative would undoubtedly cause major problems for the strategic relationship.[26]

The Soviets, moreover, are unlikely to develop an effective BMD system within the same time frame as the US might develop one, in spite of the extensive work they allegedly have been devoting to BMD over the past decade. Such is the case primarily because of their lags in pomputing and microprocessor technology, as well as their well-known systemic problems in integrating R&D developments into production lines. Secretary Weinberger's 1983 estimation that the Soviets could complete development of such a system at approximately the same time the US finished work on its system is rather optimistic. Even Presidential Science Advisor George Keyworth has noted that the US has a significant technical advantage in the area of space-based weapons systems over the Soviets and that this lead is likely to continue.[27] The Soviets may eventually be able to complete work on a reliable space-based BMD system, but is it unlikely that they could follow the US in such a development program with anywhere near the same speed as they followed the US, for example, in the development of MIRVs or cruise missiles.

A negotiated transition would be a reasonable approach, but would the US be able to pursue a firm commitment to space-based BMD if negotiations became protracted? The January 1985 White House pamphlet states that during the transition period, "arms control agreements could help to manage and establish guyidelines for the deployment of defensive systems," [28] but what would an administration committed to space-based BMD do if the Soviets tried to stall negotiations for political and/or military reasons?

The SALT negotiations took 10 years; is it likely that space-based BMD negotiations would be shorter, given a similar if not greater level of complexity? Furthermore, given the different structure of the two sides' strategic arsenals, how many thorny obstacles would DPB negotiations encounter? Should the US push for an agreement on limitations of military hardware or for a functional or "rules of the road" agreement? How soon in the BMD RDT&E process should negotiations begin? How sure will the US be of its own BMD capability at that time?

Again, one encounters a major series of issues which need to be resolved before a full commitment is given space-based BMD. Obviously, some of these issues may be attended to later than others, but it is important that the US have a well-thought out R&D and deployment plan that has considered the broad range of potential problems the deployment of such a system may create for arms control and US security.

The Soviet Reaction

The probable Soviet reaction in terms of modifications of its doctrine and defense posture is another major issue to be considered. The Soviets have frequently criticized Reagan's "Star Wars" speech, and it is likely that the Soviets will continue to react negatively to the SDI.[29] While the Soviets have generally favored subsytantial expenditures for defense, they want to avoid competition in technological areas where they cannot keep up with (or surpass) the US in the development and deployment of systems using those technologies. Given the aforementioned problems the Soviets have in computers and microelectronics, it is reasonable to expect little change in the Soviet attitude to SDI, particularly if the US does not seek a negotiated transition.

Interestingly, most of the opinions expressed by their military and political officials in the pre-SALT I years supported the development of BMD. Critical articles about US ABM developments criticized the activities of the US military establishment in general as it developed ABM, not the concept of BMD itself. The Soviets were eventually willing to curtail their ABM system development. It seems, though, that that decision resulted less from a conclusion that BMD was ineffective than from the development of the opportunity to sign an agreement with the US that would provide limits in an area of technology where the US was significantly ahead.

Although Soviet open source material on BMD declined in the 1970s, there was still heavy emphasis placed on very strong, yet flexible, defenses against both manned bombers and "unpiloted" (cruise) missiles. Furthermore, the Soviets have continually stressed protection of their military assets in general. One could assume, therefore, that the Soviets would be willing to discuss moving to a defense-dominant posture provided that they did not perceive the US as trying to confront them with a BMD *fait accompli*. Still, the likelihood that the two sides would have qualitatively equivalent systems at approximately the same time (or that the US would share the technologies for its system in time for the Soviets to build their own so that the two sides could deploy systems simultaneously) is slim. Continued Soviet criticism of the SDI is therefore to be expected. Earlier Soviet views favoring BMD cannot be taken as sufficient evidence that the Soviets are still strongly interested in BMD.

If Soviet leaders were to perceive a strong US commitment to a space-based BMD program that did not take Soviet security concerns into account, there are several options they would likely consider. Among those would be increasing their ICBM total, equipping ICBMs with new penetration aids, and pressuring the US for negotiations to limit space-based BMD deployment.[30] The Soviet response to SDI may well resemble the pattern of responses to other US technological innovations. This multi-level reaction pattern includes low-level immediate responses, such as revisions in training, tactics, or deployments, then redesigning or reapplication of existing systems in the medium term, then development of new offensive or defensive weapons systems as a long-term response.[31] Needless to say, a US Government decision to proceed apace with space-based BMD development and deployment with little or no regard for the impact of the decision on the Soviet leadership would be a poor one indeed. While such a decision may not create "hair-trigger" strategic instability, it would seriously undermine and exacerbate the superpower relationship. At the least, such a decision would probably create instabilities as each side tried to assess and redefine the parameters of its own and its adversary's strategic posture in the context of the inevitable changes in the posture that would follow such a deployment decision.

Relations with the Allies

The US Government has often run into significant problems in dealing with its European allies in the area of security policy. As is well known, West European governments support a very strong (nuclear) deterrent posture, preferably one paid for and maintained mostly by the United States. Even a limited conventional theater engagement in Europe would entail an unacceptable level of destruction, and a limited nuclear (in terms of either yields or time) war would be devastating. The issue of the decoupling of Europe from the US strategic deterrent has been a traditional cause célèbre among West Europeans, and it appeared with renewed vigor in the form of pressure in the late 1970s for the Pershing II/GLCM deployment. Although there have been a variety of European reactions to the SDI, the vast majority, at least through the spring of 1985, have been negative.[32] A few positive responses have appeared, partially in response to the Reagan Administration's request for support for SDI for which the Reagan administration petitioned NATO governments in late 1984, but the more numerous voices are counted in the opposition. This section will explore the rationale behind the more audible negative voices first, then examine the reasons adduced in Europe in support of SDI.

European arguments that the concept reveals a US intention for a disarming first strike capability against the Soviet Union are far-fetched. However, concerns that pursuit of the initiative will portend both a significant setback in superpower arms control efforts and stimulation of a Soviet strategic buildup that would threaten the British and French nuclear deterrent forces are important to address. This nuclear force posture question and its implications for deterrence strategy are the most patent issues, but they are still the tip of the iceberg. European concerns extend also to legal, technical, and economic issues.

Clearly the British and French would view the establishment of a US-Soviet BMD regime (<u>sans</u> effective US coverage for Europe) as only slightly less destabilizing than a unilateral US BMD deployment. Any scenario in which the Soviets deployed a BMD but Europe was not well protected by a US BMD would emasculate the independent deterrent forces of Britain and France.* The US might be able to sell European leaders on the idea of a BMD if it provided perfect coverage for Europe and if parts of the system (such as point defenses) were not visible and therefore did not provide a lightning rod for public opposition. Any system which did not cover Europe or gave the impression of serving a "warfighting" rather than deterrent function would be difficult for European leaders (not to mention European publics) to accept. Whether the US would want or be able to develop a space-based and layered BMD for Europe, as well as how the US would deploy such a system would be a major question US policymakers would have to address if they were considering a full-scale space-based BMD development program.

The strategic issues are closely related to the force posture concerns. The President noted in his March 23 speech the European dependence on the US nuclear deterrent and the importance he assigns both to upholding the US deterrent commitment and to consulting closely with the allies about US BMD development plans. Both he and Science Advisor George Keyworth have commented that the eventual idea is to include Europe within the US BMD umbrella,

* Interestingly, the Soviets might consider BMD in the context of the "threat" they perceive from West European nuclear forces an even more worthwhile idea than just in the context of the perceived US threat. An effective Soviet BMD would resolve many of the problems that lead them to the "equal security" argument (that their offensive forces should equal those of the US plus those of Britain and France). The Soviet argument reveals one of the problems when moving from a two-party MAD environment to an *n*-party MAD environment. These problems basically revolve around the concept that one's own forces must equal those of all perceived adversaries, a circular if not inherently destabilizing approach to deterrence. The resultant tendency to proliferate offensive weapons is one problem of MAD which could theoretically be circumvented if all parties moved to a defense-dominant posture.

developing a defense first against the more significant (as Reagan sees it) ICBM threat and then against other types of missiles.[33]

While space-based BMD may conceivably be useful against IRBMs and MRBMs, it is more likely that European countries would have to rely most heavily on a layered anti-tactical ballistic missile network such as is being contemplated using the upgraded Patriot system as one of the principal layers.[34] Such is the case because of the short times to target and the lower trajectories tactical ballistic missiles fly. The US should, of course, evaluate the BMD decision on the primary basis of its own security needs, but since Western Europe has been consistently viewed as inside the US defense perimeter, European strategic concerns must be included in such an evaluation. Staying in touch with the preferences of NATO allies is particularly important, since none of the allies was apparently consulted on the President's March 23 speech prior to its delivery. One could argue well that Europeans have legitimate interests in a US program that might transform the entire basis of NATO European security policy.

Several additional points may be made concerning the strategic issue. First, what the Europeans fear most is a conflict arising from superpower tensions, so in order to reduce such tensions, and possible instability in a transition period to BMD, it will be important to the Europeans that the US Government make every effort to convince the Soviets through negotiations or some other channel that 1) the deployment of a space-based BMD is a desirable goal for both sides and that 2) the US is willing to consider working some arrangement with the Soviets so they do not perceive the US move as a destabilizing one. Basically, the US would need to demonstrate to the Europeans that a BMD regime would either not endanger or, better, would improve superpower stability.

As mentioned before, the Europeans have relied for over a quarter of a century on the US nuclear guarantee. NATO doctrine and strategy has been hammered out over that period in an attempt to synthesize most effectively its nuclear and, secondarily, conventional deterrent capabilities. Europeans understandably prefer fitting into a superpower relationship where, over many years, the risks have become known and accepted than participating in constructing a new superpower relationship with new risks and uncertainties. Most importantly, Europeans are generally averse to a deterrence relationship in Europe which relies to a significant extent on conventional systems or gives the impression of such reliance.[35] If BMD were added as a component to the current superpower relationship, whether Western Europe had an anti-tactical missile (ATM) defense system or not, the nuclear deterrent component would have to be stressed firmly by the West.

In approaching relations with its NATO allies, the US Government would certainly have to consider the necessity of an ATM defense for Europe and what type, if any, would be the most feasible for Europe. The US Government would also have to consider how the European governments would sell such a system to their publics. A NATO point defense would clearly have to be mobile to provide the best protection to the P-II and GLCM units and their convoys of supporting vehicles, but these defenses would also have to be able to provide area protection, given the urban density of Western Europe. That the proposed layered defense could work for Europe is very questionable, and its cost, given the technological problems involved, would be large. Who would pay for the R&D, not to mention the procurement, operation and maintenance? Furthermore, it is important to note that the Europeans would not accept a partial defense, again, because of their concern for the continent's high population density. They would also be concerned at that point with the potentially provocative nature of a BMD deployment.

It is also unlikely that the Europeans would accept the argument that a US deployment of BMD solely on its own territory would strengthen the US-West

European defense tie. The assumption here, that if the US were more secure, it would be more willing to use its nuclear weapons in Europe's behalf, is not an argument that the Europeans would find persuasive. The Europeans are likely to view such a move as a retreat to "Fortress America" and could perceive a US deployment as a default on its European commitment.

A decision to deploy a European BMD obviously raises numerous questions for the transition period in terms of strategic stability, funding, NATO-Warsaw Pact relations, force posture balances, etc. Many of these questions have already been raised by defense analysts and politicians in Europe concerning the part NATO countries might play in the US development of its own BMD. These questions concerning a European deployment would not be intractable, but they are ones that cannot be overlooked in considering such a deployment, not to mention negotiating an arms control agreement involving such systems. If negotiations were instituted to ease tensions before and during the transition period before the deployment of a European BMD, the whole question of the nuclear balance in Europe, as well as the superpower strategic balance, would have to be considered. These questions are similar to those being considered now in Geneva; the cluster of issues is clearly imposing in its complexity.

In spite of these skeptical observations, since at least late 1983 there has also been evidence of support among Europeans for Reagan's SDI. In October 1983 legislators representing NATO parliaments approved a resolution calling for the US to continue its research on a three-tiered space-based BMD. The resolution was passed at a meeting of the North Atlantic Assembly, an advisory body to NATO. The Assembly's 200 representatives approved the motion with one dissenting vote. (The dissenting vote was cast by the Danish representative. Also, Turkey was not represented at the meeting). Among country leaders, Prime Minister Margaret Thatcher has agreed to support R&D on the SDI, with some reservations underlining both the value of a negotiated transition if a suitable system were found and the success up to now of the MAD doctrine. British Foreign Secretary Sir Geoffrey Howe underlined these reservations in a speech in March 1985. FRG Chancellor Kohl at a Munich conference on defense issues in February 1985 also endorsed SDI R&D, noting that there would be useful technology "spin offs" for Germany if German firms could acquire subcontracts for BMD systems. Although French leaders have generally been more consistently opposed to SDI, there were also some indications in the French press in late 1984 of positive evaluations of SDI.[36]

European NATO leaders obviously find themselves in a difficult position on this issue. Even if they firmly oppose SDI, they cannot afford to criticize it strongly in public, lest they forfeit the opportunity to exercise influence on its future development within bilateral relations with the US or within US-NATO consultations. What "bottom line" West European leaders will draw on SDI is yet to be seen.

Public Interest Issues

An infrequently discussed but not insignificant issue that US policymakers would need to address is how the Congress and the US public would perceive a decision to pursue a full-scale BMD development and deployment program. One obvious point is that the US administration that made such a decision would have a significant and multi-level lobbying campaign ahead of it. First, it would have to sell Congress not only on the feasibility of the system but also on its cost-effectiveness and the strategic advantages of moving to a defense-dominant posture. Furthermore, it would have to address a multiplicity of questions like the ones presented herein that would be raised in appropriations hearings and elsewhere. How such forces on the BMD issue would take shape twenty to thirty years in the future is, of course, hard to predict. Unless, however, the practicality of a layered defense can be very thoroughly demonstrated, significant Congressional resistance would probably be a given. Congress has generally supported presidential requests for military system procurement, especially for defensive systems. However, given the highly politicized nature of the debate surrounding the SDI, it is likely that pushing a layered BMD procurement program through Congress would pose significant challenges for whatever administration decided to acquire such a system. Indeed, one should note in passing that Congressional support for ASAT programs has not been strong; except for a few enthusiasts, there has actually been a fair amount of strong negative reaction from Congress.

The administration that wanted to push BMD deployment would also have to be able to convince many skeptical "defense intellectuals" of most of the same points as it would the Congress. The campaign directed towards this group would probably focus on the technical issues of BMD for two reasons. First, it is the technical advice of the defense intellectuals that is most often sought by the Congress for hearings, so it is important that the Congress not be able to get strong, well-supported evidence that is contrary to the Administration's goal. Second, arguments or testimony by defense intellectuals that focus on strategy/foreign policy issues can often be ignored by Members of Congress, who understandably think they can size the world up as well or better than consultants and academics can. Therefore, the administration probably focus its campaign on the technical groups who could most effectively disparage the its position.

The administration should also be prepared to face some opposition from the public at large. If the administration uses effective selling tactics, however, the general public would probably be the easiest group to convince of the soundness of the BMD program. With the public, the administration would probably have two basic tasks. One would be driving home the argument that the world will actually be more stable with defense- rather than offense-dominant postures. There are several hurdles here. Among them are the views of some people 1) that MAD is unalterable as a strategic posture, and 2) that a negotiated transition in coordination with the Soviets will be necessary to avoid giving the impression that the US seeks a "warfighting" capability. The public, like Congress, has generally supported major military programs sought by the President. Furthermore, from the few opinion polls that have attempted to assess public understanding of and support for defenses against strategic missiles, it appears that the public generally favors such programs and is skeptical about arms control for strategic weapons.[37]

Also, in spite of a greater number of activist groups in the recent past (especially compared with the number that mobilized popular sentiment against ABM systems in the late 1960s), it is unlikely that a large number of these groups would see it in their collective interest to oppose BMD. These groups would likely view other issues, such as the freeze and the comprehensive test ban, as more important issues than space-based BMD and consequently would not pool their resources against such a procurement decision. Therefore, the likelihood of strong popular sentiment against an SDI procurement decision is slim.[38]

The other basic task the administration will have in selling its position to the public is to avoid locating point defense installations where they will be plainly visible or would cause some type of environmental problem. One of the growing difficulties of the Sentinel ABM system had were from townspeople who did not want ABM missiles with nuclear warheads sited near their backyard, so to speak. As has been the case in Europe with INF modernization, the more visible the systems will be, the more the whole issue of "militarism" and defense spending will be in the fore-conscience of the public. Highly visible system deployments are clearly something to avoid. (One should note in passing that the visibility issue is sometimes hard to predict. The deployments of

Minuteman did not generate nearly as much public controversy as the ABM deployment proposals did. Perhaps the difference here could be explained by the low population density of the areas around Minuteman bases.)

The issue of avoiding potential environmental problems (except for obstacles affecting excimer laser basing, there may not be many such difficulties for space-based BMD deployment) has been amply demonstrated by controversies involving MX and Trident basing, to mention a couple of recent cases. If the proposed systems either are not highly visible in a ground-based deployment or are space-based, convincing the public of the value of such systems would be relatively easy. Selling the public, as well as Congress and the defense intellectuals, is not an impossible task, but the administration that supports procurement of a space-based BMD should be sure that its position is as solid as possible.

Arms Control Issues

There are several important points to be made about arms negotiations for space-based BMD. First, concerning present limitations, there are two treaties that proscribe the development of such systems. Article V of the 1972 ABM Treaty states that signatories would not develop, test, or deploy space-based ABM systems, and Agreed Statement D holds that in the event of the creation either of an ABM system or of components of a system based on "other physical principles," such developments (regardless of whether the system would be deployed in space or on the ground) would be subject to discussion under the SCC. The 1967 Outer Space Treaty (Article IV) bans the stationing, in space or on celestial bodies, of nuclear weapons or weapons of "mass destruction." The Outer Space Treaty (same Article) also enjoins the use of space for "peaceful purposes."

Clearly it is the ABM treaty that constrains an extensive space-based BMD program. Two points need to be made about the ABM Treaty's prohibitions.

First, "development" as the term appears in Article IV has generally been understood by both sides to mean development beyond the laboratory stage. "Development" refers, then, not to exploratory research and development but actual "field testing" on either a "prototype" or a "breadboard model".[39] Second, while the Treaty does place some restrictions on testing of ABM components, a party could state, as does the President's 1984 Arms Control Statement, that certain types of ASAT technologies (which could clearly be used as part of an eventual space-based BMD system), can indeed be tested. The Treaty limits such testing by stipulating that it should not interfere with the National Technical Means of ABM Treaty monitoring and that the new equipment being tested cannot be substituted for ABM missiles, launchers, or radars.[40]

The Outer Space Treaty's limits on space-based BMD are not specific. The prohibitions on nuclear weapons would preclude space deployment and testing of the X-ray laser (though not deployment of the pop-up version). There would be no such prohibitions on other types of lasers, though there has been disagreement on interpretation of the terms "weapons of mass destruction" and "peaceful purposes".[41] The 1963 Partial Test Ban Treaty also constrains development of the X-ray laser. Article I of the Treaty bans nuclear tests in outer space, and deployment of any type of nuclear bomb-pumped X-ray laser defense obviously would not be feasible without sufficient system testing.

As was clear in the earlier part on technologies, many of the systems for space-based BMD applications are very similar, if not identical, to those for DEW ASATs. Since a treaty limiting ASAT development might clearly limit space-based BMD programs, what should the Government do about ASAT limitations? If the Government decided that a strong space-based BMD program and possible eventual deployment are desirable, it would most likely not want to pursue a comprehensive ASAT treaty but would pursue either no ASAT treaty or a treaty covering only certain ASAT technologies. A decision in favor of BMD would also mean that the Government would have to consider amending the ABM Treaty in accordance with Article XIV.

In a transition period, perhaps the Treaty could be amended to be phased out incrementally, if a DPB-like scheme is negotiated. This approach might be more acceptable to the Soviets than wholesale amendment of the Treaty, though, as previously mentioned, the Soviets are fairly negative about the SDI altogether. Still, phasing out the ABM Treaty with a DPB scheme in place would clearly be more acceptable to the Soviets than unilateral US abrogation of the Treaty.

Interestingly, the ABM treaty as a symbol of US-Soviet detente has, in many ways, taken on a political life of its own and among some supporters developed a sort of sacrosanctity that admits no modification. Nevertheless, it is reasonable to expect that leaders on either side would anticipate proposing amendments to the treaty if they perceived such amendments to be in accordance with the national interests of their country. If, however, the US Government decided BMD was not desirable, it could evaluate the ASAT issue on its own merits and decide for or against pursuing such a treaty.

The critical question here is whether banning ASATs is such a good idea that this policy preference should govern the outcome of the space-based BMD decision. What would the Government do if it wanted to pursue space-based BMD but ban ASATs? A comprehensive ASAT treaty would exclude much R&D on BMD systems because of the technological similarities and the obvious allegation that could be made that one's opponent intends to use BMD systems for both BMD and ASAT roles. Given the current emphasis on space-based BMD, would the benefits of an ASAT treaty be worth the time and effort to negotiate it--that is, to negotiate a comprehensive ASAT treaty with the idea of repudiating it when directed-energy BMD systems are ready for procurement? Could such a treaty even be negotiated?

Answering these questions would involve an entire additional research project, but I shall lay out the basic parameters of this issue in a brief digression on ASAT. The central question to ask regarding ASATs is how valuable to the US negotiating an ASAT treaty would be.

Policy Background

Taking basically the same step-by-step approach as in evaluating BMD issues, one notes in review that the US has traditionally expended a significant amount of money researching ASATs, though it has never put any into serial production. The most recent funding initiative for ASAT development came, not in response to a shift in US space policy in favor of ASATs, but as part of an effort to develop an ASAT capability 1) in response to the Soviet ASAT R&D work and (ostensibly) 2) in order to negotiate a treaty with the Soviets to ban ASATS. While the Soviets have often stated that they will not dismantle their deployed systems because of systems the US only has on the drawing board, they were initially responsive to the US suggestion of ASAT negotiations and, according to the chief of the Carter ASAT delegation, pursued negotiations seriously.[42]

Picking up after the Carter Administration, the Reagan Administration, stating that it does not view the ASAT program as a bargaining chip, has strongly emphasized security and deterrence arguments for developing an ASAT capacity.[43] How serious is the Soviet ASAT threat, and what are the possible technological and political counters?[44]

US and Soviet Technology Developments

US ASAT systems--non-DEW and, potentially, DEW--have been discussed already. The Soviets have two types of ASATs. One is a co-orbital interceptor, deployed by an SS-9 derivative booster, that has had a fairly successful test record. The other is a system, using a similar booster, that destroys its target within the ASAT's first orbit. This system has been tested both with a radar homing device, resulting in a mediocre test record, and with an infrared homing device, resulting in a very poor test series. Both of these ASAT systems have been deployed at an altitude of approximately 1500 km and could be lofted further.[45] While both these systems have potential for further development, their testing patterns, not to mention the technical constraints of a co-orbital ASAT, call into question the reliability and the time-to-target capability of the Soviet systems.

The Soviets have also been working on directed energy weapons, possibly for ground-based ASAT as well as BMD applications, but the application of these programs, particularly to space-based systems, is a threat conceivable only for the distant future. As Stephen Meyer, a specialist on Soviet military affairs, notes, the Soviets may indeed be the first to have DEWs for ground and space use; after all, the Soviets were the first to deploy ICBMs, SLBMs, and an ABM. Given the history of Soviet deployment of weapons based on new technologies, however, Meyer comments that it would be reasonable to expect an additional decade of testing after initial deployment before the system would be put into serial production.[46] This trend, coupled with the mediocre testing history of the current ASAT, indicates that the Soviets will not be able to pose a major threat to US satellites for some time.

I use the term "major" for two reasons. The Soviets do indeed have a capability of sorts against the approximately 25 US satellites in LEO, medium, and "Molniya" orbits (perigee phase only). These satellites constitute about one-fourth of the US military and military-capable satellites in orbit, and only 14 of these 25 would be important in a strategic exchange [less than half of this total of 25 if military photoreconnaissance (MPR) satellites are discounted]. With some duplication of the capabilities of these 14 or so satellites by satellites at higher altitudes (where the Soviets have not yet tested their ASAT), and with the slow intercept times and currently questionable reliability of the Soviet ASAT, there is significant doubt that the Soviets could do a lot of damage quickly to US early warning and strategic C^3I assets. Furthermore, the Soviets would have to launch approximately 20

UNITED STATES MILITARY SATELLITE SYSTEMS

MISSION	CLASS	INITIATED	'82 LAUNCHES	COMPLEMENT	INCLINATION	PERIOD	PERIGEE	APOGEE	LIFESPAN
Communication	DSCS II	1971	1	4 + 2	2.0	G	G	G	5 years
	DSCS III	1982	1	*	2.5	G	G	G	10 years
	→SDS	1971	0	2	63.5	700	250	39,300	2 years
	FLTSATCOM	1978	0	4 + 1	2.0	G	G	G	5 years
	NATO	1970	0	3	2.8	G	G	G	7 years
	MARISAT	1976	0	3	2.5	G	G	G	10 years
	LES	1965	0	●●	25.0	G	G	G	●●
	AFSATCOM***								
Navigation	→Transit	1964	0	5	90.0	105	1,075	1,100	●●
	→NOVA	1981	0	**	90.0	110	1,170	1,190	6 years
	NTS	1974	0	(1)	125.1	468	13,440	13,770	●●
	NAVSTAR	1978	0	6 (@)	63.0	720	20,200	20,300	5-7 years
Meteorology	→NOAA	1970	0	2	99.0	102	810	860	18 months
	→DMSP	1971	1	2	99.0	102	810	870	3 years
Early Warning	DSP	1970	1	3	2.0	G	G	G	2-5 years
Nuclear Explosion Detection*	Vela Hotel	1963	0	2	32.5	6730	110,900	112,200	10+ years
Electronics Intelligence	Rhyolite	1973	0	4	0.2	G	G	G	3-6 years
Ocean Reconnaissance	→NOSS	1976	0	6	63.4	107	1040	1170	●●
Photographic Intelligence	→Key-Hole (KH-9)	●●	0	(1)	96.5	●●	52	119	6 weeks
	→Big Bird	1971	1	(1)	96.0	89	150	330	3-5 months
	→KH-11	1976	2	2	97.0	93	220	550	2+ years
Geodesy	→GEOS-3	1975	0	●●	115.0	102	840	855	●●
	LAGEOS	1976	0	●●	110.0	225	5840	5950	●●

G = Geosynchronous orbit: Satellite moves with same period as the Earth at an altitude of approximately 35,600 km.
●● = Statistic uncertain or unavailable using unclassified literature.
* = DSCS III is follow-on to DSCS II; same complement is planned.
** = NOVA satellites are being incorporated into the Transit network.
*** = AFSATCOM equipment is housed on "host" SDS, FLTSATCOM, LES, and DSCS III satellites.
(@) = NAVSTAR plans call for a network of 18 operational satellites and three spares by 1988.
Apogee = Highest known point of orbit above the earth, given in km.
→SDS = Satellite whose perigee takes it within 1500 km tested range of Soviet ASAT.

* = Other nuclear explosion detection sensors are aboard DSP and SDS satellites. The NAVSTAR system will house an advanced nuclear explosion detection system called IONDS beginning with NAVSTAR-8. Soviet nuclear detection sensors are most likely on their early warning and/or Molniya communication satellites.
Complement = Indicates the nominal number of satellites in a given network: + designates spares in orbit; ( ) = uncertain complement.
Inclination = Highest latitude reached N and S, given in degrees.
Period = Time it takes to complete one orbit, given in minutes.
Perigee = Lowest altitude of same orbit as apogee, also given in km.

Source: John Tirman, ed., The Fallacy of Star Wars (Union of Concerned Scientists) (New York: Random House, 1984), pp. 190-191.

ASATs to destroy US reconaissance and communications satellites in LEO some several hours before the desired mission completion deadline for these ASATs. US space tracking facilities would be well aware of these missions, and the US may even have time to launch the US ASAT system to counter the Soviet ASATs.[47]

In the distant future, the US may also face a Soviet threat from laser warming or illumination of US satellites. In the first case, lasers are used to heat the satellite past the point at which its cooling systems can prevent damage to sensitive electronics. In the second case, lasers are beamed at satellites to burn out optical sensors. The advantages to using these methods are 1) that the destroying mechanism cannot be tracked and therefore intercepted, since nothing is being launched into space and 2) that laser light travels so fast that once a sufficiently focussed beam can be directed past the outer edge of the atmosphere, the laser can hit a satellite in geosynchronous orbit virtually as fast as one in LEO.[48] The primary drawbacks that will negate this threat for some time to come are 1) that lasers which can propagate well through the atmosphere have yet to be developed and 2) that technologies for the difficult tasks of pointing and tracking over large distances are not sufficiently advanced.

Strategic Issues

Are the Soviets likely to begin a central exchange by destroying US satellites in this manner? Soviet military doctrine and strategy on nuclear warfare suggests a resounding "No" to this argument. The Soviets are much more likely to use the EMP capability of exoatmospheric nuclear bursts to "sweep the skies" of US early warning and strategic communications satellites, or at least to render them inoperable. Such an approach would mean that the Soviets would probably also lose their own space assets because of the strength of the EMP, gamma- and X-ray radiation. (It has been suggested that the Soviets could, before the anticipated strike, reconstitute their satellite clusters with EMP-hardened satellites designed to shed their protection after the Soviet exoatmospheric bursts that destroyed the US satellites. How effective this ploy would be against X-ray and gamma radiation from those exoatmospheric bursts would be difficult to assess, so the ploy may not be as effective as it sounds.)

The Soviets have less well-developed warning satellites than the US, and given this problem, it seems likely that the Soviets, currently, and even perhaps for the next 10-15 years, would perceive themselves better off in a crisis situation if neither side has satellites than if both sides did.[49] The implication here is that since the Soviets recognize that the US is significantly more dependent on its sophisticated early warning and communications satellites than the USSR on its satellites, Soviet military planners would be willing to risk the destruction of Soviet early warning and communication satellites if doing so meant that they could effectively and quickly destroy the US capability.

One other assumption underlying this strategic analysis needs to be clarified. This assumption applies to the prospects both of a satellite war as a prelude to a central exchange and a war confined to space. The assumption is that the Soviets are not likely to engage in a central exchange in stages, nor are they likely to fight a war limited to space. The entire weight of Soviet military doctrine and strategy on aspects of strategic surprise and use of force indicates that in a major conflict, Soviet forces are likely to strike hard and fast in order to achieve and maintain the advantage. Arguing thusly is not to assert that the Soviets would immediately escalate a war in space to a central exchange, but the strategic uncertainties that would ensue from a loss of communication and early warning capabilities (even though Soviet capabilities are not as sophisticated as those of the US) would make a war in space very difficult for the Soviets to separate from a central exchange and therefore make a limited exchange difficult to control.

If the Soviets were planning to initiate a central exchange, they would certainly destroy US satellites <u>en masse</u> and immediately do so before a strike rather than do it piecemeal over a period of several hours. As Fred Iklé said in Senate testimony in May 1983, the idea that one can strike against satellites with the assumption of being able to limit the engagement to something like a "casual war" is a dangerous way of thinking.[50] This statement by Iklé is particularly true if tensions between the powers have been aggravated to the point that a central exchange is under consideration by either side.

What if superpower conflict occurs but at a lower level of hostilities? While an advance Soviet attack against individual US early warning satellites (assuming the Soviets had the capability to mount such an attack) seems an

SOVIET MILITARY SATELLITE SYSTEMS

MISSION	CLASS	INITIATED	'82 LAUNCHES	COMPLEMENT	INCLINATION	PERIOD	PERIGEE	APOGEE	LIFESPAN
Communication	Com 1	1970	4	3	74.1	101	790	810	17 months
	Com 2	1970	2 @	24	74.0	115	1385	1565	5 months
	Molniya 1	1965	4	8	62.9	718	400	39,900	2 years
	Molniya 3	1974	2	4	62.9	718	400	39,900	2 years
	Raduga	1975	1	2 + 2	0.3	G	G	G	**
	Gorizont	1978	2	**	0.8	G	G	G	**
Navigation	Nav 2	1974	6	6	82.9	105	965	1020	16 months
	Nav 3	1976	2	4	82.9	105	965	1020	3 years
	GLONASS*	1982	3	3	64.8	673	19,075	19,075	**
Meteorology	METEOR 1	1969	0	(1)	98.0	98	630	680	**
	METEOR 2	1975	2	(3)	82.5	104	870	940	**
Early Warning	EW-1	1972	5	9	62.8	718	400	40,000	20 months
Electronics Intelligence	ELINT 2	1970	4	6	81.2	97	620	640	20 months
Ocean Reconnaissance	EORSAT	1979	5	(2)	65.0	93	425	445	6 months
	RORSAT	1967	4	(2)	65.0	90	250	265	3-4 months
Photographic Intelligence	Low Resolution	1962	3	(1)	82.3	89	210	250	2 weeks
	Med Resolution	1968	8	(1)	70.3	92	350	450	2 weeks
	HI Resolution-1	1963	23	(1)	65-80	89	170	360	2 weeks
	HI Resolution-2	1975	1	(1)	65-70	89	170	370	6 weeks
Geodesy	Geod-1	1968	0	**	3.0	109	1140	1430	**

G, ** = See footnotes below table on p. 62.

* = GLONASS will be a navigation network similar to the U.S. NAVSTAR system; 9-12 operational satellites are expected.

@ = Com 2 satellites are launched in octets by a single carrier rocket.

Electronics Intelligence (ELINT) satellites detect and intercept foreign communications and radar signals.

Geodetic satellites gather precise information about the earth's gravitational and magnetic fields; this information is used to improve missile guidance.

Source: John Tirman, ed., The Fallacy of Star Wars (Union of Concerned Scientists) (New York: Random House, 1984), pp. 192-193.

unlikely tactic for the Soviets to use in beginning central exchange, the issue of Soviet ASAT use in a conventional conflict is more problematic. Some analysts have argued that the Soviets in a conventional conflict may want to eliminate US MPR, communication, or ocean reconnaissance satellites, and that the US may want to eliminate the same Soviet capabilities. Decisionmakers on either side who supported an ASAT strike could argue that since there is no special military-tactical or international legal proscription against destroying airplanes or ships, there need not be any particular worry about eliminating satellites. (These people would assume that attacks on satellites used for verification of the ABM Treaty could be avoided and that the ASAT attack would not be nuclear.)

Opponents to US development of strong ASAT capabilities could assert that both sides have reasonably effective back-up systems and that the value of such a strike may not be worth the international political criticism it would generate by escalating the conflict to a greater level of hostilities. Additionally, opponents could argue that satellites are intrinsically global, not regional, assets like planes or ships, and that destroying such assets could easily be considered an escalatory move. Third, they could argue that the most important activities of reconnaissance satellites in a regional conflict occur before hostilities actually begin, when these satellites are gathering information on the enemy's force posture and order of battle. Unless the US sought to initiate hostilities by destroying Soviet reconnaissance satellites, it would make more sense to obstruct their intelligence-gathering activities by electronic counter-measures or other such means of interference. Fourth, those US decisionmakers opposing an ASAT strike could also argue that protecting US space assets has been a more valuable goal than destroying Soviet satellites and that, therefore, a US ASAT strike that may precipitate a Soviet strike against US satellites would not be militarily practical. Such a retaliatory decision by either side would be difficult to predict, but there would probably be several strong incentives on both sides to avoid escalating the conflict to space if at all possible.

While deployment of space-based or ground-based ASATs probably would not necessitate a wholesale re-evaluation of US strategic doctrine, US policymakers would have to take into account how the Soviets would respond to a heightened US ASAT production program focussing on space-based lasers. With a unilateral US deployment of space-based ASATs, not only would the Soviets be concerned about a threat to their satellites, but they would understandably worry about the possible BMD applications. Such a deployment would be likely to create significant instability in the strategic relationship, and it would be incumbent upon the US to demonstrate to the Soviets the deployment was not for an ulterior BMD purpose. Obviously, deployment of the current US ASAT would create somewhat less tension, but deployment of a space- or ground-based ASAT system, particularly a reliable DEW system with a quick time-to-target capability, would raise many problematic questions for the Soviets.

Furthermore, one can say with confidence that while Soviet ASAT development has been proceeding at a slow but steady pace up to now, a full US commitment to ASAT would very likely stimulate significant progress in the Soviet program. Given the strong Soviet inclination not to be caught short in any principal areas of military technology, it almost goes without saying that the Soviets would devote much more resources and time to their own ASAT program.

There are a number of related arguments that could be adduced to indicate the technical difficulties and strategic problems with deploying ASATs.[51] I have tried in the above discussion to summarize and highlight the main ones, in order to demonstrate the numerous technological and strategic uncertainties related to an ASAT deployment that must be resolved before a full commitment is made to an ASAT or BMD program. Most of the analytical dimensions can be handled in fairly short order.

Reactions of the Allies

US allies did not differentiate in their reaction to Reagan's March 23 proposal between BMD and ASAT concerns. Western Europe's primary interest in an effective deterrent against Soviet nuclear forces and in reduced antagonism between the superpowers would definitely not be aided by ASAT deployments that significantly upset the superpower relationship. Furthermore, the Europeans probably would not be enthusiastic about superpower ASAT deployments unless they could be assured their own satellites would be protected by the US. European governments would undoubtedly not want to expend the resources to develop ASAT capabilities to protect their own (mostly civilian) satellites.

It is unlikely, however, that the US would be able to protect all European satellites, so even if the superpowers negotiated an ASAT treaty, but one that allowed ASAT deployments, West European powers would seek some kind of commitment from the US for protection. Consultation with the allies to avoid these and other problems, should they develop, would be a necessity for the US. The reactions of other friendly nations that owned satellites would also be an additional concern for US policymakers considering a full commitment to ASAT deployment.

Public Interest Issues

The US administration that decided to deploy a space-based ASAT system would encounter resistance from Congress and the public, but probably not as much as the administration that decided to deploy space-based BMD. The deployment would be less expensive, and deploying an ASAT system would not entail revising nuclear deterrence policy. Selling an ASAT system to Congress and the public would be easier if the administration were able to reach some kind of agreement with the Soviets limiting deployments on both sides, limiting types of systems deployed, or limiting the uses of the deployed systems. The selling job would also be easier if the administration were able to deploy ASATs while publically foreswearing a BMD program. Even if that administration were serious about not developing BMD, its success in marketing the ASAT program would be hindered to the extent the administration's opposition was able to connect in the public's view the images of ASAT deployments with those of BMD deployments.

Because the system would not be deployed on the ground, as point defenses for layered BMD would be, the administration would not have to deal with the visibility problem. (This point, of course, does not hold in regard to ground-based directed-energy ASAT systems.)

The administration would still likely encounter criticism from Congress and the community of defense intellectuals about the practicality and cost of such a system. If the administration were able to assemble a strong bilateral coalition in Congress in favor of the deployment, critics in Congress and in the "defense intellectual" community could be ignored.

Arms Control Implications

As mentioned before, there is no specific treaty limiting ASAT deployments, yet there is a body of international law that limits or prohibits certain types of ASAT-related activities.[52] The 1972 ABM Treaty prohibits development and testing of space-based ABM components and subjects the development of ABM systems based on "other physical principles" to SCC review. The ABM Treaty and Interim Agreement, as well as the 1979 SALT II Treaty (observed but unratified), prohibit interference with national technical means of verification. The 1963 Limited Test Ban Treaty prohibits nuclear explosions in space, and the 1967 Outer Space Treaty, as well as SALT II, prohibit nuclear weapons deployments in space. The Outer Space Treaty also binds the parties to pursue international consultation before proceeding with activities that might cause "potentially harmful interference" with other signatories' peaceful exploration and use of space. The 1973 International Telecommunications Convention established regulations to prevent or minimize radio interference with satellites. Also, it could be argued that the spirit, if not the letter, of the 1971 "Accident Measures" and 1973 Prevention of Nuclear War Agreements suggests that interference with satellite early warning systems is improper. Finally, the 1977 Environmental Modification Agreement forbids "military or any other hostile use" of space or other environments of environmental modification techniques having widespread, severe, or long-lasting effects that may be injurious to other parties.

As can be seen, most of these agreements prohibit interference or destruction of satellites, not ASAT deployment. The US, therefore, would not be violating any treaty if it deployed ASATs, unless it was clear that the ASAT had been tested "in an ABM mode". If it were clear that the US had so tested an ASAT, there would be conflicts with Articles V and VI, as well as Agreed Statement D of the ABM Treaty, unless of course in the meantime the ABM Treaty had been amended to permit such testing.

The current US administration, until recently, has not been interested in continuing ASAT negotiations, primarily because it has been unsure about the verification of such a treaty. This concern has dealt primarily with constraints on R&D and production, since testing is fairly easy to identify. The major US concern regarding the present Soviet ASAT is that the Soviets may launch their ASAT from more than one booster (the F-LV, the SS-9 variant). In the March 1984 "White House Report to Congress," the Administration listed a number of other treaty concerns it has that cover a wide variety of ASAT systems and related capabilities. Most of the difficulties that the Reagan Administration has raised are legitimate concerns, but the primary driving force behind the objections is the Administration's national interest argument. If the Administration had determined beforehand that an ASAT treaty was in the national interest, one suspects that some of the objections could have been de-emphasized earlier, or a treaty could have been proposed that only created verifiable limits on certain types or uses of ASATs.

The US Government, as it evaluates the national interest issue for the upcoming negotiations with the Soviets and the possible advantages to concluding a ban on ASATs even if minor verification difficulties remain, should consider the wide variety of implications discussed here of a decision to deploy and use ASATs. For example, developing a negative approach to the talks on the basis of verification problems alone would not be a fruitful or wise decision.

From the above evidence concerning the technological and strategic problems in developing and deploying a feasible space-based ASAT, one can make a strong argument it may be in the national interest to limit directed-energy ASATs and avoid potentially negative implications of a deployment.[53] This position, while seemingly substantial, does not take into account either the current administration's BMD policy objectives or possible deterrence advantages of having a limited ASAT capability. If the Administration wanted a space-based BMD, it could not effectively outlaw DEW ASATS, since the technologies of the systems are closely related. The Administration could, on the other hand, seek to have both space-based ASATs and BMD outlawed--to preserve US and Soviet satellites in sanctuary--as a viable policy option for both the US and the USSR. This administration is not oriented to this type of ASAT arms control, but its successor might decide to pursue such an option. A ban on most space-based weapons would be relatively easy and would still leave ground-based ASAT and BMD options open.

How the Administration will balance the problems in negotiating an ASAT treaty with the advantages of having such a ban is yet to be seen. There obviously are some important verification issues involved, not to mention strategy questions. Any administration that faces the prospect of ASAT negotiations needs to make a careful evaluation of the net national interest with and without an ASAT treaty. Not only are ASAT issues under consideration, but BMD goals are important as well. In structuring the negotiating positions on what types of systems or functions to limit and how those limitations will be verified, policymakers need to be careful that they have given the national interest question a balanced examination and that they have given the permutations of the issues raised in the foregoing discussion a sufficiently thorough evaluation. The basic conclusion the BMD/ASAT analysis here suggests is that an ASAT treaty would be worth further investigation, but a policymaker convinced of the necessity of space-based BMD would perceive an ASAT agreement to be fundamentally disadvantageous.

BMD Arms Control Issues Concluded

Returning then to the legal aspects of space-based BMD, it would be important for decisionmakers to keep in mind the positive aspects of a broad ASAT treaty, so that the advantages of such a treaty are not foregone in the haste to develop a BMD system. While space-based BMD may be possible with some types of ASAT treaty (one that limits, for example, DKE ASATs but not space-based lasers), there would always be the concerns 1) that the treaty would be unworkable because of the impossibility of distinguishing among DEW technologies with regard to their applications and 2) that one country could use its ASATs against the other's BMD system and vice versa. The essential issue here is that one cannot simultaneously limit deployment of DEW ASATs and permit the deployment of DEW BMD systems by differentiating between the technologies used for the two. A treaty could be constructed that included such distinctions, but because DEW BMD systems can perform some ASAT roles and DEW ASATs could perform limited BMD functions, one is basically forced to choose between limiting both types of systems and limiting neither. This position is thoroughly tied with the assumption that both parties in such an agreement would require reliable means of verification of treaty performance by the other side.

When viewing the SDI in its broad range of technological, political, and legal implications, space-based BMD does not seem now like a worthwhile direction to pursue with the level of political and budgetary commitment currently being given it. Even including among the other favorable arguments the contention that a very strong BMD program could be a "hedge" against Soviet breakout from the ABM Treaty, there currently appear to be, on balance, more substantial arguments against rather than favoring an intense space-based BMD program at this time. These calculations may indeed change in the future, as system feasibility improves and as other factors in the strategic situation develop. For the present time, a steady but not intensive R&D funding effort--something less than the projected $25 billion over the next five years--seems a more appropriate path.

Furthermore, it is rather unprecedented that the SDI, only one of many defense R&D efforts, has such high, Presidential-level visibility. Usually, public Presidential support for a defense programs comes after most of the R&D has been completed and the administration seeks to sell the system's procurement to Congress. Given the significant amount of long-term uncertainty tied with the application of directed-energy technologies to specific weapons systems for procurement, the Administration should consider the wisdom of giving the effort somewhat less public attention in case the eventual results do not bear out the initial optimistic projections.

The current administration or a future one may decide that in spite of the variety of technological and other difficulties associated with space-based BMD as it is presently understood, the net payoff to US security from the procurement of such a system would be positive. One can only hope that such a decision would be well considered.

PART III: SPACE-BASED BMD IN THE CONTEXT OF THE ABM CONTROVERSY

The ABM controversy provides some interesting insights for the current space-based BMD debate. Many of the arguments of the two controversies are similar, but there are a few important differences, primarily concerning the feasibility of the systems currently under consideration and the implications of these systems for US nuclear deterrence policy. Many analysts inside the Government and outside it justifiably maintain that only a partial defense is possible in the near-term. Under this assumption, the two controversies look approximately the same. Even though a feasible perfect defense is highly unlikely in the near or mid-term, I will assume that level of feasibility in pursuing the following analysis. It was a perfect defense which President Reagan offered in the March 23 speech, and the President hopefully realized that unless he could offer a system that was radically different from Safeguard/Sentinel, he would be uselessly opening an old debate. President Reagan may have too visionary in the "Star Wars" speech, but I will work on the assumption as before, that the primary goal of the SDI is a near-perfect, not partial, defense.

The literature from the ABM debate is extensive, so for the following analysis, I have simply listed in Appendix II the the major arguments for and against the Safeguard and Sentinel systems taken together. I think that the important lessons can be sufficiently gleaned from such an approach without going into detail about each of the positions.[1]

Reviewing the arguments adduced in the late 1960s on either side of the debate, it is clear that the positions espoused during that controversy bear strong resemblance to those heard during the current controversy. Needless to say, the primary focus around which both sets of arguments revolve is that of the value of MAD. In the ABM debate, a primary component of this part of the debate was whether the addition of any damage-limiting capability detracts from MAD. Without the ABM Treaty, one wonders whether this question would have been settled on the basis of strategic theory or on the basis of the relatively high cost of deployment of the system ($15-$20 billion).

In the current debate the question is not whether to build a damage-limiting capability or not, but whether a perfect defense is worth the cost both in money and in the problems that will inevitably develop as one superpower attempts to encourage the other to modify the basis of their relationship. Therefore, if one assumes a perfect defense is eventually possible, one will not only have to evaluate whether the benefits derived from deploying the defense are worth the system cost (what if an efficient ground-based defense is developed in the meantime?), but also whether the deployment of any defense is more desirable, strategically or economically, than the current state of no defense.

A related difference is that whereas much of the ABM controversy focussed on fairly well defined cost-effectiveness ratios and kill probability calculations for specific systems, the current debate has clearly not reached that level of analysis. Because the kill mechanisms under consideration have not been sufficiently developed for significant system testing, meaningful calculations for more than just rough cost-effectiveness ratios will have to wait a number of years.

Third, the problem of testing will probably be a less thorny question for the space-based BMD decisions than it was for ABM decisions, since nuclear explosions are not employed, except in one of the technologies. BMD testing would necessitate modifications of the ABM Treaty, but such testing would not damage the atmosphere the way ABM nuclear warhead testing would have. One should mention in passing that large-scale tests, whether with nuclear or non-nuclear warheads, are not practical. Also, there is the problem common to both controversies that one cannot test a defense in an near-saturated scenario. These last two points reflect similarities in the controversies.

A fourth significant difference between the space-based BMD and ABM controversies is that the majority of supporters of the DEW systems do not argue their case in terms of regaining US superiority in the superpower relationship but rather of creating a more stable relationship based on defense. Significantly, these supporters generally do not argue that a BMD deployment by only one side (viz., the US) would increase stability. As David Schwartz points out in a recent essay on the ABM controversy, the concept of the superpowers' nuclear parity is one that has been generally accepted by the US defense community as well as the US public.[2] This dynamic, plus the move away from the perspective of the 1950s and 1960s that, with the right set of circumstances, the US could somehow provide the umbrella against nuclear aggression elsewhere in the world has led BMD supporters to avoid focusing their arguments on the potential for reacquisition of US superiority.

The current debate is also marked by an absence of central arguments dealing with demonstration or "blackmail" strikes by small nuclear powers. In the earlier debate, this argument mainly concerned the PRC's capability, and better information about PRC military capabilities in the past decade plus improved US-PRC relations have relegated these arguments to the background. There is generally less paranoia today about small nuclear powers' development of an ICBM capacity.

A sixth major difference is that the prospect of a BMD deployment would not be treated as a real bargaining chip in negotiations to limit offensive nuclear weapons. The stated goal of deploying a BMD is not to damage-limit but rather to protect entirely from nuclear catastrophe. Therefore the US, if it decided that BMD was desirable, would not "trade" the system for limitations on Soviet offensive missiles. President Reagan stated in his second major re-election debate with Walter Mondale that a US suggestion about sharing BMD technology might be a vehicle to motivate the Soviets to reduce nuclear arms along with the US. Still, it is clear that parts of a layered BMD would probably not be given up in negotiations for reduction of a certain number of the opponent's offensive missiles.

Seventh, public involvement in the BMD debate may be much more extensive than in the ABM debate. Public involvement in the ABM controversy was manifested earliest in the 1968 mass demonstrations in several of the cities where ABM sites were to be located in opposition to their deployment. In the following year, significant public involvement occurred again in the appearance of non-military scientists to testify in Congressional hearings.[3] Since that time, the proliferation of "freeze", "disarmament", and "concerned professionals" groups, which are often well organized, has meant that there are sufficient resources to mobilize a significant amount of public opinion and activity against certain weapons deployment initiatives. These resources may, of course, not be used in a coordinated anti-SDI effort, and such activity may not lead to better or more numerous expert testimony in Congress opposing BMD deployment. Popular consciousness-raising may, if it develops great momentum, create a major irritant to a pro-BMD administration.

Finally, there is a larger corpus of international arms control agreements now than in the late 1960s. Policymakers seeking to proceed with weapons system deployments must take into consideration not only the black letter law of the treaties that a particular deployment may violate, but also the political significance of the treaty if amendments to the treaty were sought to facilitate the deployment. Nearly two decades of arms control negotiations have, for better or worse, enshrined the process and the results as worthwhile endeavors. Policymakers supporting space-based BMD have to concern themselves far more than their predecessors with the legal aspects of their programs. Deployments that would run counter to the letter or spirit of specific arms control agreements will require significant justification from arguments based on national interests, cost-effectiveness, etc.[4] This issue transcends any one administration, so even if one group of leaders were not favorably inclined toward arms control, it should indeed be sensitive both to how the next group might view the benefits of arms control and to the problems a BMD deployment might create for that successor administration.

What is the value of this historical comparison for those involved in the current debate? First, the Administration position will be stronger when cost-effectiveness information becomes available (assuming the analyses are favorable). Because the critical technologies are still in the R&D stage, the Administration is open to the charge that its vision of space-based BMD is little more than dreaming. When firmer cost-effectiveness figures are vailable, SDI advocates will probably be able to document better the feasibility of space-based BMD. Such figures can indeed be manipulated, but their availability will probably provide some benefit to SDI supporters. Second, much of the US defense community in the late 1960s thought that ABM was possible. In the current controversy, support for a strong space-based program geared towards eventual deployment is not as 6idespread (NB. DeLauer's comment six months after the President's "Star Wars" speech that the costs alone of the program are "staggering"). The President and his successor, if that administration wishes to continue the DEW funding, would do well to amass greater support within the military community. Third, given the difficulties of the controversies revolving around major weapons issues such as the ABM, SALT II, and MX, it is clear that relatively bipartisan Congressional support will be essential to getting the appropriations for the procurement of such a program passed.

PART IV: CONCLUSIONS

As mentioned in the opening section, this paper has not been intended to argue a particular position on BMD questions but to explicate systematically the problems and advantages of the concept. Therefore, there are no earth-shaking conclusions to be offered. Closing comments and analyses were presented at the end of each of the previous major sections, so here I will try to summarize those observations.

Combining the results from the first three sections, one may draw the following broad conclusions. First, the US defense establishment has traditionally maintained a strong and creative research effort in the areas of BMD and ASAT technology. While few of the products of that effort have reached the testing stage, the resource base is significant; therefore, a reliable space-based BMD probably is an eventually achievable goal. Given the level of technology currently available for the systems being considered, however, the goal of a reliable, layered space-based BMD will probably not be met in the very near term.

Second, as space-based BMD development continues, it is important to keep in mind whether the defense systems one can field at a given point in time will be effective enough that if deployed, they can offer the US more security than the current offence-dominant posture does. The principal concept of the net strategic advantage of the deployment of a defense-dominant strategic posture in comparison with the current offense-dominant posture needs to be firmly at the center of BMD procurement decisionmaking.

Third, US administrations have generally supported strategic and space arms control initiatives and have given these initiatives a fair amount of weight in comparing their value with the value of further weapons systems deployments. A combination of strong military research programs together with arms control initiatives is a traditional pattern in US military space policy, and, therefore, a reasonable one to pursue in the future. Third, in considering how much support to give to space-based BMD developments or an ASAT treaty, there is a broad range of complex questions that need to be addressed in making such evaluations. Any simple answer to these questions is likely to be insufficient, if not misleading.

Finally, any US administration that hopes to sell Congress on the procurement of a space-based system is going to have to be very well prepared. Even if the concept receives strong Congressional and public support, there may be strong sectors of resistance in the Congress and among the public at large.

APPENDIX I
TECHNOLOGIES FOR SPACE-BASED BMD

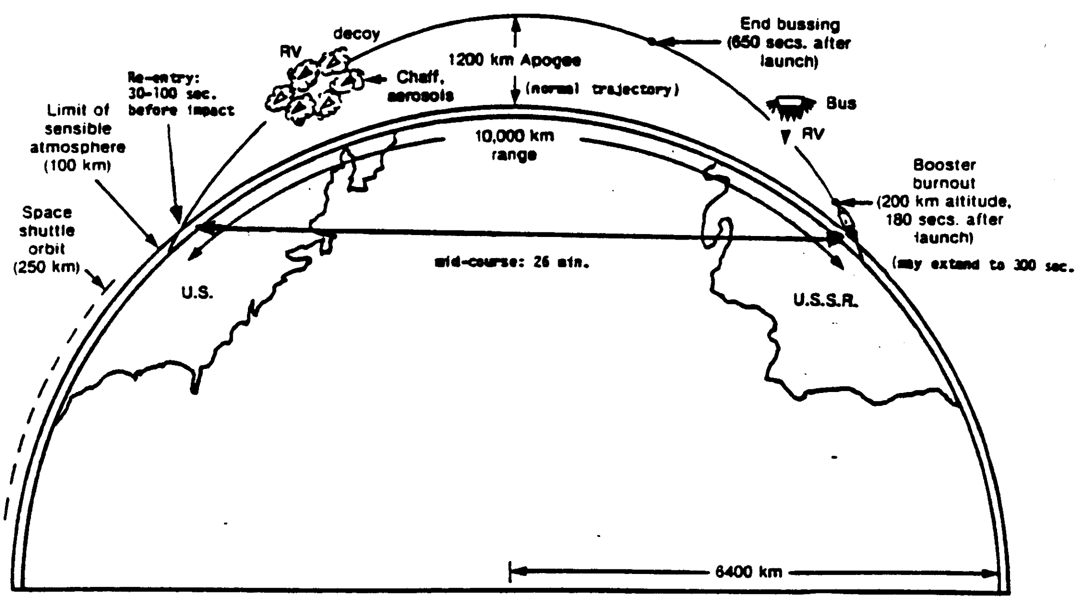
This section focuses on directed-energy technologies and their applications for boost-phase intercept, since it is such technologies and applications that have received the most publicity. The information presented below constitutes a summary of the available technical literature on this topic, and many of the arguments are taken from Ashton Carter's 1984 study for the Congressional Office of Technology, Directed Energy Missile Defense in Space--A Background Paper, but there are a number of places where I have expanded upon Dr. Carter's calculations.

There are basically six types of directed energy concepts that could be employed in a space-based BMD system: chemical lasers, ground-based lasers with space-based mirrors, nuclear-powered X-ray lasers, particle beams, directed kinetic energy, and microwave generators.[1] (NB: The calculations offered in this section are only rough approximations of actual system performance.)

Chemical Lasers

Chemical lasers can be based on reactions employing hydrogen flouride, carbon dioxide, carbon monoxide, deuterium flouride, and iodine. The principal one being studied by DARPA involves a hydrogen flouride (HF) laser

The Flight of a Hypothetical Future Soviet ICBM With the Booster Characteristics of the U.S. MX Peacekeeper, Drawn to Scale



Source: Based on Ashton Carter, Directed Energy Missile Defense in Space (Washington: Office of Technology Assessment, 1984), p. 7.

that includes a 20-Megawatt laser with a 10-meter mirror. This laser produces a beam which, at 4000 km., produces a cone of light with a 1.3 m diameter and an energy of 1.5 Kw/cm^2. The light produced by this laser needs to dwell on a target for about 6.6 seconds to deliver enough thermal energy to burn through the missile skin and destroy the missile. The total amount of energy necessary for the kill would be about 10 Kj/cm^2 or 10 $Kw/sec/cm^2$. Most Soviet missiles currently have about 10 Kj/cm^2 hardness, so a kill at this power output is possible. Since the beam travels at 3600 km/sec and the missile is traveling at several km/sec, a laser battle station at 4000 km would have to lead the missile by about 50 m.

While laser light propagates reasonably well through space without much "blooming" of its beam, the laser battle station has to aim the beam accurately and stabilize it over the 4000 km distance so that the beam does not wave about or "jitter". To handle the 1400 boosters the Soviets would be likely to fire simultaneously (this figure assumes they fire all their ICBMs but withhold their approximately 990 SLBMs), about 160 laser battle stations (32 clusters of five stations) would be needed.[2] This is the number of battle stations necessary to insure that the Soviet Union is always covered by enough battle stations to destroy the 1400 missiles in their boost phase (this phase lasts for about 280 seconds after launch). Only three or so of these clusters would be over the Soviet Union at the time of launch (less than that if the Soviets grouped their ICBMs in a single geographic region), so the US would have to buy about 11 times more stations than would actually be used in an engagement.

A spot diameter of approximately 2 meters at a lethal fluence of 10 Kj/cm^2 results in an energy expenditure of 300 MJ per booster killed (at a fuel consumption rate of 1 kg/MJ). Destroying 1400 Soviet boosters necessitates about 420,000 kg of chemicals in position over the Soviet ICBM fields, or about 4.6 million kg [(420,000 kg/3 orbital positions) x 11] worldwide. Given that the space shuttle can carry a maximum of 15,000 kg per trip, about 310 shuttle loads would be necessary just to fuel these stations, not to mention building them. Taking optimistic estimates that NASA will be able to fly one shuttle mission per week by the 1990s, the laser battle station constellation could theoretically be deployed in a year and a half or so. Whether reality would correspond to theory here is hard to say at this time.

On a more positive note, if the Air Force is successful in pushing the development of its expendable launch vehicles that have a much higher payload capacity than the shuttle, the length of time to deploy the desired number of battle stations would be significantly reduced. [3]

Ground-based Lasers with Space-Based Mirrors

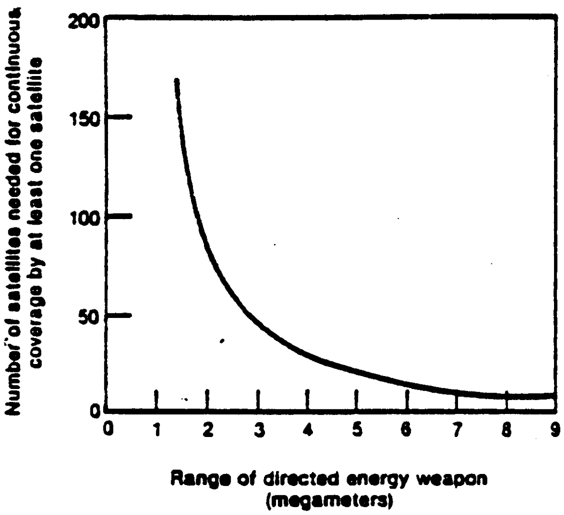
Ground-based lasers are derived from excited dimer (excimer) physics and use combinations of noble gases and halogen atoms, particularly xenon flouride, xenon choride, and krypton flouride. The wavelengths of these lasers are shorter than those of chemical lasers, thus permitting smaller mirrors. However, since the rest of the equipment to produce this type of laser light is cumbersome, ground basing is currently the only feasible alternative. The scheme using an excimer or free-electron technology would probably necessitate basing lasers on mountain tops to lessen beam propagation problems caused by the atmosphere. These laser stations would produce a beam that would be reflected around the curve of the earth by a space-based relay mirror. The relay mirror would reflect the light to intercept mirrors over the Soviet Union and then to the ICBMs. Because of inevitable atmospheric interference with beam propagation, the power at the laser source must be about 400 MW, or about 10 times that reflected by each intercept mirror. Because of this atmospheric interference, space-based laser beacons for adaptive optics are necessary to correct perturbations in the beam from the ground.

Excimer lasers destroy their targets by impulse kill as well as by thermal kill, the process used in chemical lasers. Impulse kill works through the deposit of the necessary lethal fluence (10 Kj/cm^2) on the target in a very short time--millionths of a second instead of several seconds. Instead of burning through the missile skins, the laser pulse vaporizes a small layer of booster skin. The superheated gases, together with the surrounding air, then explode, sending a lethal shockwave into the booster. Because excimer lasers emit light in pulses rather than in a continuous wave, and because their location on the ground may permit usage of larger energy sources than stations in space, fast impulse kill may be preferable for excimer lasers than slower thermal kill. Currently, the technology for excimer lasers as they may employ either type of kill is still underdeveloped. (Chemical lasers may operate by impulse kill as well, but because of the tremendous fuel requirements to generate the necessary power, space-based impulse-kill systems are not considered practical.)

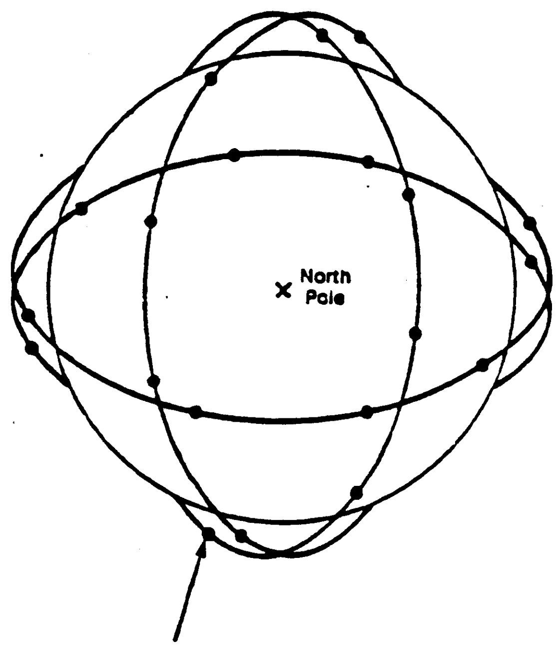
For thermal kill of ICBMs in the boost phase, approximately 12 mountaintop lasers rated at 400 MW are needed (assuming a .5 sec dwell time), as well as 10 30-meter-diameter finely ground relay mirrors, 10 adaptive optic beacons, and about 100 intercept mirrors. The technology to manage such systems makes them currently infeasible.

Nuclear Bomb-Powered X-Ray Lasers

These lasers are based on the concept of using a 1 megaton or so bomb to excite the electrons in lasant rods. These lasant rods are aimed at a missile, and their beams destroy it by building up a charge of energy on the missile skin, causing it to explode and sending a shockwave through the



The number of satellites needed in a constellation to ensure that at least one satellite is over each Soviet ICBM field at all times depends on the effective range of the directed energy weapon. For every one defensive weapon required overhead a Soviet ICBM field to defend against a rapid Soviet attack, an entire constellation must be maintained on orbit. Since there are many Soviet ICBM fields distributed over much of the Soviet landmass, more than one satellite in each constellation would be in position to participate in a defensive engagement. The ratio of the number of satellites in the constellation to the number over or within range of Soviet ICBM fields is called the absentee ratio. If all Soviet ICBMs were deployed in one relatively small region of the U.S.S.R., the absentee ratio would be the same as the number of satellites in the constellation.



● = Cluster of 5 chemical laser battle stations
Total of 32 × 5 = 160 battle stations

Constellation of hypothetical directed energy weapon satellites with 4,000 km range. The orbits are circular with 1000 km altitude. Each of the four orbital planes consists of eight positions spaced 45° apart around the circle. In the example given in the text, five chemical laser battle stations are clustered at each point shown in this figure, for a total of 32 x 5 = 160 battle stations.

Source: Ashton Carter, Directed Energy Missile Defense in Space (Washington: Office of Technology Assessment, 1984), p. 19.

missile. X-ray lasers, such as used in the Excalibur program, require about the same amount of energy for their kill as visible lasers that use impulse kill, which is about 20 Kj/cm^2. Since these lasers employ impulse rather than thermal kill, dwell time is not a factor. Rods of each battle station could be bundled so that a station could hit several boosters simultaneously, but since about one X-ray laser battle station is needed per Soviet booster, the cost tradeoff for launching a new laser for each new booster deployed isinefficient. X-ray lasers have also been investigated in a pop-up concept, whereby these lasers would be shot into space on boosters based in the US or Great Britain or on submarines. For an effective X-ray laser defense, a very fast-burn booster is needed which would place the laser in orbit before the end of the 180-second boost period of the ICBM. If the Soviets chose to depress the ICBM trajectory, the time allowed for boosting the laser would be even less.

Particle Beams

Neutral particle beams are produced by electron accelerators. (Charged particle beams have long been considered impractical because of their sensitivity to the earth's magnetic field, but recent research indicates that these difficulties may be surmountable.) The fuel needed is a plasma from a gas or radioactive substance whose electrons are accelerated by a high-current and high-energy accelerator to create a hydrogen (or deuterium or tritium) beam. When this hydrogen beam hits its target, it deposits high-energy electrons along its entry path, thereby melting what it penetrates. Irradiation and thermal properties for such beams as they strike a target are not fully understood, and the beams themselves propagate very poorly through the atmosphere. Therefore, these beams are only useful against missiles for the very short part of their boost phase when they have left the atmosphere (about 10 seconds duration).

Assume the existence of a space-based accelerator that can produce a beam whose power is 0.4 Kw/cm^2 at 2000 km. (Such an accelerator is significantly more powerful than any accelerator currently in existence in the US.) Given the necesesary dwell time of 5 seconds per booster, approximately one accelerator can destroy two boosters (in the 10 second period). This determination means that in order to counter a Soviet missile launch of 1400 boosters, about 7200 satellites are needed worldwide, assuming a battle station range of 4000 km [(700 satellites/3 clusters over USSR) x 32 clusters]. Given the problems with beam propagation plus the means by which the Soviets could shorten the boost phase, particle beam technology is not cost-effective at this time.

Directed Kinetic Energy Weapons

Directed kinetic energy (DKE) weapons rely on high velocity collisions by projectiles shot from satellites, either by rockets or by rail guns on the satellite. The rocket attack relies on long-range homing devices located on the carrier satellite or other satellites to direct the rocket to the target, since it is currently too expensive to mount long-range sensors on each rocket (efficient terminal homing combined with long-range sensors may be a possibility in the future). Current problems with DKE weapons mainly concern the velocity at which the rocket or projectile travels, which result in tradeoffs between the range of the carrier satellite and the number of carrier satellites needed. Given that a rocket can travel from its carrier at about 5 km/sec and has only 300 sec of its target's burn time to travel to the target, the carrier cannot be more than 1500 km from the target. This means that about 10 carriers or so above the Soviet Union at launch time would be needed, each carrying 140 projectiles. Assuming that the rockets with their fuel and projectiles weigh at least 80 kg, each carrier weill weigh at least 11,000 kg (140 rockets x 80 kg/rocket). Given that the Space Shuttle can only carry 15,000 kg per trip. establishing the worldwide system of about 240 satellites (for full USSR coverage) would take over 200 shuttle launches (taking into account the weight of the carrier satellite and its contents.)

Microwave Beams

Microwave generators would destroy a booster by damaging sensitive electronics in the missile. Because this technology is in its very early stages, a lethal space-based microwave generator has yet to be developed. The main challenges facing designers of such generators are engineering a suitable power source and a means to prevent the significant beam spreading and attenuation, since microwaves propagate very poorly through all but the thinnest atmosphere.

APPENDIX II
SUMMARY OF ARGUMENTS FOR AND AGAINST THE ABM SYSTEM[1]

Technological Arguments

For ABM:

Defenses cost as much to defeat as to build. ABM does not favor the offense.

An ABM system cannot be tested in its entirety because it uses nuclear warheads. System components individually can be tested well enough to make the determination that the system is operationally sound.

ABM opponents rate Soviet ICBM kill probabilities too high when figuring cost-exchange ratios.

Against ABM:

ABM systems are too expensive.

ABM systems are ineffective; the cost-exchange ratio favors the offense.

It is impossible to test ABM systems well enough to determine their operational capability.

ABM systems can be easily countered with decoys, chaff, etc.

Strategy/Arms Race Arguments

For ABM:

An ABM will prevent a catalytic, nuclear war provoked by small powers.

An ABM will insure against a nuclear war started by the accidental launching of one or more ICBMs.

Defensive measures are always stabilizing. It is the mission of a nation's military to defend that nation.

The Soviets have an ABM system, so the US should also.

A superpower military relationship based on defense would produce a safer world.

Having an ABM might produce a "winning" position and ensure US strategic superiority.

The Soviets have built up their ICBM force, and the US needs a counter.

An ABM strengthens the US second strike capability.

An ABM reduces the credibility of small, token, or demonstration/bargaining strikes in crises.

The Soviets have never said that there is a particular percentage of the US population they seek to destroy in a nuclear conflict. Therefore, the Soviets will not regard the US acquisition of a damage-limiting capability as destabilizing.
It is true that an ABM capability is most stable when it is paired with arms control efforts, but ABM detractors do not have a good scheme for arms control.

Against ABM:

An ABM system is destabilizing because it suggests that a country's principal goal is to survive a nuclear conflict after launching a first strike.

An ABM creates uncertainty about the effectiveness of a nation's strategic forces.

One of the principal means of countering ABM is proliferating offensive missiles. A US ABM will mean that the Soviets will acquire more ICBMs.

ABM supporters simply want to turn back the clock to a period of American nuclear hegemony.

The inevitable future decisions to modernize a limited ABM deployment will blur the clear initial purpose that the system was designed to deter nuclear powers with small capabilities, not the Soviet Union.

ABM generates a false sense of security.

An ABM deployment decision should be based on the risk of war, not on an estimation of the force levels of the other side. The risk of war is not great at this time, so ABM should not be deployed.

An ABM deployment could easily be a prelude to a US or Soviet breakout to a position of superiority.

Arguments Based on Analyses of Soviet Intentions

For ABM:

The Soviets favor the concept of ABM and do not regard damage-limiting capabilities as destabilizing.

The Soviets may try to counter the US ABM by countermeasures rather than proliferating missiles, and the US ability to overcome these countermeasures will increase with time.

Against ABM:

A US ABM capability will erode the growing detente between the two nations.

The Soviets have shown much less interest in the recent past than earlier in continuing their ABM construction.

Arguments Relating ABM to Relations with the Allies

For ABM:

An ABM increases the credibility of the US guarantee to the allies.

An ABM reduces the possibility of nations with limited nuclear capabilities blackmailing the allies with their nuclear forces, since those nations know the US will not respond.

Against ABM:

If the US is without an ABM, the security of the allies is enhanced because the USSR will know that the US will not launch a first strike since it would be unable to defend against the inevitable crushing Soviet response.

Public Interest/Domestic Political Arguments

For ABM:

An ABM deployment will provide economic benefits, such as employment, federal investment in community economies, etc.

An ABM will provide damage-limiting capability, with the result that recovery from a nuclear exchange will be assured.

Against ABM:

The funds spent on ABM should be spent for more pressing non-military domestic needs.

Safeguard is a system looking for a mission. The Nixon Administration is considering deployment only because so much money and time and so many careers were invested in the previous system, Sentinel.

An ABM deployment demonstrates that Man cannot control the technological revolution.

Legal Arguments

For ABM:

Since a superpower relationship based on defense is more stable than one based on offense, an ABM deployment could be considered a disarmament measure.

Arguments that weapons acquisition fuels the arms race and leads to war are not historically demonstrable.

An ABM deployment could serve as a bargaining chip in the proposed superpower arms limitation negotiations.

Against ABM:

An ABM deployment reduces the possibility of a comprehensive nuclear test ban treaty and a partial test ban treaty because of the additional testing that needs to be done before deployment.

An ABM threatens the viability of the Non-Proliferation Treaty.

An ABM deployment endangers any possibilities for disarmament negotiations.

There have always been asymmetries in the Soviet and US defense posture, so the potential for ABM as a bargaining chip is nil.

NOTES

Introduction

[1]Although the primary goal will be to arrive at conclusions on space-based directed energy weapons, several ground-based systems using directed energy will be included in the analysis, since the capabilities, military value, and political constraints of the two types of systems are similar. Also one must note that there is an exception to the point about the methodological problems of single-issue arguments, and that is the exception dealing with the technological bases for space-based BMD. A very large number of scientists knowledgeable about directed energy weapons believe that Reagan's vision of the feasibility of such weapons is purely fantasy--that the complete deployed systems Reagan wants are not possible within 40 years, not to mention 15 to 20. If one accepts this position, further discussion of other areas of concern related to space-based BMD is irrelevant. For the current examination, I will assume that there is some prospect for the deployment of a space-based BMD system within the next 25-35 years and frame the related arguments within that time period. Although I will discuss the promising and less promising aspects of space-based BMD technologies, the final determination of the technological feasibility of the initiative is left to those who are involved with the research for the relevant technologies.

[2]"President's Speech on Military Spending and a New Defense," New York Times, May 24, 1983, p. 20.

[3]See Lamberson's written testimony in U.S., Congress, Senate, Committee on Armed Services, Hearings. Department of Defense Authorization for Appropriations for Fiscal Year 1984. 98th Cong., 1st sess., 1983 (Part 5), p. 2651.

[4]Among the few examples of analyses displaying this sufficient breadth are Ashton Carter and David Schwartz, eds., Ballistic Missile Defense (Washington: The Brookings Institution, 1984) [hereafter Carter and Schwartz], Colin Gray and Keith Payne, "Star Wars: Pros and Cons," Foreign Affairs 62 (Spring 1984) [hereafter Gray and Payne]: 820-842, Sidney Drell, Philip Farley, and David Holloway, The Reagan Strategic Defense Initiative: A Technical, Political, and Arms Control Assessment (Stanford, CA: International Strategic Institute, 1984)[hereafter Drell, Farley, and Holloway; this book was reissued in 1985 under the same title by Ballinger Publishing Co., Cambridge, MA]; and a forthcoming book, Weapons in Space, edited by Jeffrey Boutwell and Donald Hafner, to be published in the fall of 1985 by W.W. Norton and Co. Boutwell and Hafner's volume will appear as the joint Spring/Summer 1985 issue of Daedalus.

PART I: US Military Space Policy, 1950-1984

[1]Jack Manno, Arming the Heavens. The Hidden Military Agenda for Space, 1945-1995 (New York: Dodd, Mead & Co., 1984) [hereafter Manno], pp. 11-14.

[2]Ibid., pp. 48-50.

[3]Ibid., pp. 16-17.

[4]John Gaddis, The United States and the Origins of the Cold War, 1941-1947 (New York: Columbia University Press, 1972), pp. 247, 281, 337-352; and Seyom Brown, The Faces of Power (New York: Columbia University Press, 1983) [hereafter Brown], pp. 39-51. See also Gregg Herken, The Winning Weapon (New York: Vintage Books, 1981), pp. 145-155.

[5]Manno, pp. 25-26; Brown, pp. 72-77; and Lawrence Freedman, The Evolution of Nuclear Strategy (New York: St. Martin's Press, 1981) [hereafter Freedman], pp. 76-90.

[6]Manno, pp. 21, 42-45; and Bruno Augenstein, "Evolution of the U.S. Military Space Program, 1945-1960: Some Key Events in Study, Planning, and Program Development," in International Security Dimensions of Space, eds. Uri Ra'anan and Robert Pfaltzgraff (Hamden, CT: Archon Books, 1984)[hereafter Augenstein], pp. 274-276. For more information on the history of US civilian and military space programs, see Hans Mark's paper, "War and Peace in Space," to be published in the Summer 1985 issue of the Journal of International Affairs.

[7]Freedman, pp. 158-160; and Manno, pp. 41, 46-47.

[8]Michael Gordon, "Proposed U.S. Anti-Satellite System Threatens Arms Control in Space," National Journal 15 (December 31, 1983) [hereafter Gordon]: 2662; and Manno, pp. 41, 46-47.

[9]Gordon, p. 2662; and Manno, p. 89.

[10]On Nike-Zeus and Nike-X developments, see C.F. Barnaby, "The Development and Characteristics of Anti-Ballistic Missile Systems," in Implications of Anti-Ballistic Missile Systems (Pugwash Monograph II), ed. C.F. Barnaby and A. Boserup (London: Souvenir Press, 1969); Abram Chayes, et al. "An Overview," in ABM. An Evaluation of the Decision to Deploy an Antiballistic Missile System, eds. Abram Chayes and Jerome Wiesner (New York: Signet Books, 1969), pp. 3-10; D.G. Brennan and Johan Holst, Ballistic Missile Defense: Two Views, Adelphi Paper no. 43 (London: Institute for Strategic Studies, 1967), pp. 2-4; David Schwartz, "Past and Present: The Historical Legacy," in Ballistic Missile Defense, eds. Ashton Carter and David Schwartz (Washington: The Brookings Institution, 1984) [hereafter BMD], pp. 330-343; and Fred Kaplan, The Wizards of Armageddon (New York: Simon and Schuster, 1983), pp. 343-355. The reference to the 70% success rate comes from Barnaby and Boserup, p. 4.

[11]Manno, pp. 50-53.

[12]Ibid, pp. 54-68, 76-85; and Augenstein, pp. 278-279.

[13]Ibid. pp. 86-88.

[14]Ibid, pp. 28-30, 101-103.

[15]Ibid, pp. 105-106, 116.

[16]For discussions of arms control in the Eisenhower and Kennedy years, see Manno, pp. 26-27, 32-33, 60, 76-77, 85; Bernhard Bechhoefer, Postwar Negotiations for Arms Control (Washington: The Brookings Institution, 1961), pp. 159-598; Freedman, pp. 195-207, 244; Brown, 94-97, 242-258; and Jerome

Kahan, Security in the Nuclear Age (Washington: The Brookings Institution, 1975), pp. 56-60.

[17]Paul Stares, "Space and U.S. National Security," in National Interests and the Military Uses of Space, ed. William Durch (Cambridge, MA: Ballinger, 1984), p. 38.

[18]Gordon, p. 2662.

[19]Marcia Smith, "Antisatellites and Space-based Ballistic Missile Defense," Issue Brief no. B81123 (Washington: Congressional Research Service, 1984) [hereafter Smith], pp. 6-7; John Pike, "Anti-Satellite Weapons," Federation of American Scientists Public Interest Report 36 (November 1983) [hereafter Pike]: 3-4; and Manno, p. 143.

[20]Pike, p. 5; and Smith, p. 7. According to a January 1983 GAO report Smith cites, the MAL program has become more costly than originally estimated. The GAO report consequently comments that alternative technologies should be investigated more carefully before PMAL enters production.

[21]Interview with Carter Administration defense official, May 13, 1985.

[22]See Larry Pressler's Los Angeles Times article, reprinted in U.S., Congress, Senate, Committee on Foreign Relations, Hearings. Controlling Space Weapons, Hearings before the Committee on Foreign Relations on S. Res. 43 and S.J. Res. 28. 98th Cong., 1st sess., 1983 [hereafter Hearings. Controlling Space Weapons], p. 12; Gordon, p. 2664; Manno, p. 145; and James Canan, War in Space (New York: Harper and Row, 1982), pp. 23-24.

[23]U.S., Congress, Senate, Committee on Foreign Relations, Arms Control and the Militarization of Space, Hearings before the Subcommittee on Arms Control, Oceans, International Operations and Environment of the Committee on Foreign Relations on S. Res. 129. 97th Cong., 2nd sess., 1983 [hereafter Arms Control and the Militarization of Space], pp. 47-48. The justifications for an ASAT capability listed here do not constitute the complete list Bucheim provided in testimony.

[24]See Zeiberg's comments in U.S., Congress, Senate, Committee on Armed Services, Hearings. Department of Defense Authorization for Appropriation for Fiscal Year 1980. 96th Cong., 1st sess., 1979, p. 3027.; and "Priorities Set for Antisatellite System," Aviation Week and Space Technology 111 (September 3, 1979): 57.

[25]Arms Control and the Militarization of Space, pp. 34-35. For a useful breakdown of DEW funding in the Carter and Reagan administrations, see the appendix in Jeff Hecht's Beam Weapons. The Next Arms Race (New York: Plenum Press, 1984), p. 353.

[26]See Appendix A in Colin Gray, American Military Space Policy (Cambridge, MA: Abt Books, 1982)[hereafter Gray, American Military Space Policy], p. 112.

[27]"U.S. Policy on ASAT Arms Control. White House Report to Congress," March 31, 1984 [hereafter "U.S. Policy on ASAT Arms Control], pp. 8, 12.

[28]For a summary of those debates, see Freedman, pp. 344-395.

[29]On Site Defense, see Clarence Robinson, "Army Spurs Missile Defense Technology," Aviation Week and Space Technology 100 (September 22, 1974): 12-15; Clarence Robinson, "U.S. Shifts Emphasis on Missile Defense," Aviation Week and Space Technology 100 (May 6, 1974): 40-44; and Clarence Robinson, "U.S. Pushes Expanded ABM Data Base," Aviation Week and Space Technology 102 (April 21, 1975): 18-20; and Stephen Weiner, "Systems and Technology," in BMD, pp. 63-75. See also the discussion of point defense, particularly the Swarmjet system, in Daniel Graham, High Frontier. A New National Strategy (Washington: Heritage Foundation, 1982) [hereafter Graham], pp. 115-117. On LoADS, see R. Jeffrey Smith, "Carter's Plan for MX Lives On," Science 216 (April 30, 1982): 492-495; Alan Jones, "Implications of Arms Control Agreements and Negotiations for Space-Based BMD Lasers," in Laser Weapons in Space. Policy and Doctrine, ed. Keith Payne (Boulder, CO: Westview Press, 1983) [hereafter Jones], pp. 36-68; Clarence Robinson, "U.S. to Test ABM System with MX," Aviation Week and Space Technology 110 (March 19, 1979): 23-26; Office of Technology Assessment, MX Missile Basing (Washington: GPO, 1981) [hereafter MX Missile Basing], pp. 114-129; and "Low-Cost ABM Radar Given Emphasis," Aviation Week and Space Technology 116 (March 1, 1982): 74-75.

[30]Clarence Robinson, "Technology Program Spurs Missile Intercept Advances," Aviation Week and Space Technology 108 (June 5, 1978): 108-111; Jones, pp. 55-60; MX Missile Basing, pp. 129-137; and Clarence Robinson, "ICBM Intercept in Boost Phase Pushed," Aviation Week and Space Technology 109 (July 17, 1978): 47-50. The technology for the HOE passive infrared sensor was borrowed from that used for the MHV; see note 22, Part II. A variant in the late 1970s of the Army's HOE program was the Homing Intercept Technology (HIT) program. For a discussion of HIT, see Robert Aldridge, "Missile Killers: The Hidden Arms Race," Nation 231 (October 18, 1980) [hereafter Aldridge]: 370.

[31]Aldridge, p. 370; and "DARPA Developing Advanced Weaponry," Aviation Week and Space Technology 112 (June 16, 1980): 59.

[32]"DOD's Space-Based Laser Program--Potential, Progress, and Problems," Report by the Comptroller General of the United States, C-MASAD-82-10 (Unclassified digest) (Washington: GPO, 1982); and Clarence Robinson, "GAO Pushing Accelerated Laser Programn," Aviation Week and Space Technology 116 (April 12, 1982): 16-19. The GAO report has been criticized for being too optimistic about DEW BMD applications. In addition to the programs DARPA has been managing, the Air Force in the early 1980s tested a CO_2 laser in a specially mounted pod on an NKC-135. This program, the Airborne Laser Laboratory, was pursued as a proof-of-concept project; it successfully destroyed five AIM-9 Sidewinders in a 1983 demonstration. On the Airborne Laser Laboratory, see Barry Smernoff, "The Strategic Value of Space-Based Laser Weapons," Air University Review 33 (March-April 1982)[hereafter Smernoff]: 9-13; and J. Raloff, "'Major milestone' in laser weapons tests," Science News 124 (August 6, 1983): 5-6.

[33]Edward Ulsamer, "Space Command: Setting the Course for the Future," Air Force Magazine 65 (August 1982): 48-55; and Clarence Robinson, "Defense Dept. Backs Space-Based Missile Defense," Aviation Week and Space Technology 117 (September 27, 1982): 14-16.

[34]"DOD Space Policy Fact Sheet," U.S. Department of Defense, August 11, 1982.

[35]For summaries of the developments leading to the March 23 speech, see William Broad, "Reagan's 'Star Wars' Bid: Many Ideas Converging," New York Times, March 4, 1985, pp. A1, A8; and Laurence Barrett, "How Reagan Became a Believer," Time 125 (March 11, 1985):16.

[36]"Transcript of Group Interview with President at White House," New York Times, March 30, 1983, p. A14.

[37]Clarence Robinson, "Panel Urges Defense Technology Advances," Aviation Week and Space Technology 119 (October 17, 1983): 16.

[38]Charles Mohr, "Reagan to Spur Research on Missle Defense Plan," New York Times, January 20, 1984, p. 12; and Michael Getter, "Reagan Signs Anti-Missle Research Order," Washington Post, January 26, 1984, p. 1; "The President's Strategic Defense Initiative," The White House, January 1985 [hereafter "SDI"], p. 1.

[39]"US Optimistic on Killer Satellite Ban," Aviation Week and Space Technology 108 (June 26, 1978): 20.

[40]Gordon, pp. 2664-2665.

[41]See Amb. Robert Buchheim's Statement in Hearings. Arms Control and the Militarization of Space, pp. 50-52; and Gordon, p. 2665.

[42]See the Hon. Eugene Rostow's Statement in Ibid., pp. 7, 13-15.

[43]See Statement of the Hon. Kenneth Adelman in Hearings. Controlling Space Weapons, pp. 3-7, 15-16.

[44]Seth Mydans, "Soviet Says Tests of Space Weapons Could Doom Talks," New York Times, July 7, 1984, pp. A1,7; Leslie Gelb, "Reagan Is Willing To Delay A Parley On Space Weapons," New York Times, July 15, 1984, [hereafter Gelb] pp. A1,15; Bernard Gwertzman, "U.S. To Emphasize Private Meetings On Arms Control," New York Times, November 18, 1984, pp. 1, 17; Benjamin Taylor, "US, Soviets agree to new arms talks," Boston Globe, November 23, 1984 [hereafter Taylor], pp. 1, 9; and William Beecher, "Difficult decisions lie ahead," Boston Globe, November 23, 1984 [hereafter Beecher], pp. 1, 8. For remarks on the current commitment of the Administration to the Geneva talks, see Ambassador Max Kampelman's February 26, 1985 Congressional testimony reported in "Arms Negotiator Urges Persistence," New York Times, February 27, 1985, p. A3.

[45]Jones, pp. 69-70.

[46]Transcript of "The Today Show," September 7, 1984 (NBC/WRC-TV, Washington, D.C.) reprinted in Current News, October 25, 1984 [hereafter Transcript of "Today Show"], pp. 28-29; Beecher, p. 8; and David Ignatius, "U.S. Threatens to Renounce ABM Treaty To Develop Space-Based Missile Defenses," Wall Street Journal, September 10, 1984, p. 4; "Amending of ABM pact hinted by Weinberger," Baltimore Sun, March 25, 1983, p. 6; and "SDI", p. 2.

[47]Gelb, pp. A1,15.

[48]"Arms Control in Space," Workshop proceedings of a conference sponsored by the Office of Technology Assessment, U.S. Congress, January 30-31, 1984 (Washington: GPO, 1984), [hereafter "Arms Control in Space"], p. 30.

[49]Ibid., pp. 23-24.

[50]Bernard Weinraub, "Reagan Adamant on Space Defense Even After Talks," New York Times, February 12, 1985, pp. Al, 11; and Taylor, p. 1.

[51]"Arms Control in Space", p. 30.

PART II: Aspects of the Current Debate

[1]Charles Mohr, "General Expects Decision on Space Defense in 1990's," New York Times, March 16, 1985 [hereafter Mohr, "General Expects"], p. 4.

[2]Ashton Carter, Directed Energy Missile Defense in Space--A Background Paper (Washington: U.S. Congress, Office of Technology Assessment, OTA-BP-ISC-26, Aprill 1984) [hereafter Carter], pp. 45-52.

[3]Clarence Robinson, "Panel Urges Defense Technology Advances," Aviation Week and Space Technology 119 (October 17, 1983): 16-18; and Daniel Graham, High Frontier. A New National Strategy (Washington: Heritage Foundation, 1982) [hereafter Graham]: pp. 68-71, 119-125. (The High Frontier study was published the following year by Abt Books as The Non-Nuclear Defense of Cities.)

[4]Carter, pp. 21, 67-68.

[5]Herbert Lin, "Military Software and BMD: An Insoluble Problem," Working paper for the Center for International Studies, MIT, February 1985, pp. 6, 28. Lin also discusses software problems with the Worlwide Military Command and Control System (WWMCCS) and other computer systems less complicated than that needed for space-based BMD. Charles Zraket of the MITRE Corporation also provides and interesting discussion of systems issues pertinent to the SDI in his paper, "Strategic Defense: A Systems Perspective," Mitre Technical Report, 1985.

[6]See Dr. Lowell Wood's comments in Transcript of "Today Show," p. 20. Lt. General James Abrahamson, head of the Strategic Defense Initiative Office, commented in Senate testimony in March 1985 said that a "'reasonably confident decision'" could be made on the feasibility of SDI technologies by the end of the 1980s or by the early 1990s. See Mohr, "General Expects," p. 4.

[7]James Fletcher, "The Technologies for Ballistic Missile Defense," Issues in Science and Technology 1 (Fall 1984)[hereafter Fletcher]: 26. For additional responses to skeptics of BMD R&D, see George Keyworth, "The Case for Strategic Defense," Issues in Science and Technology 1 (Fall 1984) [hereafter Keyworth]: pp. 40-43.

[8]Carter, p. 35.

[9]See DeLauer's comments in U.S., Congress, House of Representative, Committee on Armed Services, Hearing on H.R. 3073 People Protection Act before the Research and Development Subcommittee amd Investigations Subcommittee of the Committee on Armed Services. 98th Cong., 1st sess., 1983, pp. 24-26; and Michael Gordon, "Reagan's 'Star Wars' Proposals Prompt Debate over Future Nuclear Strategy," National Journal 16 (January 7, 1984) [hereafter Gordon]:

16. For useful breakdowns of SDI funding levels, see "Analysis of the Costs of the Administration's Strategic Defense Initiative 1985-1989," Staff Working Paper of the Congressional Budget Office, U.S. Congress (Washington: Congressional Budget Office, 1984).

10 Robert Richardson, "High Frontier: 'The Only Game in Town'," Journal of Social, Political, and Economic Studies 7 (Spring-Summer 1982): 56-61.

11 Graham, pp. 1-25.

12 "President's Speech on Military Spending and a New Defense," New York Times, March 24, 1983, p. A20.

13 See Secretary of Defense Caspar Weinberger's comments quoted in "Onward and upward with space defense," Bulletin of the Atomic Scientists 39 (June-July, 1983) [hereafter "Onward and upward"]: 4-5.

14 On the issue of a partial deployment, see "Transcript of Reagan Interview on a Range of Foreign Issues," New York Times, February 12, 1985 [hereafter "Transcript of Reagan Interview"], p. A10; Zbigniew Brzezinski, Robert Jastrow, and Max Kampelman, "Defense In Space Is Not 'Star Wars'," The New York Times Magazine, January 27, 1985, p. 48; and Lt. General Glenn Kent, "National Security and the Role of the SDI," presentation at the American Academy of Arts and Sciences, Cambridge, MA, March 7, 1985 [hereafter Kent]. The statement about the purpose of the SDI is borrowed from Kent.

15 For a good summary of this argument, see Robert Jastrow, "Reagan vs. the Scientists: Why the President is Right About Missile Defense," Commentary 77 (January 1984): 23-32. A more thoughtful exposition of this approach to strategy in comparison with other leading strategy alternatives may be found in Colin Gray's Nuclear Strategy and Strategic Planning, Philadelphia Policy Papers series (Philadelphia: Foreign Policy Research Institute, 1984). See also Gray and Payne, pp. 822-839; and Smernoff, pp. 2-17. The 2.5:1 ratio noted on p. 41 was obtained by comparing RV loadings on SS-17s, -18s, and -19s with those on Minuteman IIs and IIIs. Interesting counterarguments to BMD deployment are raised by Hans Bethe, et al., "Space-based Ballistic-Missile Defense," Scientific American 251 (October 1984): 39-49; Sidney Drell, Philip Farley, and David Holloway, "Preserving the ABM Treaty: A Critique of the Reagan Strategic Defensive," International Security 9 (Fall 1984): 51-90; Drell, Farley, and Hollway, pp. 39-99; Charles Glaser, "Why Even Good Defenses May Be Bad," International Security 9 (Fall 1984): 91-123; and Sidney Drell and Wolfgang Panofsky, "The Case Against Strategic Defense," Issues in Science and Technology 1 (Fall 1984): 45-65.

16 The radar at Abalakova is most likely an early warning radar that fills in an important gap in the northeast Siberian air defense perimeter. The Soviet, however, sited the radar in south-central Siberia and thus opened themselves to charges that the radar could be used for battle management (see the appropriate proscription in the ABM Treaty, Article VIb). Soviet attempts to present the installation as a space tracking facility increased US cynicism about the Soviets' real motives in constructing the radar. Phased array radars do generally have inherent space-tracking capabilities, but the face of the Soviet radar is oriented toward the horizon, not directly up toward space, as a space-tracking radar would be.

[17]The arguments about the Soviets choosing to strike cities or not may be based on faulty assumptions about Soviet targeting policy. There is strong evidence that if the Soviets were hit by a US counterforce strike, they would retaliate at all nuclear force bases, major US troop concentrations, and any areas of concentrated defense industry, whether or not those areas were located near population centers. The Soviets hardly ever discuss the differences between counterforce and countervalue strikes the way the terms are used in the US. On Soviet targeting, see Peter Almquist's paper, "Strategic Targeting and the RVSN," Research memo prepared for the Soviet Security Studies Working Group, Center for International Studies, MIT, 1983.

[18]Jeff Nesmith, "Criticism of 'Star Wars' plan short-sighted, director says," Atlanta Journal and Constitution, September 9, 1984, p. 10-A.

[19]Ray Pollock and Patrick Garrity, "Strategic defense: option for the future," Christian Science Monitor, September 5, 1984, p. 14.

[20]On the bomber and cruise missile question, see Bill Keller, "Weinberger Says a Space Defense Also Needs a Counter to Bombers," New York Times, January 17, 1985, pp. A1, A18.

[21]Walter McDougal, "How Not to Think About Space Lasers," National Review 35 (May 13, 1983) [hereafter McDougal]: 555.

[22]"SDI", p. 5; and Kent.

[23]McDougal, p. 555; and see Secretary of Defense Weinberger and Sen. Malcolm Wallop's comments in R. Jeffrey Smith, "The Search for a Nuclear Sanctuary (II)," Science 221 (July 1, 1983) [hereafter Smith, "Sanctuary (II)"]: 135.

[24]"Onward and upward,' pp. 4-5; "Transcript of Group Interview with President at White House," New York Times, March 30, 1983, p. A14.; and Victor Weisskopf and Hans Bethe's views reported in Smith, "Sanctuary (II)", p. 138. There has been some controversy concerning Reagan's comments about sharing BMD technology as to whether he meant sharing it after the US had decided to use a particular BMD technology but before system deployment began or whether he meant sharing it after the system was deployed. There has been little official elaboration of Reagan's initial comments on sharing the technology, but what has been said on this topic suggests that the US would probably offer it to the Soviets, if it decided to do so at all, before or at the beginning of deployment. In his second debate with Walter Mondale, President Reagan said the US might agree to deliver the technology to the Soviets, perhaps after a demonstration of the system for the Soviets to witness, with the idea of pursuing negotiations to reduce strategic offensive arms. At the debate, Reagan himself was not very clear when this transfer might take place. Hopefully the assumption is not to strive for a *fait accompli*. Reagan only said that if the Soviets "are willing to join us in getting rid of all the nuclear weapons in the world, then we'll give [them] this one so that we would both know that no one can cheat...." As mentioned before, the thought here is not that parts of the space-based BMD would be foregone as concessions to Soviet offensive missile reductions, but that each side's possession of an effective layered BMD would facilitate strategic weapons reductions. ("Transcript of the Reagan-Mondale Debate on Foreign Policy," New York Times, October 22, 1984, pp. B5-6. See also "Transcript of Reagan Interview, p.

A10.) For reasons discussed in the text of the paper, not to mention the classification and sensitive technology transfer issues, this proposal seems chimerical.

25See Alvin Weinberg and Jack Barkenbus, "Stabilizing Star Wars," Foreign Policy no. 54 (Spring 1984): 164-176. For additional discussion of the transition period, see Keith Payne, "Strategic Defense and Stability," Orbis 28 (Summer 1984): 214-227; and Colin Gray, "Deterrence, Arms Control, and the Defense Transition," Orbis 28 (Summer 1984): 227-240.

26As examples of the very extensive Soviet literature criticizing the SDI, see "Otvety Yu. V. Andropova na voprosy korrespondenta 'Pravda'," Pravda, March 27, 1983, p. 1; Oleg Tsarev, "Militaristskaya orbita," Pravda, October 24, 1983, p. 5; and L. Koryavin, "Kosmicheskaya likhoradka v Vashingtonye," Izvestiya, October 30, 1984, p. 5.

27R. Jeffrey Smith, "The Search for a Nuclear Sanctuary (I)," Science 221 (July 1, 1983) [hereafter Smith, "Sanctuary (I)"]: 32.

28"SDI", p. 5.

29For interesting interpretations of the Soviet view of BMD and strategic defense in general, see Rebecca Strode, "Space-Based Lasers for Ballistic Missile Defense: Soviet Policy Options," in Laser Weapons in Space. Policy and Doctrine, ed. Keith Payne (Boulder, CO: Westview Press, 1983) [hereafter Strode]; Matthew Partan, "Soviet Views on Strategic Defense," Paper presented to the MIT Soviet Security Studies Working Group, April 19, 1984, especially his reviews of Batitsky (1973), Ogarkov (1980), and Ustinov (1980) articles, pp. 8-9, 24-26; Jacqueline Davis, et al., The Soviet Union and Ballistic Missile Defense (Cambridge, MA: Institute for Foreign Policy Analysis, 1973), especially the chapter by Michael Deane; Clarence Robinson, "Soviets Push ABM Development," Aviation Week and Space Technology 102 (April 7, 1975): 12-14; Clarence Robinson, "Soviets Grasping Strategic Lead," Aviation Week and Space Technology 105 (August 30, 1976): 14-18; Sayre Stevens, "The Soviet BMD Program," in Ballistic Missile Defense, eds. Ashton Carter and David Schwartz (Washington: The Brookings Institution, 1984); John Thomas, "The Role of Missile Defense in Soviet Strategy and Foreign Policy," in The Military-Technical Revolution: Its Impact on Strategy and Foreign Policy, ed. John Erickson (New York: Praeger, 1966); and Johan Holst, "Missile Defense, the Soviet Union, and the Arms Race," in Why ABM?, eds. Johan Holst and William Schneider (New York: Pergamon Press, 1969).

30These options are suggested in Strode, pp. 134-149.

31Daniel Shepard, "Soviet Responses to U.S. Tactical Aviation, 1970-1985," Paper presented at the Ninth Annual Conference of the New England Slavic Association, March 22, 1985. This paper is part of a contract on Soviet responses to US technology advances done under contract with DARPA by the Soviet Security Studies Working Group, Center for International Studies, MIT.

32Smith, "Sanctuary (I)," p. 30; Gordon, p. 12; and Gray and Payne, pp. 830-832. See also "Präsident Reagan begräbt die letzte groBe Hoffnung auf Frieden," Frankfurter Allgemeine, March 26, 1983, pp. 1,2; "Skepsis und Verwirrung nach Reagans Rede," Neue Zücher Zeitung, March 26/27, 1983, pp. 3-4; "Reagans neues Verteidigungskonzept," Neue Zücher Zeitung, March 25, 1983, p. 1; Dieter Schröder, "Ronald Reagans Horror-Vision," Süddeutsche

Zeitung, March 25, 1983, p. 4; Christoph Betram, "Ein Schritt vor, ein schritt zurück," Die Zeit, April 1, 1983, p. 1; Robert Solé, "La nouvelle stratégie de 'guerre des étoiles' présentée par M. Reagan divise les Américains," Le Monde, March 29, 1983, p. 3; Michel Fauré, "Reagan prophete de la guerre des étoiles," Libération, March 25, 1983, p. 17; Michel Tatu, "Militarisation de l'espace: les craintes de Londres et Paris rejoignent celles de Moscow," Le Monde, December 19, 1984, pp. 1,4; Andre Fontaine, "La guerre froide dans l'espace," Le Monde, July 14, 1984, p. 3; "A Twist to the Spiral," Times (London), March 25, 1983, p. 15; Hubertus Hoffman, "A Missile Defense for Europe?," Strategic Review 12 (Summer 1984): 45-55; and Ian Smart, "Perspectives from Europe," in SALT: The Moscow Agreements and Beyond, eds. Mason Willrich and John Rhinelander (New York: Free Press, 1974), pp. 185-208. One US analyst who has good connections within West European governments suggests that the Europeans may rank SDI alternatives in the following manner (in descending order of preference): 1) no space-based BMD built by either the US or USSR, 2) US and Soviet BMD regimes that at the same time fully protect Europe, 3) US and Soviet BMD regimes that do not protect Europe, 4) only a US space-based BMD, and 5) only a Soviet space-based BMD.

[33]See "President's Speech on Military Spending and a New Defense," New York Times, March 24, 1983, p. 20; and George Keyworth's interview in "Can Reagan's 'Star Wars' Plan Really Work?," U.S. News and World Report 94 (April 11, 1983): 25.

[34]See Clarence Robinson, "Panel Urges Defense Technology Advance," Aviation Week and Space Technology 115 (October 17, 1983): 16-18; and David Yost, "Ballistic Missile Defense and the Atlantic Alliance," International Security 7 (Fall 1982): 143-174.

[35]For an interesting summary of views of European leaders on this question and others related to SDI, see Paul Gallis, Mark Lowenthal, and Marcia Smith, "The Strategic Defense Initiative and United States Alliance Strategy," report of the Congressional Research Service (Washington: Congressional Research Service, February 1, 1985). For this report the authors interviewed European politicians and NATO leaders for their evaluation of SDI and concluded that most European leaders were skeptical of, if not opposed to, SDI. One troubling issue with this report, commissioned by Sen. William Proxmire, is that there is no statement of methodology concerning how the interviewees were selected. One is inclined to give the authors the benefit of the doubt that they have selected a representative sample of officials to interview. Without more information on their methodology, however, one could argue that the authors primarily interviewed people who were negatively inclined toward SDI.

[36]Michael Feazel, "Europeans Support U.S. Space-Based Systems," Aviation Week and Space Technology 119 (October 24, 1983), p. 59; Christopher Thomas, "Thatcher gives Reagan her backing for critical Geneva meeting," The Times (London) December 24, 1984, p. 4; Henry Stanhope, "Howe underlines the risks in Star Wars," The Times (London), March 16, 1985, p. 5; Anna Tomforde, "Europeans plan joint SDI response," Boston Globe, April 24, 1985, p. 8; Hedrick Smith, "Allies Lukewarm About 'Star Wars'," New York Times, May 3, 1985, p. A11; James Markham, "Kohl Gives the U.S. Guarded Support on Space Defense," New York Times, February 10, 1985, pp. A1, A14; and hoplites (a pseudonym for a French general officer), "La France dans la 'guerre des etoiles'," Le Monde, March 6, 1985, pp. 1, 4. On the technology question, see William Griffith, "Europe limping in high-tech race," Boston Globe, July 22, 1984, p. 2.

[37]See the opinion polls in Thomas Graham's The Politics of Failure: Nuclear Arms Control and Domestic Politics in the United States, 1945-1984 (Ph.D. dissertation in progress; Massachusetts Institute of Technology, 1984).

[38]Ibid.

[39]See the statement by Gerard Smith, in U.S. Congress, Senate, Committee on Armed Services, Military Implications of the Treaty on the Limitations of Anti-Ballistic Missile Systems and the Interim Agreement on Limitation of Strategic Offensive Arms, Hearing before the Committee on Armed Services. 92nd Cong., 2nd sess., 1972, p. 377. A "prototype" is a full-scale system or piece of equipment that has undergone virtually all the R&D necessary before mass production. A "breadboard model" may be full- or partial-scale, and it usually does not contain all the components or circuits that it will have at the completion of its development. A breadboard model basically represents the first attempt to build a roughly complete mock-up of the system. On the topic of R&D as it relates to monitoring and verification see Alan Jones, "Implications of Arms Control Agreements and Negotiations for Space-Based BMD Lasers," in Laser Weapons in Space. Policy and Doctrine, ed. Keith Payne (Boulder, CO: Westview Press). Jones' article, pp. 37-46, provides a detailed discussion of the term "development" as the term is used in the ABM Treaty.

[40]The Impact Statement is quoted in the Union of Concerned Scientists' Anti-Satellite Weapons: Arms Control or Arms Race? (Cambridge, MA: Union of Concerned Scientists, 1983), pp. 17-18 (this volume was expanded and published in 1984 by Random House as The Fallacy of Star Wars). The National Technical Means reference is from Article XII of the ABM Treaty. Interestingly, the PMAL employs the mid-course intercept concept of the Homing Overlay Experiment (see infra at 18 and Smith, "Sanctuary (II)," p. 30).

[41]See Malcolm Russell, "Military Activities in Outer Space: Soviet Legal Views," Harvard International Law Journal 25 (Winter 1984): 160-161, 171-175, 186. This article was published as a chapter of National Interests and the Military Uses of Space, ed. William Durch (Cambridge, MA: Ballinger, 1984).

[42]See Amb. Buchheim's Statement in Hearings. Arms Control and the Militarization of Space, pp. 54-55.

[43]See the Statement by Dr. DeLauer in Ibid., p. 27; and "U.S. Policy on ASAT Arms Control. White House Report to the Congress," March 31, 1984, pp. 1-2.

[44]William Durch, in his thorough and insightful essay "Anti-Satellite Weapons, Arms Control Options, and the Military Use of Space," (Washington, D.C.: Arms Control and Disarmament Agency, 1984)[hereafter Durch], suggests on pp. 8-9 four criteria for evaluating the utility of an ASAT capability. These questions are: 1) Is the weapon effective? 2) Does the weapon threaten capabilities or values that are important and difficult or costly to replace? 3) Is there a plausible scenario for use of the weapon? and 4) Can countermeasures to the weapon readily be deployed? Durch evaluates US and Soviet ASAT capabilities using these catagories and arrives at conclusions similar in most respects to the ones developed herein.

[45]Stephen Meyer, "Soviet Military Programmes and the 'New High Ground'," Survival 25 (September-October 1983) [hereafter Meyer]: 212; and John Pike,

"Antisatellite Weapons," Federation of American Scientists Public Interest Report 36 (November 1983) [hereafter Pike]: 6. According to the proceedings of a conference sponsored by the Office of Technology Assessment in January 1984, participants with widely differing views on the merits of ASATs generally agreed that the US ASAT system was "clearly technically superior" to the Soviet system (see "Arms Control in Space, pp. 3, 11).

[46]Meyer, p. 213. For additional background on the Soviet laser program, see Philip Klass, "Anti-Satellite Laser Use Suspected," Aviation Week and Space Technology 102 (December 8, 1975): 12-13; Clarence Robinson, "Soviets Push for Beam Weapon," Aviation Week and Space Technology 106 (May 2, 1977): 16-23; Clarence Robinson and Philip Klass, "Soviets Build Directed-Energy Weapon," Aviation Week and Space Technology 113 (July 28, 1980): 47-50; and Richard Burt, "US Says Russians Develop Satellite-Killing Laser," New York Times, May 22, 1980, p. A9. For a worst-case analysis of the Soviet ASAT weapon threat, see James Oberg's "Andropov's Orbiting Bombs," Reason 15 (December 1983): 25-30.

[47]Pike, p. 6; Meyer, p. 212. See also Dr. Kurt Gottfried, Adm. Noel Gayler, and Dr. Richard Garwin's Responses to Additional Questions Submitted for the Record, in Hearings. Controlling Space Weapons, p. 164. For an interesting summary of current and future US military satellite capabilities, see Patrick Friel, "New Directions for the U.S. Military and Civilian Space Programs," in International Security Dimensions of Space, eds. Uri Ra'anan and Robert Pfaltzgraff (Hamden, CT: Archon Books, 1984), pp. 119-138. "Soviet Military Space Doctrine," DOD Report DDB-1400-16-84 (Washington: Defense Intelligence Agency, 1984) offers some hypothetical formulations of Soviet views on the military uses of space.

[48]It may be possible that with the proper equipment, a ground-based laser beam could be tracked and that it could be interrupted by putting a block of matter in its path.

[49]Meyer, p. 214. See the High Frontier comments on the effects of EMP on space objects in Graham, pp. 142-143. The argument that US ASATs are needed to counter the threat to naval forces from Soviet RORSATs and EORSATs is criticized both by Meyer and by the report of the January 1984 Office of Technology Assessment conference (see "Arms Control in Space", p. 52).

[50]See Dr. Fred Iklé's testimony in Hearings. Controlling Space Weapons, p. 106; and Dr. Richard Garwin's testimony in Hearings. Arms Control and the Militarization of Space, p. 57. See also Durch, pp. 19-27. One of the controversial issues dealing with battle management, as it would have an impact upon escalation of hostilities, concerns the ability to determine whether a satellite has simply malfunctioned or has been destroyed by an opponent's ASAT. Specialists participating in the January 1984 Office of Technology Assessment conference suggested that in addition to being able to track intercepting satellites, ground stations could tell from the fairly reliable "state of health" technology that exists for satellites whether a satellite's malfunction was internally or externally induced (see "Arms Control in Space", pp. 42-44). Needless to say, the tracking capability would be virtually irrelevant if the ASAT was a DEW, given the range of such systems. Furthermore, one should also note that if constellations of US military satellites failed *en masse*, there would be a reasonbly certainty even without data from "state of health" technology that the failure was due to attack rather than malfunction.

[51]One secondary aspect of the technology issue that should receive attention is that of possible counters to ASAT activities. Among these measures are hardening of the satellite, installing on-board threat sensors to warn a satellite to begin evasive maneuvers, using improved antenna designs to prevent jamming, migrating from one altitude to another in case of threat, having mission duplication among a number of satellites, and accompanying the satellite with defensive satellites (DSATs) (See Pike, pp. 12-13). Other means of reducing vulnerability include using radioisotope electric power sources instead of external solar cell, and using precision gyros for attitude control rather than external infrared horizon sensors [See Philip Klass, "Anti-Satellite Use Suspected," Aviation Week and Space Technology 103 (December 8, 1975): 12.] The argument that for actual hostilities, the US should devote as much to countermeasures as to ASAT development is a strong one. Unless the US can reconstitute its most critical satellites quickly, of what real value is it to us if we can destroy Soviet satellites after they have destroyed ours? Developing ASATs for deterrence is logical, but developing them for retaliation is not. The other argument for ASATs--to destroy "threatening" Soviet satellites, is dealt with in the section on Soviet reactions. For additional analysis on ASAT countermeasures, see Robert Giffen, "Space System Survivability: Strategic Alternatives for the 1990s," in International Security Dimensions of Space, eds. Uri Ra'anan and Robert Pfaltzgraff (Hamden, CT: Archon Books, 1984), pp. 79-101.

[52]See Colin Gray, American Military Space Policy (Cambridge, MA: Abt Books, 1982), pp. 79-80; Durch, pp. 29-31, 48-50; and D.L. Haffner, "Anti-Satellite Weapons: The Prospects for Arms Control," in Outer Space. A New Dimension of the Arms Race, ed. Bhupendra Jasani (SIPRI)(London: Taylor and Francis, Ltd., 1982)[hereafter Haffner], pp. 311-323.

[53]As mentioned in the text, evaluating various arms control proposals for BMD or ASAT is beyond the scope of the current effort. Various proposals are offered in Haffner, pp. 311ff; Durch, pp. 32-55; Francis Kane, "Anti-Satellite Systems and U.S. Options," Strategic Review 10 (Winter 1982): 60-63; Union of Concerned Scientists, Anti-Satellite Weapons: Arms Control or Arms Race? (Cambridge, MA: Union of Concerned Scientists, 1983), pp. 33-35; and Pike, pp. 13-16; and several US Congressmen and Senators.

PART III: Space-Based BMD in the Context of the ABM Controversy

[1]David Schwartz, "Past and Present: The Historical Legacy," in Ballistic Missile Defense, eds. Ashton Carter and David Schwartz (Washington: The Brookings Institution, 1984), pp. 343-349.

[2]Ibid., pp. 340-341.

[3]For background on some of the general and specific problems facing negotiators in this area, see Barry Blechman, "Do Negotiated Arms Limitations Have A Future," Foreign Affairs 59 (Fall 1980): 102-125; William Kincade, "Arms Control in the 1980s. What Is Needed?," Current no. 241 (March-April 1982): 44-61; Donald Hafner, "Averting a Brobdingnagian skeet shoot," International Security 5 (Winter 1980-1981): 41-60; David Adelman, "Space Wars," Foreign Policy no. 44 (Fall 1981): 94-106; Peter Jankowitsch, "International Cooperation in Outer Space," Occasional Paper no. 11 (Muscatine, IA: The

Stanley Foundation, 1976); and Herbert Scoville and Kosta Tsipis, "Can Space Remain a Peaceful Environment?," Occasional Paper no. 18 (Muscatine, IA: The Stanley Foundation, 1978).

APPENDIX I: Technologies for Space-Based BMD

[1]See primarily Carter; but see also Patrick Friel,"Space-Based Ballistic Missile Defense: An Overview of the Technical Issues," in Laser Weapons in Space. Policy and Doctrine, ed. Keith Payne (Boulder, CO: Westview Press, 1983) ; and Fletcher, 15-29. Perhaps the best book-length study of laser weapons and their applications is Jeff Hecht's Beam Weapons (New York: Plenum Press, 1984). Other useful sources in making this technical assessment were Eric Kintner, "Exoatmospheric Ballistic Missile Defense: A Technical Overview (Cambridge, MA: Center for International Studies of the Massachusetts Institute of Technology, 1983); Drell, Farley, and Holloway, pp 39-63; Clarence Robinson and Philip Klass, "Technology Eyed to Defend ICBMs, Spacecraft," Aviation Week and Space Technology 113 (July 28, 1980): 32-42; Clarence Robinson and Philip Klass, "Directed-Energy Effort Shifted," Aviation Week and Space Technology 113 (August 4, 1982): 44-47; Clarence Robinson and Philip Klass "U.S. Nears Laser Weapons Decisions," Aviation Week and Space Technology," (August 4, 1982): 48-54; Clarence Robinson and Philip Klass, "Accelerator Deemed Beam Weapon Key," Aviation Week and Space Technology (August 4, 1982): 60-63; Clarence Robinson and Philip Klass, "White Horse Concentrates on Neutral Particle Beam," Aviation Week and Space Technology 113 (August 4, 1982): 63-66; Clarence Robinson and Philip Klass, "High-Intensity Electron Beam Pushed," Aviation Week and Space Technology; Kosta Tsipis, "Laser Weapons," Scientific American 245 (December 1981): 51-57; E. Walbridge, "Angle constraint for nuclear-pumped X-ray laser weapons," Nature 310 (July 19, 1984): 180-182; John Parmentola and Kosta Tsipis, "Particle Beam Weapons," Scientific American 240 (April 1979) 54-651 and "Star Wars," Economist 290 (March 3, 1984): 90-91; and Graham, pp. 135-143. For an interesting discussion of DEW systems as well as their support vehicles, including the Space Shuttle, see David Baker, The Shape of Wars to Come (New York: Stein and Day, 1981).

[2]Two notes of explanation are needed here. First, as was mentioned in the text of the Appendix, parameters for factors such as laser power, fluence, mirror size, orbital placement, and retarget time are provided for heuristic purposes and are not alleged to be precise. Given the variety of assumptions possible involving these parameter, there has been disagreement among specialists regarding the number of battle stations needed irrespective of what basic technology is chosen. For an analysis that evaluates the data of this section on technology, one may look at Fletcher, pp. 27-28 and Keyworth, 41-42.

Second, the assumption that the Soviets may not launch their SLBMs as part of a first strike is made for several reasons. If the Soviets have planned a counterforce strike, they may withhold SLBMs because these missiles do not have the accuracy to destroy hard targets (silos) or because the Soviets may want to have a reserve strike force to use against soft targets if the US responds with a second strike against both counterforce and countervalue targets. Making this assumption about withholding SLBMs also makes the rough calculations of required battle stations easier, since a wider dispersal of launch sites would significantly increase the number of battle stations one has to deploy. Furthermore, SLBMs can be more feasibly launched on a flatter trajectory than ICBMs, thus complicating space-based BMD tracking and fire control functions and making the battle station force requirement even more difficult to assess. Of course, the Soviets may not withhold SLBMs, and US planners to account for this possiblity would have to increase the number of deployed battle stations.

[3]See, for example, Philip Boffey, "New Rocket Proposed For Military Satellites," New York Times, September 5, 1984, p. B7; and Bruce Smith, "Output of Atlas, Titan Tied To Military, Private Markets," Aviation Week and Space Technology 120 (June 25, 1984): 159-161.

APPENDIX II: Summary of Arguments For and Against the ABM System

[1]The following list of arguments was based on a similar table in C.F. Barnaby, "Arguments For and Against the Deployment of Anti-Ballistic Missile Systems," in Implications of Anti-Ballistic Missile Systems (Pugwash Monograph II), eds. C.F. Barnaby and A. Boserup (London: Souvenir Press, 1969). The literature on the ABM controversy is extensive, and among the other sources consulted in compiling this list were ABM. An Evaluation of the Decision to Deploy an Antiballistic Missile System, eds. Abram Chayes and Jerome Wiesner (New York: Signet Books, 1969); D.G. Brennan and Johan Holst, Ballistic Missile Defense: Two Views, Adelphi Paper no. 43 (London: Institute for Strategic Studies, 1967),; Johan Holst and William Schneider, eds., Why ABM? (New York: Pergamon Press, 1969); Eugene Rabinowitch and Ruth Adams, eds., Debate the Antiballistic Missile (Chicago: Bulletin of the Atomic Scientists, 1967); William Kintner, ed., Safeguard: Why The ABM Makes Sense (New York: Hawthorn Books, Inc., 1969); USSR vs. USA. The ABM and the Changed Strategic Military Balance (Washington: Acropolis Books, 1969); Robert Jayne, The ABM Debate. Strategic Defense and National Security, unpublished Ph.D. dissertation (Cambridge, MA: Massachusetts Institute of Technology, 1969); John Erickson, ed., The Military-Technical Revolution. Its Impact of Strategy and Foreign Policy (New York: Praeger, 1966); James Dougherty and J.F. Lehman, eds. Arms Control for the Late Sixties (Mew York: D. VanNostrand Co., Inc., 1967); Jeremy Stone, The Case Against Missile Defense, Adelphi Paper no. 47 (April 1968); Mason Willrich and John Rhinelander, eds., SALT: The Moscow Agreements and Beyond (London: Free Press, 1974); George Rathjens, The Future of the Strategic Arms Race (New York: Carnegie Endowment for Peace, 1969); William Kinter and Robert Pfaltzgraff, eds. SALT: Implications for Arms Control in the 1970s (Pittsburgh: University of Pittsburgh Press, 1973); John Newhouse, Cold Dawn (New York: Holt, Rhinehart, & Winston, 1973); Strobe Talbot, Endgame (New York: Harper and Row, 1979); Center for the Study of Democratic Institutions, Anti-Ballistic Missile: Yes or No? (New York: Hill and Wang, 1969); Joseph Coffey, Arms Control and European Security (New York: Praeger, 1977); Thomas Wolfe, The SALT Experience (Cambridge, MA: Ballinger Co., 1979); Gerard Smith, Doubletalk (New York: Doubleday, 1980); G.W. Rathjens, Abram Chayes, and J.P. Ruina, Nuclear Arms Control Agreements: Process and Impact (Washington: Carnegie Endowment for Peace, 1974); Alan Platt and Lawrence Weiler, eds., Congress and Arms Control (Boulder, CO: Westview Press, 1978); Stephen Posen, "Safeguarding Deterrence," Foreign Policy no. 35 (Summer 1979): 109-123; and Michael Nacht, "ABM ABCs," Foreign Policy no. 46 (Spring 1982): 155-174.

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