Chapter 3

MILSATS, ASATS, and National Security

Contents

MILSATs, ASATs, and National Security

THE ROLE AND VALUE OF MILITARY SATELLITES

The Role of Military Satellites

Force Support and Force Enhancement

Satellites are used for a variety of military applications by the United states, the U. S. S. R., and-in smaller numbers—by several other nations. Most military satellites (MILSATs) perform nondestructive functions. For example, Soviet military satellites are used for meteorological surveillance, surveillance of ballistic missile launch areas to provide rapid warning of possible missile attack, relaying of radio communications to distant force elements, optical and radar reconnaissance of foreign force dispositions on land and at sea, interception of foreign radio communications and radar signals, transmission of radionavigation signals, and logistic support for space systems.1 Even though these functions are nondestructive and the satellites which perform them are not considered weapons, they support force elements which would engage in direct combat and enhance the combat effectiveness of those force elements.

The value, or utility, of military satellites is very real, but it is extremely difficult to quantify.[2] The timeliness of information or the speed of communications may make the difference between winning a battle and losing one—or it may greatly affect the number of casualties suffered in a battle without deciding victory. In some cases satellites provide capabilities that could not be obtained in any other way —e.g., surveillance of areas which would otherwise be closed to our observation, or providing very early warning of enemy missile launches. In other cases, satellites provide a cheaper and easier way of of doing something that could be accomplished by other means-e. g., trans-Atlantic communications. Then there are the navigation satellites, which provide an added degree of precision which may be critical in some applications and only of marginal utility in others.

In a few special cases, satellites contribute to a military mission the objectives or requirements of which can be quantified, as can, therefore, the value of the support provided by satellites. For example, the use of navigation satellites may improve the accuracy with which certain munitions are delivered, thereby reducing wastage of munitions. If so, then the effectiveness of the munitions used would be "multiplied" by satellite support—they would be as effective as a *larger* number of munitions delivered without the assistance of navigation satellites. The effectiveness of munitions delivery systems would be similarly multiplied. For missions such as this, it is reasonable to think of satellites as "force multipliers, " and the factor by which the forces are multiplied can in principle be used to assess the value of the satellite. This has led some analysts to assess the significance of anti-satellite weapons in terms of the additional forces which the United States would have to procure to maintain military capability if it could not use MILSATs–or could not rely on their availability—in a conflict severe enough to justify Soviet ASAT use.

'E.g., maintenance and retrieval.

*The term *utility* is used here in the sense defined by John von Neumann and Oskar Morgenstern, The *Theory of Games and Economic Behavior* (Princeton, NJ: Princeton University Press, 1953), pp. 26-27; i.e., as a numerical index of the relative preferability of an outcome [e.g., occurrence of nonnuclear war and survival of all high-altitude satellites] which could result from a decision [e.g., an agreement to ban ASAT weapon testing]. Of any two possible outcomes, the one having a higher utility would be preferred over the other. Practical methods of assessing the utilities of a decisionmaker for possible outcomes have been described and reviewed by M.W. Merkhofer, *Comparative Evaluation of Quantitative Decision-Making Approaches,* National Science Foundation report NSF/PRA-83014, April 1983.

Other notions of utility have been used in the classified literature on satellite utility. Some of these notions are vaguely defined, while others-e. g., force multiplication factors—are precisely defined and, in principle, objectively calculable, although less clearly related to national interests than are Von Neumann-Morgenstern utilities.

However, in assessing the importance of ASATS, it maybe more important to consider the dependence of military capabilities on space systems. If space system support suddenly becomes unavailable to a force element which has become accustomed to it, the combat effectiveness of that force element maybe reduced to lower than it was before it began using space system support. Its effectiveness will be reduced to a fraction of what it was with space system support; the smaller this fraction, the greater the force element's dependence on space support.

There is a trend in both the United States and the U.S.S.R. to use increasingly sophisticated satellites to perform more functions and to do so more capably. It is generally believed that because of its sophisticated and still advancing space technology and because of the global distribution of its interests, commitments, and forces, the United States derives considerable utility from space system support: without satellites, performance of many military missions would become impossible, and performance of others would require large increases in the unit strengths of various U.S. force elements. Other force elements probably derive negligible force multiplication from space support. In general, however, the utility of military satellites to both the United States and the Soviet Union is probably increasing.[3] It is also generally believed that because of the expense of other means of providing comparable support to these forces, the United States has not vigorously developed alternative means of support and has consequently become highly dependent on space system support.[4]

Whether the United States derives more military utility from space system support than does the Soviet Union probably cannot be answered in general terms,[5] although force multiplication of particular types of force elements has been estimated in several studies.[6] Insofar as such estimates are comparable, judgments of comparative space support differ. Such differences may attributable, in part, to exclusion from the scope of some studies, for reasons of security classification, of consideration of some types of satellites which are of great value to the United States but for which the U.S.S.R. has no counterpart or from which the U.S.S.R. might derive much less utility. The utility of some functions of such satellites may be unquantifiable in any case, and this may lead to their neglect in quantitative assessments of utility.

It is easier to argue that the United States is more dependent on space system support for performing important military functions than is the Soviet Union,[7] because the Soviet Union has less need for some types of space system support and more alternative terrestrial means of providing similar support [see table 3-l]. Moreover, the Soviet Union has

[3]See, e.g., Stephen M. Meyer, "Soviet Military Programs and the 'New High Ground '," *Survival*, Sept./Oct. 1983, pp. 204-215.

‘Ibid.

‘According to accepted (e.g., Von Neumann-Morgernstern) axioms of utility theory, utility cannot be assessed in absolute terms but only to within an affine transformation; hence interpersonal or international comparisons of utility are not justifiable in general. See, e.g., Thomas Schelling, The Strategy *of Conflict* (New York: Oxford University Press, 1960), p. 288n, and John Rawls, A *Theory of* Justice (Cambridge, MA: Harvard University Press, 1971), p. 90.

[6]Force multiplication, in those cases where it is meaningful and can be assessed, can be assessed in absolute terms and compared between nations.

‘Just as international comparison of utility is unjustifiable in principle, international comparison of dependence on space systems is also unjustifiable, if dependence is defined as the loss in utility which it would suffer if its satellites were suddenly incapacitated. Nevertheless, it is apparent that the United States is more dependent on MI LSATs *to perform important military functions than is* the Soviet Union, even though the value of these functions cannot be easily quantified.

Table 3"1.—Asymmetries in U.S. and Soviet Space System Need and Use

Asymmetry	United States	Soviet Union
MILSAT reliability	(+) High	(–) Lower
MILSAT endurance	(+) **Long**	**(–)** Shorter
Launch rate.	(–) Low	(+) High
Stockpile of spare MI LSATS	(–) Low	(+ Higher
C^3 requirements	(–) Global and oceanic	(+ **Continental and littoral**
Terrestrial C^3 alternatives (relative to requirements)	(–) Few	(+ More
Terrestrial alternatives for information collection (relative to requirements)	(–) Few	(+) More
Operational ASAT capability	(–) No	(+) Yes
ASAT altitude reach . . .	(–) Low	(+) Higher
ASAT responsiveness . .	(+) High	(–) Low

greater capability to reconstitute satellites which provide such support in case they are lost in action, hence even to the extent the Soviet Union is dependent on space system support, it is less dependent on individual satellites for some functions.

Force Application

Satellites have also been used to provide destructive capabilities. For example, since 1968 the U.S.S.R. has tested a coorbital interceptor—a satellite which could be used to intercept and destroy other satellites. The U.S. Department of Defense estimates that the Soviet Union attained an operational anti-satellite capability with this weapon in 1971.* Although to date there has been little testing and apparently no long-term basing or actual use of weapons in orbit, there is increasing technological potential to do so and, in the United States, increasing overt interest in doing so. In particular, there is strong interest in the United States in using space-based (i.e., satellite) weapons for defensive missions, especially ballistic missile defense and air defense.

Satellites could also provide destructive capabilities in support of other missions. Public Soviet statements have indicated a decreasing interest—indeed, growing opposition—to space-based weapons, although such statements have been interpreted by some in the West as disingenuous and propagandistic, intended for political gain and strategic deception. [g]

Nonmilitary Functions Contributing to National Security

Satellites are also used for nonmilitary applications which contribute to national security, such as monitoring compliance with arms control agreements[10] and collecting data 'or scientific research which could improve future military capabilities.

Current and Projected MILSAT Capabilities

Important asymmetries exist between the space systems of the United States and the Soviet Union and between the ways in which these systems would be employed [see table 3-l]. However, simple comparisons of U.S. and Soviet space systems can be misleading. The Soviet Union has an operational ASAT weapon, the United States does not. Yet, the U.S. ASAT, if developed, will be more capable and versatile than the Soviet ASAT. U.S. satellites are more sophisticated, more reliable, and capable of performing more functions than their Soviet counterparts. Yet, the Soviet's rapid launch capability and policy of maintaining spares would allow them to reconstitute some space assets during a conflict. *1

These factors are further modified by the different roles that satellites or ASAT weapons would play in different theaters of war at different levels of conflict. Soviet forces are de ployed largely on the Eurasion land mass, and would, in many scenarios, be able to rely on terrestrial communication and information links. In many'of the same scenarios, satellite communications would be critical to globally deployed U.S. forces which might lack the same terrestrial communication links. Even in peacetime, the United States relies heavily on surveillance satellites to monitor Soviet compliance with arms control agreements by monitoring Soviet activities which could not be monitored by other lawful means, although similar activities in the United States would be readily observable by Soviet personnel k+ gaily in the country.

[8]U.S. Department of Defense, *Soviet Military Power,* 4th cd., Apr. 1985, p. 55. According to analysts of the Congressional Research Service, the U.S.S.R. has also tested a fractional-orbit bombardment system (FOBS), and possibly also a multiple-orbit bombardment system (MOBS), which could employ satellites to bombard terrestrial targets with nuclear warheads [U.S. Congress, Library of Congress, Congressional Research Service, Science Policy Research Division, *Soviet Space Programs, 1971-1975,* Committee Print prepared for the U.S. Senate, Committee on Aeronautical and Space Sciences, Aug. 30, 1976].

'U.S. Department of Defense, Defense Intelligence Agency, *Soviet Military Space Doctrine,* report DDB-1400-16-84, Aug. 1, 1984 [UNCLASSIFIED].

[10]Les Aspin, "The Verification of the SALT II Agreement, " Scientific *American,* vol. 240, No. 2, February 1979, pp. 38-45.

"president Ronald Reagan, *Report to the Congress: U.S. Policy on ASA T Arms Control,* Mar. 31, 1984[UNCLASSIFIED].

Soviet MILSAT Capabilities

The Soviet Union currently uses satellites to perform missile launch detection, communications relaying, radionavigation, meteorological surveillance, photographic and radar reconnaissance, collection of electronic intelligence (ELINT: e.g., radar emissions), and other functions.[12] These functions support a variety of military applications. Of particular concern to the Administration and in Congressl[$] are:

> . . . present and projected Soviet space systems which, while not weapons themselves, are designed to support directly the U. S. S.R. 'S terrestrial forces in the event of a conflict. These include ocean reconnaissance satellites which use radar and electronic intelligence in efforts to provide targeting data to Soviet weapon[14] platforms which can quickly attack U.S. and allied surface fleets. In view of the fundamental importance of U.S. and Allied access to the seas in wartime, including for Allied reinforcement by sea, the protection of U.S. and allied navies against such targeting is critical.[ls]

Soviet ELINT ocean reconnaissance satellites (EORSATS) attempt to detect, localize, and classify ships by detecting the radio signals emitted by their communications and radar systems, while Soviet radar ocean reconnaissance satellites (RORSATS) attempt to detect, localize, and classify ships by detecting radar "echoes" reflected by the ships. RORSATS and EORSATS are typically deployed at altitudes of about 250 and 425 kilometers, respectively, in nearly circular orbits inclined about 650 with respect to the equatorial plane [see figure 3-1 and table 3-2] From these altitudes, these satellites can observe shipping over a limited range. The observation "swath' of each satellite will eventually cover the entire earth and ocean surface between latitudes of about 650 north and south. If only one or two RORSATS or EORSATS were operational at one time—as has been customary in peacetime–then a ship in this latitude band would be exposed to observation only intermittently.l[8] However, larger numbers of RORSATS or EORSATS could be operational during wartime.

Even if only intermittent, surveillance by RORSATS or EORSATS could assist Soviet forces in targeting Allied shipping to an extent dependent on details of satellite capabilities, such as resolution. For example, Soviet oceanographic radar satellites of the Kosmos-1500 class can obtain radar imagery with a resolution of only 1.5 to 2 kilometers [see figure 3-2], which is inadequate to distinguish an aircraft carrier from a tanker, for example.1[7] Various countermeasures could be used by ships to evade observation by these satellites or to reduce the value of their observations to the enemy; la some of these are discussed below, in the section entitled "The Role and Value of Anti-Satellite Capabilities. "

U.S. MILSAT Capabilities

The United States uses MILSATS to perform most of the functions performed by Soviet satellites, as well as some other functions.

[12] Ibid., pp. 7 and 12; and U.S. Navy, Office of the Chief of Naval Operations, *Understanding Sow"et Naval Developments*, 4th cd., NAVSO P-3560 (Rev. 1/81), Jan. 1981 IUNCLASSIFIED], p. 46.

[13] *Hearings before the Subcommittee on Strategic and Theater Nuclear Forces of the Committee on Armed Services United States Senate, Testimony on Space Defense Matters in Review of the FY1985 Defense Authorization Bill, S.* Hrg 98-724, Pt. 7, pp. 3568-3569.

"Specifically, anti-ship cruise missiles launched against U.S. surface ships: see U.S. Department of Defense, *Soviet Military* Power, 3d cd., 1984; p. 41.

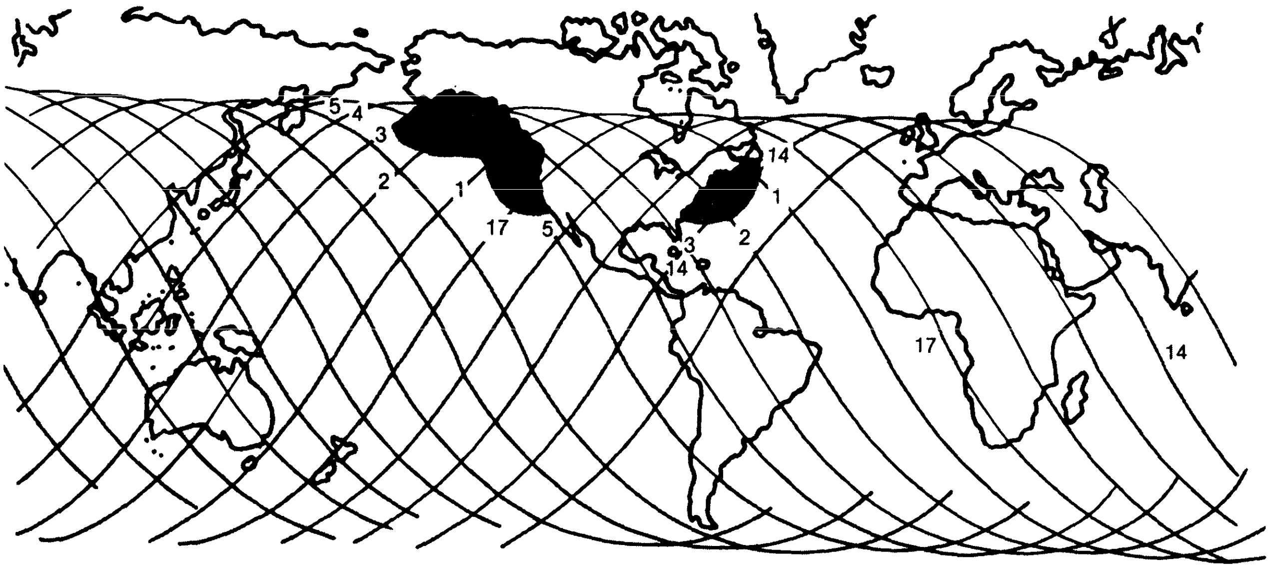
[15] Reagan, op. cit.

[16] Compare the discussion of radar search satellites in *MX Missile Basing*, OTA report OTA-ISC-140, September 1981.

[17] In 1983 the Soviet Union launched a civil Ocean-surveillance satellite (Kosmos 1500) equipped with a side-looking radar and in the same year placed two satellites (Venera 15 and Venera 16) equipped with similar radar systems into orbits around Venus. The U.S.S.R, has exhibited radar imagery obtained by these satellites. Although the resolution of this radar imagery is poor compared to the 25-meter resolution imagery obtained by NASA's Seasat-A radar satellite in 1978 [see Figure 76B of U.S. Congress, Office of Technology Assessment, *MX Missile Basing*, OTA-ISC-140, Sept. 1981], the 40-meter resolution imagery obtained by NASA's experimental Shuttle Imaging Radar (SIR-A) device in 1982 [see figure 3-3], or the 25-meter resolution imagery obtained by NASA's experimental Shuttle Imaging Radar (SIR-A) device in 1984, Soviet satellite radar technology can be expected to improve, and synthetic aperture radar could be used on future satellites.

"Reagan, op. cit., p. 13. See also testimony of VADM Gordon R. Nagler, USN, before the HAC Subcommittee on Defense, Mar. 23, 1983.

Figure 3.1 .—Ground Track of Soviet Radar Ocean Reconnaissance Satellite



600 inclination
160-170 nmi altitude
1.5-1.6 hr period

SOURCE Office of Technology Assessment

Table 3“2.—Orbits of Some Soviet Military Satellites

Per[gee-Apogee (km) (km)	Inclination	Apparent mission •
35,785-35,785	0	communications
19,000-19,200	65	navigation
965-1,020	47	communications
940-960	83	meteorological
855-895	81	meteorologyical
790-810	74	communications
620-660	81	electronic Intelligence (ELI NT)
425-445	65	ELINT ocean reconnaissance (RORSAT)
760-40,000	63	launch detection
400-40,000	63	communicatlons
356-415	73	photo- reconnaissance[a]
250-265	65	radar ocean reconnaissance (RORSAT)
172-351	67	photo-reconnaissance [b]

[a]Maneuverable initial parameters for Kosmos 1499 given
[b]Maneuverable initial parameters for Kosmos 1454 given

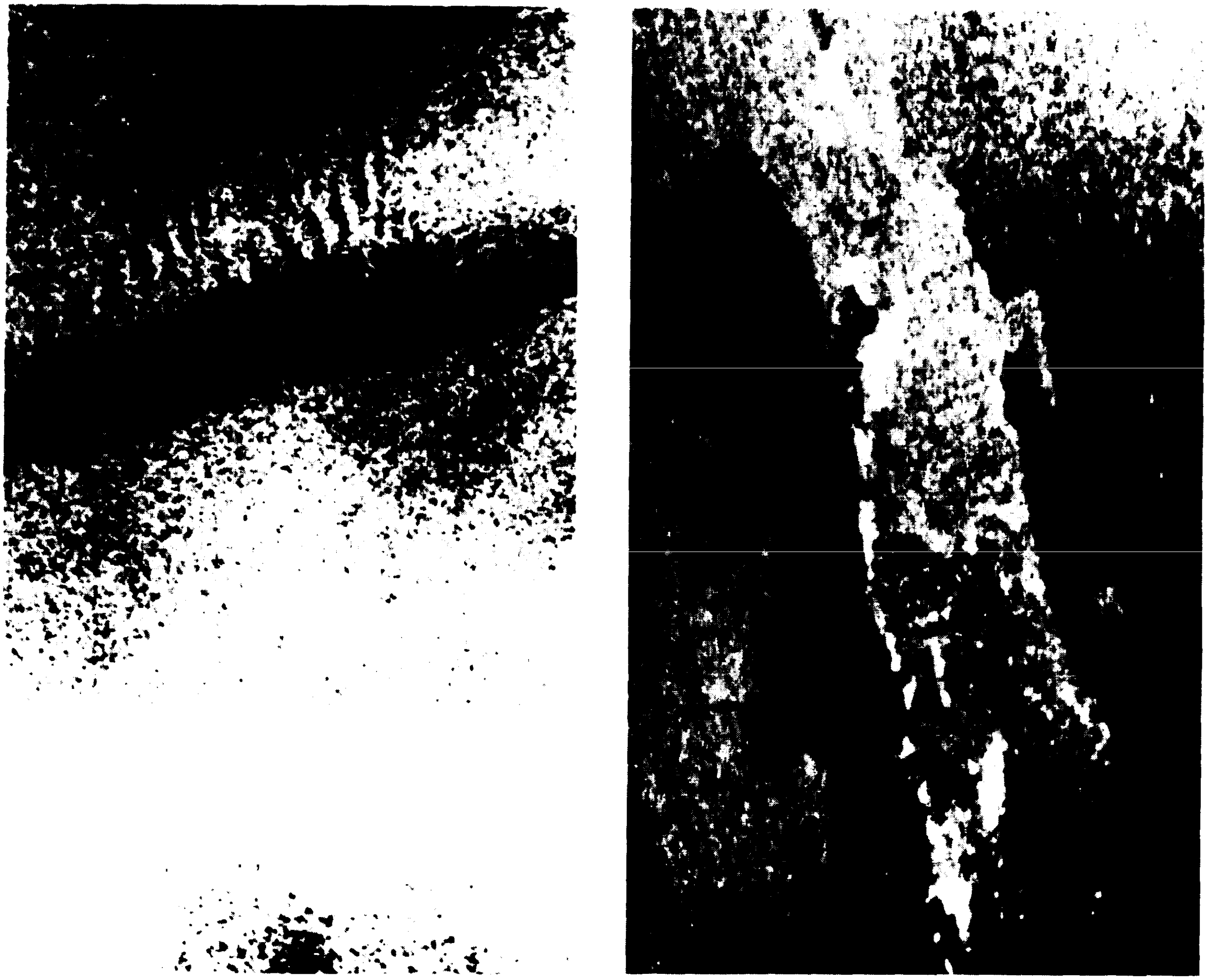
SOURCES NASA *Satellite Situation Report* VOl 24 No 5 Dec 31 1984 and “ Nicholas L Johnson *The Soviet* Year In Space 7983 (Colorado Springs CO Teledyne Brown Engineering 1984)

U.S. satellites are designed to have longer operational lifetimes in orbit than Soviet satellites, hence fewer satellite launches per year **are** required to perform similar functions. The complexity of a U.S. satellite may differ from that of a Soviet satellite performing the same function, and the value of this function to the United States may differ from its value to the U.S.S.R.

Attack Warning.-The United States uses infrared sensors aboard satellites in geostationary orbit to detect and promptly report ICBM and SLBM launches; these reports would provide early warning of a missile attack. [19]

[19]U.S. Department of Defense, *Report of the Secretary of Defense Caspar W. Weinberger to the Congress on the FY 1985 Budget, FY 1986 Authorization Request, and FY 1985-89 Defense Programs,* Feb. 1,1984 [UNCLASSIFIED], p. 196.

Figure 3-2.- Radar Imagery From Kosmos 1500



Left, imagery of Atlantic Ocean waves obtained by the Soviet Kosmos 1500 Oceanographic Research Satellite in 1983:

Right, imagery of Honshu Island, Japan obtained by same satellite.

SOURCE: Photographs courtesy of *Aviation Week and Space Technology* (reprinted by permission)

Navigation and Detection of Nuclear Detonations.—U.S. NAVSTAR satellites carry radionavigation beacons for use by Global Positioning System (GPS) receivers on aircraft, ships, and land vehicles. They also carry Integrated Operational Nuclear Detonation Detection System (IONDS) sensors designed to detect nuclear detonations in order to monitor compliance with the Limited Test Ban Treaty and other treaties in peacetime. In wartime they could be used to confirm a nuclear attack on the United States or its allies in order to support a decision by the National Command Authorities to retaliate, and to assess the success of a retaliatory strike.[20]

[20] Ibid.

Command and Control Communications.—The United States also uses several different military and commercial communications satellites to provide command and control communications among its globally distributed forces. An advanced satellite communications system called MILSTAR has been designed to replace these and is intended to provide survivable and enduring command and control communications to all four services at all levels of conflict, including general nuclear war."

Meteorological Surveillance.–Defense Meteorological Satellite Program (DMSP) meteorological surveillance satellites provide timely information about weather conditions worldwide. This information is of considerable value in planning military operations, especially flight operations.

Compliance Monitoring.–Photoreconnaissance satellites are used to monitor compliance with arms control treaties and agreements; this function could not be performed as well by any alternative means which is politically acceptable in peacetime, and this function would be unnecessary during war with another party to such treaties, which would be suspended during such a war. However, in wartime the United States would attempt to collect intelligence using satellites[22] and other means, such as aircraft overflight, which are acceptable during wartime.

[21]The Honorable Caspar W. Weinberger, Secretary of Defense, *Annual Report to the Congress on the FY 1984 Budget, FY 1985 Authorization Request, and FY 1984-88 Defense Programs,* Feb. 1, 1983 [UNCLASSIFIED].

[22]The Honorable Richard Perle, Assistant Secretary of Defense for International Security Policy, has stated:

> We believe that this Soviet anti-satellite capability is effective against critical U.S. satellites in relatively low orbit, that in wartime we would have to face the possibility, indeed the likelihood, that critical assets of the United States would be destroyed by Soviet antisatellite systems. If, in wartime, the Soviet Union were to attack critical satellites upon which our knowledge of the unfolding conventional war depended, . . . we would have little choice but . to deter continuing attacks on our eyes and ears, without which we could not hope to prosecute successfully a conventional war,

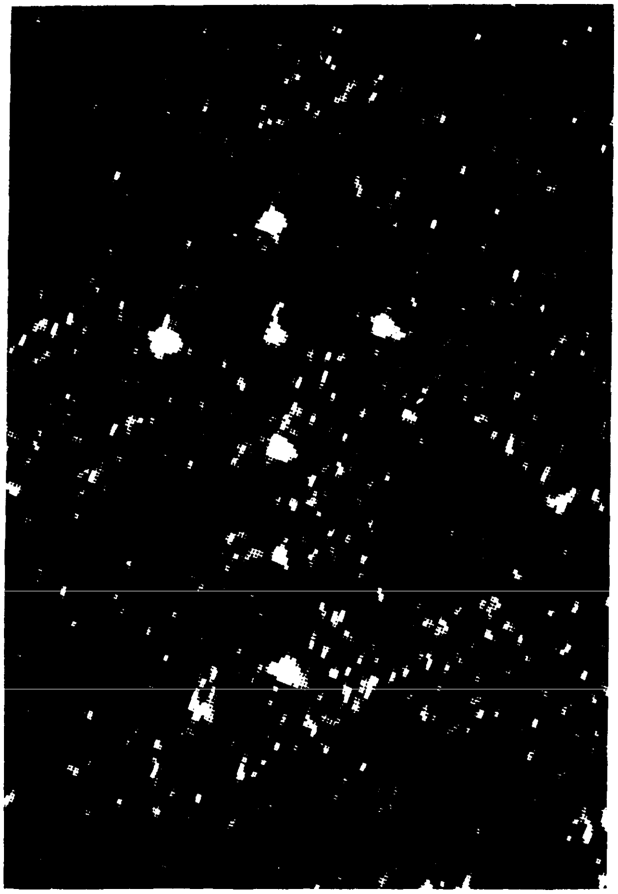
[Hearings before the Subcommittee on Strategic and Theater Nuclear Forces of the Committee on Armed Services United States Senate, Testimony on Space Defense Matters in Review of the FY1985 Defense Authorization Bill, S.Hrg. 98-724, Pt. 7., Mar. 15, 1984, p, 3452.]

Possible Advanced-Technology MILSAT Capabilities

Recent and prospective technological advances could be exploited by both the United States and the U.S.S.R.–at different rates–to develop MILSATS which could perform those functions now performed by MILSATS more effectively or economically. Such improvements are possible in the performance of each of the functions mentioned. Of particular interest and concern are possible marked improvements in ocean surveillance, logistic support of space systems, and anti-satellite capability which appear technologically feasible.

For example, radar ocean surveillance satellites using synthetic aperture radar techniques could provide radar imagery of sufficient resolution to permit classification of ships. An example of the potential quality of radar imagery is provided by the radar imagery obtained by the Shuttle Imaging Radar system SIR-A in 1981 [see figure 3-3]. The synthetic aperture radar carried by SIR-A distinguished features as small as 40 meters across. Earlier, in 1978, NASA's Seasat-A demonstrated a resolution of 25 meters; more recently, in 1984, SIR-B demonstrated a comparable resolution. Even finer resolution is possible, and several satellites could be deployed at once to provide frequent opportunities to observe each point on the ocean surface. [Deploying such satellites at higher altitudes for greater coverage would greatly increase the power required and hence also satellite cost.] Both the United States and the U.S.S.R. could deploy radar ocean surveillance satellites using high-resolution synthetic aperture radar technology in the future. Soviet deployment of radar ocean surveillance satellites with improved performance would threaten U.S. and allied shipping to a greater extent than does the existing RORSAT and would provide the United States with a greater incentive to maintain, or, if necessary, develop an A SAT capability to destroy such satellites or otherwise interfere with their performance. Future EORSAT performance could also be improved. With regard to the threat posed by

F g e 3 3 magery Ob a ed b S n he Ape e Sa e e Rada



such Soviet MILSATS to U.S. and allied shipping, the Administration has expressed concern that "as Soviet military space technology improves, the capabilities of Soviet satellites that can be used for targeting are likely to be enhanced and represent a greater threat to U.S. and allied security. "[23]

The logistic support and anti-satellite capabilities of space systems could also be enhanced greatly in the future. Potential future ASAT capabilities are discussed in chapter 4 of this report.

Recent and prospective technological advances could also be exploited to enable future MILSATS to perform functions not now performed by MILSATS. For example, the United States could develop and deploy space surveillance satellites to detect and track foreign satellites. This capability could be used to detect impending attacks on U.S. or allied satellites in time to permit countermeasures to be used; it could confirm success of such attacks in order to support a decision to retaliate (not necessarily in kind); it could monitor compliance with possible future ASAT arms control or "Rules of the Road in Space" agreements; and it could provide targeting information for U.S. anti-satellite weapons. Space surveillance satellites could provide continuous space object detection and tracking capabilities which cannot be duplicated by ground-based radars (which have limited search range) and photographic or electro-optical sensors (which cannot be used in daytime or through overcast).

The United States and the U.S.S.R. could also develop satellite (i.e., space-based) weapons capable of attacking a variety of targets other than satellites—e.g., ballistic missiles, aircraft, ships, and fixed or mobile targets on land.[24] Assessment of the military capabilities which such weapons might eventually be able to provide requires an understanding of the feasibility of making them survivable at affordable costs and is beyond the scope of this report, which is limited to survivability issues. The feasibility and value of space-based ballistic missile defense system components–including weapons—is discussed in a companion OTA report, *Ballistic Missile Defense Technologies.*

The Value of Military Satellites

Estimation of the force multiplication effects which satellites might provide under specific circumstances might be done objectively, by means of combat modeling and simulation,

[23] Reagan, op. cit., p. 'i. See also testimony of VADM Gordon R. Nagler, USN, before the HAC Subcommittee on Defense, Mar. 23, 1983.

[24] LTC David Lupton, USAF (Ret.), op. cit., pp. 36-47.

and analysis of historical combat data. The costs of the additional "equivalent forces' which the satellite services would, in effect, replace might be used as an upper bound on the value of the satellites under those circumstances. However, the expected utility, or worth, of such force multiplication cannot determined by such an analysis without assuming probabilities that the forces supported will be involved in various conflict situations, estimating the force multiplication expected in each such situation and the additional costs averted by such force multiplication, and averaging these averted costs over all such situations. This would be a demanding, and probably infeasible, analytical task, because assessment of such values and probabilities is necessarily subjective and hence subject to dispute. However, some judgments of value are conventionally accepted and can be rationalized to a considerable extent.

For example, the missile attack warning function performed by U.S. MII.SATs has been described as being of "vital' importance to national security. " The navigation and nuclear detonation detection functions performed by the GPS and IONDS mission packages aboard NAVSTAR satellites have been described as "critical," as has the communications function to be performed by MILSTAR and currently performed by a variety of satellites [see box entitled "The Dependence of U.S. Command and Control Performance on Satellite Communications Systems"]." Surveillance satellites have been described as "criticaI assets, "[27] and the surveillance function which they perform has been called "vital.' '28

Other satellites are seldom judged to be of importance comparable to those aforementioned, although some are of considerable value. For example, after DMSP cloud imagery and DMSP-derived forecasts were made available to aircraft carriers operating in Southeast Asia, sorties of carrier-based aircraft scheduled for strike and reconnaissance missions which required clear weather in the target area were canceled when meteorological data from DMSP satellites showed overcast in the target area, and the aircraft which had been assigned to the canceled sorties were reassigned to other missions. This use of DMSP data decreased the number of aircraft required to perform a number of assigned missions in a given time, or, equivalently, increased the number of aircraft available to fly such missions.

As another example, the navigational accuracy of missiles and aircraft which rely on very accurate, unaided inertial navigation systems depends on geopotential anomaly data collected by geophysical research satellites.

Some of the functions performed by satellites, and the satellites which perform them, are most valuable in peacetime, while others would be more important in crisis, conventional war, or nuclear war. However, determination of the nature of the dependence of satellite value on the level of conflict is complicated by the fact that in many cases the

[25]The Honorable Hans Mark, then Secretary of the Air Force, in testimony in 1980 hearings before the U.S. Congress, House of Representatives, Committee on Science and Technology, stated that "two missions [strategic missile warning and surveillance] above all others stand out as being of vital importance to national security." [*United States Civilian Space Policy*, House Document 153, 96th Cong., 2d sess., July 23-24, 1980; pp. 93-94].

[26]Responses of LTG Robert D. Russ, USAF, Deputy Chief of Staff for Research, Development, and Acquisition, to questions submitted by The Honorable Norman Dicks in FY1985 Defense Appropriations hearings before the U.S. House of Representatives, Committee on Appropriations, Subcommittee on Defense, vol. V, 1984.

[27]The Honorable Richard Perle, Assistant Secretary of Defense (International Security Policy), has stated that "We believe that this Soviet anti-satellite capability is effective against critical U. S. satellites in relatively low orbit, that in wartime we would have to face the possibility', indeed the likelihood, that critical assets of the on it ed States would he destroyed by Soviet anti- satellite systems."---Statement of The Honorable Richard Perle, Assistant Secretary of Defense (1 nternational Security Policy), Hearings *before the Subcommittee on Strategic and Theater Nuclear Forces of the Committee on Armed Services United States Senate. Testimony on Space Defense Matters in Review of the FY1985 Defense Authorization Bill*, Mar. 15, 1984, S, Hrg. 98-724, Pt. i', p. 3452.

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The Dependence of U.S. Command and Control Performance on Satellite Communications Systems

It has been estimated that about 70 percent of all U.S. military electronic communications are routed through communications satellites.[1] In peacetime, much of such traffic consists of administrative messages which would be unessential to the conduct of war. Therefore, the dependence of U.S. military capabilities on satellite communication systems, although undoubtedly substantial, is not necessarily represented accurately by the fraction of message traffic routed through satellites during peacetime. The dependence of U.S. military capabilities in several theaters on satellite communication systems is reflected qualitatively in the following views of military commanders and staff analysts.

Command and Control in the Southwest Asian Theater.–The dependence of command and control within the Southwest Asian theater and between that theater and the continental United States on satellite communications systems has been noted by Lieutenant General Robert C. Kingston, USA (Commander, Rapid Deployment Joint Task Force):

> . . . the challenge is to establish and maintain strategic communications upward, necessary linkages laterally, and tactical communications downward. Strategic connectivity in the [Southwest Asian] region is limited today. The backbone of the Defense Communications System cannot be accessed directly except by satellite or HF over long distances. The FLTSAT and DSCS II systems support this need for all the services. DSCS 111, the follow-on satellite, will soon be launched with a new booster. The HF programs, however, especially in the anti-jamming arena, need better interoperability. At present, limited HF links must transmit beyond optimum distances to reach DCA entry points and are subject to frequent atmospheric interruptions.[2]

Command and Control in the Pacific Theater.–Similar concern has been expressed by Lieutenant General Joseph T. Palastra, Jr., USA (Deputy Commander-in-Chief, Pacific) about the dependence of command and control within the Pacific theater and between that theater and the continental United States on satellite communications systems:

> A critical problem is the Pacific area's heavy reliance on satellite and undersea cable systems. The Soviet Union's demonstrated ability to destroy satellites has made it urgent to implement countermeasures and modernize backup high frequency systems so we can deploy at least minimum essential communications.[3]

Command and Control in the European Theater.–Command and control between the European theater and the continental United States depends on similar means which are similarly vulnerable. Command and control within the European theater depends less on satellite communications, for reasons noted by Major General Robert A. Rosenberg, USAF (then Assistant Chief of Staff, Studies and Analyses, Headquarters, U.S. Air Force):

> It is interesting to watch a simulated war-game exercise in the central region of Europe when the communications circuits are removed to simulate loss or destruction. The German Post Office telephone system is used to contact another command center when the military primary lines are down.[4]

[1] Colonel Robert B. Giffen, *US Space System Survivability: Strategic Alternatives for the 1990s,* National Security Affairs Monograph Series 82-4 (Washington, D.C.: National Defense University Press, Fort Leslie J. McNair, 1982), pp. 22-23.

[2] Lieutenant General Robert C. Kingston, USA, "C³I and the Rapid Deployment Force," *Worldwide Deployment of Tactical Forces and the C³I Connection,* Proceedings of the National Security Issues 1982 Symposium, Oct. 4-5, 1982, MITRE Corp. document M82-64, 1982.

[3] Lieutenant General Joseph T. Palastra, Jr., USA, "Pacific Command Perspectives," *Worldwide Deployment of Tactical Forces and the C³I Connection, Proceedings* of the National Security Issues 1982 Symposium, Oct. 4-5, 1982, MITRE Corp. document M82-64, 1982.

[4] Major General Robert A. Rosenberg, USAF, "Satisfying C³I Requirements for Deployed Air Forces," *Worldwide Deployment of Tactical Forces and the C³I Connection,* Proceedings of the National Security Issues 1982 Symposium, Oct. 4-5, 1982, MITRE Corp. document M82-64, 1982.

value of a function performed by a satellite may be realized at a later time and at a different–probably higher-level of conflict than that at which the function was performed.

For example, missile attack warning data would be most valuable during a nonnuclear war, when anticipation of such an attack would be most intense and when it would be most important to be reassured that the nation is not under attack when such is indeed the case. Once the United States has confirmed that it has been so attacked, or is under attack, or decides to retaliate for a nonnuclear attack by Warsaw Pact forces against NATO allies, further warning information would be of value only if additional salvos were expected, as in "nuclear war-fighting" scenarios.

As another example, the value of geopotential anomaly data collected by satellite might be greatest during nuclear war, although to be of value then such data must have been collected and analyzed-a lengthy process–during peacetime.

The problem of assessing the values of MILSAT capabilities and ASAT capabilities will be discussed in greater detail in appendix D to this report.

The Vulnerability and Protection of Military Space Systems

The value of MILSAT functions performed during wartime can be realized only if MILSATS survive long enough to perform them. Most current MILSATS are vulnerable to deliberate nuclear or nonnuclear attack, and some are vulnerable to nondestructive electronic countermeasures and electro-optical countermeasures. However, only a few U.S. MILSATS are potentially vulnerable to current Soviet nonnuclear A SAT weapons, and these could be made less so.

Satellites operate as components of space systems, which include terrestrial components such as satellite control facilities and user terminals (the "ground segment") as well as the satellites themselves (the "space segment"). Attacks against either segment can disrupt the functioning of a military space system and negate or reverse the force enhancement it pro vides. Hence both MILSATS and their associated ground equipment must be effectively protected against attack if the value of their wartime functions is to be realized. Technical measures—i.e., active and passive countermeasures—can provide some protection by reducing the MILSAT vulnerability, and legal measures—i.e., arms control treaties treaty or customary law banning threatening activities in space—can provide some protection by constraining ASAT capabilities which could be used against MILSATS. Arms control measures could be used in combination with pas*sive* countermeasures to constrain potential ASAT threats and reduce vulnerability to those which would remain. However, some arms control measures would be incompatible with some active countermeasures, such as shoot-back with ASAT weapons.

U.S. responses to current and future ASAT threats need not be limited to legally constraining such threats and protecting and defending satellites from those which remain. Other possible responses include deterrence of ASAT attack by maintaining a capability to retaliate (not necessarily in kind), using nondestructive electronic countermeasures and electro-optica.1 countermeasures against the space and ground segments of A SAT systems, attacking the ground segment of ASAT systems, augmenting other forces to compensate for MILSAT vulnerability, and reducing dependence on MILSATS.

[Technical countermeasures are discussed in greater detail in chapter 4 of this report, and arms control and other legal measures are discussed in chapters 5 and 6. In practice, passive countermeasures, and probably active countermeasures as well, would be used in conjunction with arms control; such combinations of arms control and technical countermeasures are discussed in greater detail in chapter 7 of this report.]

THE ROLE AND VALUE OF ANTI-SATELLITE CAPABILITIES

To the extent that enemy MILSATS could increase the effectiveness of enemy forces, capabilities to damage such MILSATS or to degrade their functioning would be valuable in wartime. In addition to such destructive and nondestructive ASAT capabilities, other options are available to reduce the utility of MILSATS to an enemy or to compensate for their disutility to the United States.

Electronic and electro-optical countermeasures can be used to provide nondestructive ASAT capabilities which could be used at any level of conflict. They would be particularly valuable during crises short of declared war, in which satellite destruction would be escalator and hence in many cases undesirable. "Active" electronic countermeasures such as "jamming" (i.e., overloading enemy receivers with strong signals) and "spoofing" (i.e., sending deceptive signals) could be used to interfere with satellite functioning, as could such active electro-optical countermeasures as temporary blinding (or "dazzling": the optical counterpart to jamming) and spoofing. Such nondestructive ASAT measures are discussed in chapter 4 of this report.

At higher levels of conflict, ASAT weapons could be used to destroy enemy satellites. The inherent ASAT capabilities of nuclear weapons such as ICBMS and SLBMS could be used for negation of low-altitude MILSATS at nuclear levels of conflict, while at nonnuclear levels of conflict the inherent ASAT capabilities of the experimental nonnuclear ABM technologies demonstrated in Homing Overlay Experiment (HOE) tests could be used for low-altitude MILSAT negation, as could the U.S. Air Force's Miniature Vehicle ASAT weapon, when operational. Negation of satellites at higher altitudes or more rapid negation of low-altitude satellites would require more capable ASAT weapons such as are discussed in chapter 4 of this report.

Alternatively, or supplementally, various passive measures could be used in peacetime, crisis, and war not to interfere with the functioning of enemy MILSATS but rather to decrease the value of their functions to the enemy and, more importantly, to mitigate or compensate for the harm such satellites could cause the United States. Intelligence-gathering satellites may be particularly susceptible to such measures. For example, terrestrial force elements might employ maneuver to avoid observation by enemy imaging satellites, and they could use camouflage and concealment to prevent recognition if observed. Decoys which would also be "recognized" erroneously could be used to thwart image interpretation by causing confusion as to the numbers and locations of the assets simulated by the decoys. Ships, aircraft, and other assets might be designed to reflect radar signals only weakly in order to evade detection by radar satellites, and radio silence might be practiced, or covert signaling techniques used, in order to prevent detection of radio emissions by satellites. Of course, these passive measures would impose either operational constraints or financial costs or both.

Still other options are available to compensate for, rather than mitigate, the harm which foreign MILSATS could cause to U.S. and allied security. For example, to the extent that foreign MILSATS provide a force multiplier effect to foreign force elements which engage in direct combat, U.S. or allied force elements which might oppose these foreign force elements might be augmented in order to maintain relative combat strength. That is, force augmentation could offset the force multiplication provided to enemy forces by space support. Force augmentation would be costly, but not necessarily more costly than an ASAT capability of comparable security benefit.

These possible responses to threatening MILSAT capabilities are summarized in table 3-3. These response options would be more effective used in combination rather than individually.

Assessment of the value of ASAT capability is subject to the same methodological difficulties which confound assessment of the value of MILSAT capability .29 These prob-

*'The value of a U.S. ASAT capability to the United States in a conflict could be assumed to be equal in magnitude to the

Table 3-3.—Possible Responses to Enemy MILSAT Capabilities

- Force augmentation
  - —offsets force multiplication by MILSATS
- Passive measures against satellite reconnaissance and targeting
  - — Evasion
  - —Concealment
  - —Camouflage
  - —Decoys
  - —Radio/radar silence
  - —Covert communications techniques
- Nondestructive anti-satellite measures
  - —Electronic countermeasures
    - Jamming
    - Spoofing
  - —Electro-optical countermeasures
    - Jamming
    - Spoofing
- Destructive anti-satellite measures
  - —Use inherent ASAT capabilities of ICBMS, SLBMS, and ABMs
  - —Develop deliberate ASAT weapons

lems, noted above, are discussed *in* greater detail in appendix D to this report. Although quantification of the value of ASAT capability is necessarily subjective or complicated, or both, it is clear that operational ASAT capabilities would have some value to the extent that they would be inexpensive, stabilizing, and compatible with other (e.g., diplomatic) options for enhancing security.

[negative] total value *to the United States* of those enemy MILSATS which it would be expected to destroy. No analytically sophisticated studies known to OTA have attempted to systematically assess and compare the utility of U.S. MILSATs to the United States with the disutility of Soviet MILSATs *to the United States* [but compare Stephen M. Meyer, op. cit., pp. 204-215]. It is these utilities which should be compared to determine whether the United States would fare better in a regime in which U.S. and Soviet MILSATs were mutually *vulnerable* to the other's ASAT weapons or in a regime in which U.S. and Soviet MILSATs were protected from A SAT threats by active or passive countermeasures or arms control.

MILITARY SPACE POLICY

Military Space Policy Issues

The fundamental task of military space policy formulation is deciding how much proposed military space programs are worth, both in terms of the resources for which they would compete with other proposed national programs, and in terms of opportunity costs which might be incurred by failing to take other actions (e.g., arms control) with which such programs are incompatible for nonbudgetary (e.g., legal) reasons. Because the costs, risks, and benefits differ in character, a political determination of levels at which military space efforts should be pursued is required.[30]

Prerequisite for this is the task of deciding the *relative* values of proposed military space systems, anti-satellite systems, and arms control agreements; judgment of these values also requires political choice.[31]

[30] Representative of such determinations are the annual budgets prepared by the *executive* branch and funds authorized and appropriated by Congress.

[31] Representative of such determinations are President Carter's Presidential Directive 37 (PD-37) issued in June 1978, President Reagan's July 4, 1982, statement on National Space Policy, and President Reagan's *Report to the Congress: U.S. Policy on ASAT Arms Control*, Mar. 31, 1984,

ASAT Policy Issues

Particularly apparent is the incompatibility between ASAT capabilities and ASAT arms control agreements; these would have different kinds of benefits and risks, and a decision to pursue one or the other must be based on a political judgement of their respective expected net benefits. A national *ASAT policy* reflects such a judgement and should attempt to establish goals for national efforts to enhance security by the chosen approach. In particular, a national ASAT policy should:

1. describe *military posture objectives;* it should attempt to answer the question: "What ASAT capabilities do we need, and why?"
2. indicate the extent to which pursuit of security by the chosen approach would probably benefit from increased spending in various areas of *research and technology development, so* that national research and development policy might be formulated cognizant of these potential benefits.
3. establish *ASA T arms control policy*; i.e., it should indicate types of arms control

provisions or agreed confidence-building measures which are judged to be in the national interest, in order to coordinate formulation of negotiating postures, in particular, and foreign policy in general;[32] and

4. specify U.S. ASAT employment *policy;* i.e., it should specify conditions under which U.S. use of ASAT capabilities—especially in conflicts short of declared war-would be deemed justifiable and in the national interest. In addition, if we de sire to deter Soviet ASAT attacks, we must arrive at and announce a public policy which we believe will make this deterrence as effective as possible. Whether this policy should be explicit or instead one of calculated ambiguity is a matter of political judgment.

Ballistic Missile Defense as an ASAT Policy Issue

The incompatibility between ballistic missile defense capabilities and ASAT arms control agreements is apparent. Ballistic missile defense weapons which would be capable of attacking ballistic missile components in *space* generally would have some inherent capability to attack satellites at altitudes or ranges comparable to those at which ballistic missile components would be engaged, depending on satellite "hardness." The inherent ASAT capabilities of some possible advanced-technology BMD weapons would be considerable, and any arms control agreement which would attempt to limit the threat of such weapons to satellites must ban or limit such weapons. Hence a restrictive ASAT arms control agreement would also restrict BMD capabilities, just as the ABM Treaty-which limits, by intent, weapons capable of attacking ballistic missiles-also limits ASAT weapons with inherent BMD capability. Of all the opportunity costs which might be imposed on the United States by an agreement to limit ASAT capabilities, restrictions on the development and deployment of BMD capabilities beyond those already imposed by the ABM Treaty are considered most costly by those who believe that exploitation of advanced technology may make possible BMD weapons of great effectiveness.

A more fundamental incompatibility between ASAT and BMD capabilities is physical rather than legal: the most capable BMD systems now envisioned would use space-based sensors, and perhaps also space-based weapons, which would be subject to attack by deliberate ASAT weapons or by BMD or other weapons with inherent ASAT capabilities. Such BMD systems would be effective only if their sensors and weapons could be protected from such ASAT threats at reasonable cost by passive countermeasures, active countermeasures, arms control measures, or a combination of these. If so, perhaps such measures could be used to protect other satellites, or else the functions now performed by other satellites could be performed by secondary mission payloads "piggybacking" on BMD satellites. If not, such BMD capabilities would be of little value, if any, and the opportunity costs which would be incurred by restricting them would be small.

[Chapter 5 of this report contains a discussion of past arms control efforts which had the intent or effect of constraining ASAT capabilities. Other ASAT arms control options are described and evaluated on a provision-by-provision basis in chapter 6 and as packages of provisions in chapter 7.]

[32]Representative of such a policy is President Reagan's *Report to the Congress: U.S. Policy on ASAT Arms Control,* delivered Mar. 31, 1984.