CASE STUDY 1

THE HISTORY OF US ANTI-SATELLITE WEAPONS

THE HISTORY OF US ANTISATELLITE WEAPON SYSTEMS

Contents

I. INTRODUCTION

The military significance of antisatellite (ASAT) systems is in the importance of the capabilities that they threaten. The uses of satellites in support of military programs has burgeoned into an ever increasing number of areas. Reconnaissance satellites provide information on the location and numbers of strategic weapons, the disposition of fleets and strike forces, and the deployment of tactical forces in wartime. Communications satellites provide enormously enhanced command-and-control capabilities in the disposition of one's forces. Early-warning systems alert one to the launch of the opponent's strategic missiles. Geodetic satellites provide information for the targeting of one's own weapons and the improvement of their accuracy. Weather satellites aid fleets to hide under cover and aircraft to improve their routes to targets or destinations. Ferret satellites provide electronic intelligence that is crucial to the successful operation of one's own forces. These are only a very small sampling of some of the more commonly discussed functions of military satellite programs, functions that have been concentrated in the strategic mission, but that are now spreading into tactical areas also.

Clearly satellites are becoming increasingly important to the military operations of both the US and the USSR. The question of whether one or both nations will develop fully operational antisatellite systems — particularly as they are developed with non-nuclear warheads — has therefore also become increasingly important with time. The United States has a history of the development of antisatellite systems dating back to 1957; from 1964-1975 it deployed a minimal ground-based direct-ascent missile system. The USSR has been carrying out more extensive tests of an orbital-intercept system since 1968. Currently both countries are simultaneously engaged in the active development of ASAT systems. For a brief period during the Carter administration, they were also engaged in negotiations on possible controls. As the development programs have become more sophisticated in the early 1980s, there has again developed renewed emphasis on negotiations to ban ASAT weapons.

This study examines the policy determinants in the history of anti satellite systems in the United States, looking at the particular decisions made regarding these weapon systems and why they were made. What kinds of programs were proposed and initiated, what happened to them, why were other kinds of programs rejected or not initiated? The emphasis is on the early years — the late 1950s through the end of the 1960s — when the ideas were first generated and the R&D and the first deployed systems initiated. Many factors are involved: the assessment of institutional and technological pressures, the role of threat assessment — the perception of the enemy threat — the effectiveness and costs of the measures proposed, competition from other programs that might achieve the same goals, and interaction with programs or policies with contradictory objectives. One would like to know to what degree US weapon programs, both R&D and deployment (and perhaps even the publicity involved in the effort to obtain the decisions to support particular programs), stimulated development programs in the USSR. Similarly, to what degree did development programs in the USSR stimulate ones in the US. These questions apply both to weapon systems of the same type, that is, the effects of antisatellite weapon development in one country on antisatellite development in the other, as well as to weapons of other types. For example, did the original US concepts and proposals seek a general antisatellite capability, or were they intended only against a particular kind of space vehicle that might contain a nuclear weapon? To what degree was the early US capability developed more for political purposes than for military ones, both in terms of domestic US pressures and vis-à-vis the USSR?

Finally, an important aspect of this particular case study is to explore whether US policy-makers were explicitly exercising restraint in their decisions for or against specific weapon systems developments. Were the decisions and the actual deployed ASAT capability very much downplayed, so that the US could continue to keep the maximum possible free use of its other military satellite programs, programs that supported and enhanced a wide and proliferating variety of essential US military functions? Was it accepted that a large US ASAT program would risk those functions by very likely stimulating the development of an analagous USSR system? An interesting side issue is whether such restraint should correctly be termed "arms control", or should in fact be placed in a more traditional category of policy criteria, as a decision maximizing the overall effectiveness of US military systems — or whether the two are identical.

This study is only part of the story:

- As indicated, the emphasis is on the earlier years in the development of the US programs. Less attention is given to events in more recent years — the late 1970s and early 1980s — when US ASAT development programs were reinitiated with emphasis on a Miniature Homing Vehicle.

- The relevant systems of the USSR are insufficiently discussed; not only the USSR's ASAT system, but its manned military space systems which are analogous to some of the programs that were discussed in the United States but were never developed. They were, however, carried through R&D in the USSR and have been operational in some form since 1968.

- Many technical aspects of the systems involved have been omitted from the main text. More detailed sources are available regarding both the US systems — particularly the more recent ones — and those of the USSR.

Section II of the paper contains the historical narrative, and interpretation and analysis follows in Section III. In addition, several Appendices were prepared on the early technical "building blocks" that went into or surrounded the development of a US ASAT capability: the Spacetrack and Spadats space tracking and identification systems, Dyna-Soar, MOL, etc. Most of these appendices have been included here to provide the reader with a somewhat more concrete idea of what military research and development of complex integrated systems and capabilities is comprised of. The appendices do not describe the process by which basic scientific research (described in the introductory chapter to all these case studies) is adapted into the technical components that eventually result in the deployed military systems. They are only designed to indicate something of the progression in the development of these final systems.

II HISTORY

1. The General Context: The Genesis of Ideas and the Derivation of US Programs

Antisatellite capabilities depend on an aggregate of technological systems to perform the functions of detection, identification, interception and destruction. Jamming or otherwise interfering with a satellite so that it cannot perform its functions is also pertinent. The underlying necessity is a capability to monitor satellites through the use of radar, optical, electro-optical devices, and a central computational facility. The radars must be capable of monitoring thousands of objects in orbit simultaneously, old ones as well as new ones, in order to identify the newest additions. The computers must be able to store the orbit data for all of these objects, and compute their future orbits, thus providing the targeting coordinates for any antisatellite interceptor. Depending on the nature of the satellite that one wants to target, varying amounts of information are needed to distinguish its function and capability. A series of advances in technology since the early and mid-1960s in both radar and electro-optics has permitted the US ground-based Space Object Identification (SOI) Program to take on a significant portion of these objectives which were earlier sought in orbital satellite rendezvous and inspection vehicles, manned or unmanned.

Interception requires a vehicle that can get close enough to its rapidly orbiting target in space so that its warhead can be effective. There are two basic techniques with which to attempt this. The first is by the direct ascent of an interceptor missile into the orbital parth of its target; the second is by use of a second satellite that makes one or many orbits in the course of intercepting its target. This can be done in several different ways. The more demanding the parameters of the intercept, or the less capable the computer or its software for orbital prediction or the guidance of the interceptor, the greater is the need for terminal homing in the interceptor vehicle, or the use of a nuclear warhead for its kill-mechanism.

The first US studies of military space satellites were initiated in 1946 by the US Navy, and by the Army Air Force at the RAND Corporation. (1) These early studies were to some extent undertaken to convince the Joint Research and Development Board of the War Department that one or both of these Services had a claim to weapons development in the space medium.

The studies continued, and the first public disclosure of them was given by Secretary Forrestal in the First Annual Report of the Secretary of Defense, in late 1948. A Soviet response to the disclosure condemned the proposed space satellites as "instruments of blackmail". (2) One idea which appeared relatively early in this period was for a combined reconnaissance and nuclear missile launching satellite, orbiting at an altitude of 1,000 miles. In that context, it did not take long for notions of anti-satellite defense to develop, for example, as early as April 1954, far in advance of the launching of the first satellites. (3)

Planning and preliminary studies for the US Air Force SAINT, Satellite Interceptor, program was begun in 1957. (4) In the same year when Army General Gavin testified to the Senate of his hopes for US satellites, which he foresaw performing functions of reconnaissance, geodetics and mapping, and weather reporting, he simultaneously coupled these hopes for US satellites with the explicit recommendation for an antisatellite capability to prevent another country from acquiring similar capabilities over US or allied territory. (5)

Senator Saltonstall was surprised, in the same Hearings, to hear an industrial executive of the North American Corporation refer to a prospective "antispace" program and antispace operations. (6) Only a year later (1958) the National Aeronautical Space Administration, NASA, presented testimony to Congress on research that it was carrying out under the funding of the US Dept. of Defense (ARPA) on both anti-ballistic missiles (ABM) and anti-satellite weapon systems. In this case, the design of the antisatellite weapon was "to nullify the information that the enemy obtain with the reconnaissance satellite... (not) necessarily knock it down, but to nullify it so no one can get the information off of it." (7) It was soon realized that the intercept altitude for the antisatellite mission would be within the capability of a missile originally conceived of for the ABM mission. By 1961, the Army was very strenuously pushing for the role of the Nike-Zeus as an antisatellite (ASAT) missile. (8) Writing in the mid-1970's but presumably referring to his period of tenure up till 1960, President Eisenhower's Special Assistant for Science and Technology, Dr. Kistiakowsky — whose primary responsibilities concerned problems of weapons development — wrote:

> During the period covered in this diary there was considerable occasional pressure to develop antisatellite missiles. I opposed the proposals, successfully using the arguments that for us the satellites were far more important than for the Soviet Union, which could get

> most of the information from the open press, such as Aviation Week (9).

The genesis of the ideas for antisatellite weapons is similar to the origin of concepts for antiballistic missiles in the US. R&D for ABM systems in the US began as a response to and very soon after the initiation of the United States own programs to develop reentry vehicles for long-range ballistic missiles. Though in this case it was clearly understood that the USSR was also in the process of developing ballistic missile systems, the impetus for attempting to devise ABM mechanisms is usually considered an outgrowth of the United States own weapon development process, rather than a direct response to Soviet ICBM development. It would appear that the situation was not very different for satellite-antisatellite systems.

The period of the late 1950s and early 1960s — roughly 1957-1963 — was a period full of ideas and concept studies involving space-based nuclear weapon systems that would now be considered quite extravagant. Some were conceptual studies that were intended to lead to specific weapon systems; others were still more general ideas. Among the studies that examined proposals for specific weapon systems were those for:

- an orbital manned glide bomber;
- a group of study proposals for space-based ABM systems which were to lead to a Space Combat Weapon System, Project 649E. The best known of these was for a space-based ballistic missile intercept system (BAMBI); others were SPAD and the Random Barrage System;
- orbital unmanned nuclear weapon platforms for release of a reentry vehicle intended to hit a particular target on earth, for example the Positive Control Bombardment System.

The general concepts were, if anything, even more extravagant. There were repeated statements by senior US Air Force officers of the necessity for "space control" by the US. These rather ambiguous notions all involved manned space vehicles and "space patrols" very similar to aircraft missions within the atmosphere. In the context of this paper, it is significant that nearly all of them included explicit reference to a capability for satellite rendezvous, inspection, and destruction capability.

> Military patrol capabilities for the space region could provide on call protection for U.S. space activities, both scientific and military in the event of hostile enemy actions in the space region. This objective includes: an improved detection and tracking system; a means of inspecting unidentified space devices; a means of disabling hostile satellites, if this should be required in the national interest. (10)

The ideas seem to have followed a progression of advocates from the former German General, Walter Dornberger, the persistant supporter of orbital bombers, to Generals White, Ferguson, Schriever and others. These advocates spoke of space as the "high ground", arguing that the nation that controlled space would control the planet, and that national survival might be at stake in this effort. Space control evolved into the shorter-lived but more specific proposal that the US introduce a policy of "space denial". This latter suggestion, however, came in the 1962-1963 period, when the US was already beginning its own extensive utilization of satellite resources, and it did not necessarily involve manned space vehicles or missions. (11)

USSR "plans" for similar weapons were often cited in support of US programs. The same sentence would contain an amalgam of a projection of Soviet systems, the claim that such weapons would be extremely threatening in USSR hands, the fear that the USSR would obtain them — and the hope that they would nevertheless be obtained by the US first. In some cases, there was evidence that the USSR knew of the systems in question from statements and discussion in the US literature. In other cases there was evidence that the USSR had initiated its own interest. For example it was known that the USSR had shown some interest just after World War II in Sanger's ideas of an exo-atmospheric skip bomber. During discussions in 1960 of the US proposals for the Satellite Inspector (SAINT) program, it was flatly stated that, "The Soviet Union has been considering similar systems, and some US scientists believe Russia will have an antisatellite capability by 1963." (12) This general complex of proposals, allegations of threat, and generally extravagant level of language was the first of several major stimulii to proposals for ASAT development that can be identified.

The second was simpler and more direct. Although General Gavin's 1957 proposal of US antisatellite capabilities (and Lanphier's) was phrased in terms of preventing USSR <u>reconnaissance</u> capability, nearly all the subsequent public discussion and proposals for US ASATs through the end of 1960s were in the context of interception of USSR orbital satellites carrying nuclear weapons. That certainly seemed to be the context in which the two US ground-based direct-ascent antisatellite systems were conceived and deployed in 1962-1964. The USSR Fractional Orbital Bombardment System, FOBs, testing program which began in 1966-1967 reinforced this context.

However, within the government, there also seems to have been some consideration given (in 1962-1964) to a US ASAT as a deterrent against possible USSR interception or interference with US satellites.

> Almost 10 years ago, (Air Force) Secretary McLucas told Air Force Magazine, the Air Force started the development of a nuclear-armed anti-satellite system at the request of former Defense Secretary R.S.McNamara. Known as Program 437, this system was premised on Secretary McNamara's belief that the US "needed assurance that if the Soviets or any one else started playing around with our satellites we should have the ability to do likewise." (13)

A similar position was presented by Secretary of the Air Force Zuckert in 1961, both in the specific context of the SAINT program, and in support of obtaining authorization for general US military space efforts. (14) However, it was not until well after the initiation of the USSR ASAT testing program in 1968 — in fact, not until 1976-1977 — that this became the overriding rationale for US ASAT proposals.

A third major influence on US decisions in the early 1960s was the symbiotic relationship that existed in the Air Force's position on satellite rendezvous, inspection and destruction and its hopes for a manned space program. Each was used to reinforce the proposals for the other. The Air Force's position for many years was that rendezvous and inspection were necessary before destruction. The position was aided by the inability of ground-based technology at the time to make fine distinctions of satellite configuration, and by the critical assumption that one was looking for a nuclear weapon. (15) On the other hand, when the Air Force in effect terminated its SAINT program in 1962, it was stated that:

> The decision was difficult, Air Force officials concede, because its spokesmen have stressed the need for satellite inspection and rendezvous capability in attempting to arouse public and congressional support for an expanded military space program. (16)

A satellite inspection capability was a preliminary to — and often a proxy for — proposing a satellite destruction capability, because it was politically a safer suggestion. At the same time, it was clearly also intended to stimulate support for Air Force manned military space programs in general. This double argumentation adds some degree of difficulty to the task of clearly identifying the pressures for ASAT development.

2. Orbital Weapons, The USSR Threat, US Concept Studies and Early Negotiations (1962-1963)

There seems little doubt that studies in the US on nuclear bombardment satellites in the 1959-1961 period stimulated our own antisatellite interceptor studies. (17) In fact, the argument that satellite interceptors could destroy an orbiting bomb platform was one of the early arguments (though not the most instrumental one) used against proposals for developing nuclear-armed bombardment satellites. The major argument and the position of the US Department of Defense, particularly the Director, Defense Research and Engineering (DDR&E) under Harold Brown and the Office of Systems Analysis (DOD/OSA) however, was that orbital nuclear weapons were far less attractive than ordinary ICBMs. They were more expensive, their accuracy was very much poorer, their reliability would be lower, and there were command-and-control and safety problems. Nevertheless, removing them from active consideration for development by the US required interagency debate and a presidential action, though the resolution was achieved with relative simplicity when compared to such arms control issues as a comprehensive nuclear test ban, the ABM Treaty, or SALT I and II. Prados writes:

> "In July (1962) President Kennedy ordered more detailed examination of a space weapons ban. This was still opposed by the Joint Chiefs and the Pentagon along with the CIA..." (18)

Raymond Garthoff has recently written the first detailed rendition of the episode, and supplies further detail:

> The Defense, JCS, NRO and CIA members opposed a separate ban, ... ('separate' meant not as part of the pie-in-the-sky General and Complete Disarmament — GCD — package) ... in at least one instance (the JCS) because of a belief that the United States should keep open the option of such deployment...
> The JCS opposed <u>any</u> separate space weapons agreement: The United States itself <u>could</u> not accept inspection, and should not agree to an uninspected ban: hence we should only support arms control in space in the context of a General and Complete Disarmament (GCD) package. Defense (ISA) supported a <u>private</u> informal agreement with the USSR, but a formal agreement only <u>in the</u> GCD context, and further preferred unilateral statements of US policy, such as Gilpatric's speech of September 5 " (20)

The intervention and decision of President Kennedy led to a non-treaty action in the United Nations, discussed below, and to a separate treaty several years later. There was, however, some persistent support at least for a while for the weapons in the Air Force. At the FY 1964 DOD Authorization Hearings, Secretary McNamara indicated that DOD was still studying the use of nuclear weapons in orbit, "... and should we find any situation in which there does appear to be a military advantage in having a warhead in space, we want to have the capability to put one quickly in space. That we are working on." (20)

The US studies undoubtedly stimulated the presumption in US planning that the USSR was going to deploy such systems, or at least permitted the use of the argument in requesting programs to counter their potential capability. In a similar way, US studies on concepts for orbital or space bombers, Dyna-Soar, etc., very likely also fed the same presumptions, and hence the requests for space inspection and ASAT capabilities. Soviet launch vehicles were assumed to have the payload capabilities to place the appropriate systems in orbit, and they had demonstrated the technology of ejecting a second vehicle from a satellite in parking orbit in the early Venus probes. It was also possible to refer to both USSR threats and claims in regard to orbital weapons. A Soviet General Pokrovsky "... had mentioned the possibility of bombardment satellites in an article...", written in 1956, just before the launching of Sputnik I. (21) Other Soviet statements, some by Premier Khrushchev, in the 1960-1962 period threatened the possibility of bombardment satellites. One statement in February 1963 by a senior USSR military official even claimed their existence. (22)

Another suggestion was that an orbiting satellite could contain a very high-yield weapon which could be detonated in space, in low orbit, and do substantial damage to the earth below. The potential for such devices was often attributed to the USSR because of their very high-yield nuclear weapon tests. It is not clear from open sources to what degree concept studies of this last idea were carried out in the US as well, but the estimates prevalent around 1960 indicate the damage potential of such a device were apparently inaccurate, and were publicly corrected in 1963 by an Assistant Secretary of Defense. (13)

US-USSR Negotiations in 1963: UN Resolution 1884 on Nuclear Weapons in Orbit

Between 1957 and 1965 most of the US discussion of a satellite rendezvous, inspection and destruction capability was in terms of the possible deployment of orbital nuclear weapons by the USSR. Any agreement between the US and the USSR on this point should therefore have had some effect on US decisions on ASAT requirements.

In September 1962, in the course of the US decision process described above, US Deputy Secretary of Defense Roswell Gilpatric in an authoritative statement said that the US had no program to place any weapons of mass destruction in orbit. A US commitment to such a program would be a stimulus to the USSR to do likewise and would not contribute to US security. Nevertheless, he stated, the US would take whatever steps it felt necessary to defend itself and its allies. (24) A shorter statement to the same effect was made to the UN by Senator Gore on December 3, 1962. (25) On September 19, 1963, Soviet Foreign Minister Gromyko announced in speaking to the UN General Assembly that the USSR "... deems it necessary to reach agreement with the United States Government to ban the placing into orbit of objects with nuclear weapons on board." (26) At that time, a few months after the signing of the Limited Test Ban Treaty, the USSR indicated that it was willing to negotiate separately on this issue as well. President Kennedy quickly acknowledged the new USSR offer while also addressing the UN on the following day. (27) Agreement was rapidly reached on a verbal ban and, as the US had already done, the USSR expressed its intention not to station weapons of mass destruction in orbit. UN Resolution No. 1884 incorporating their two separate declarations was unanimously endorsed by the General Assembly on October 17, 1963. The resolution made no provision for any inspection necessary to confirm the adherence to the commitment.

However, in a press conference some two weeks later, on October 9, 1963, President Kennedy stated that this was "not an agreement". (28) He stated that the US would not place nuclear weapons in orbit, regardless of what the USSR would do. At the same time, in the absence of means for verifying compliance with this declatory policy, President Kennedy indicated that the United States would "... obviously have to take (its) own precautions." The decision to construct the two US ground-launched direct ascent ASAT systems, the Air Force Thor (program 437) and the Army Nike-Zeus (program 505), had by then already been taken, and would have had to be revoked.

> The weapons' existence has been disclosed to key members of Congress to allay fears about hostile bombs in orbit... The President pulled back part of the secrecy veil over U.S. anti-satellite activity while urging that all nations agree to ban nuclear weapons from space. (29)

There had been suggestions after the October 3 communiqué that the issue might be covered by a bilateral US-USSR statement, or by simultaneous declarations in Moscow and Washington. However, the US administration decided that it did not want to make any arms control agreements, even short of treaties, that did not contain verification provisions. It was thought that making any agreement not subject to verification would set a bad precedent for other arms control and disarmament negotiations. (30) At his October 1964 announcement of the US deployment of the Program 505 and 437 direct-ascent ASATs in the Pacific, Secretary of Defense McNamara stated that the US was "satisfied we have information to establish the hostile nature of a satellite."

There were also no verification provisions included when the substance of the 1963 UN resolution became part of the Outer Space Treaty several years later. The same position, that the US could determine the nature of a hostile satellite, was taken by the Secretaries of Defense and State at the Senate Hearings on ratification of the 1967 Outer Space Treaty. The Joint Chiefs of Staff limited themselves to expressing a mild wish for further inspection capability as a safeguard. (31) The treaty was signed in January 1967, and entered into force on October 10, 1967.

It is not known whether — or to what degree — these two arms control events in 1963 and in 1967 affected US ASAT programs. The US direct-ascent systems were at times subsequently referred to as a safeguard against USSR violation of the UN resolution, but the decision to deploy them had certainly been made previously. It is not known whether the UN resolution provided any more support to the Office of the Secretary of Defense beyond that which its own analyses already afforded, as to whether USSR orbital weapons were likely, or the feasibility of various US Air Force ASAT proposals, manned or unmanned, or on the pace of US ASAT-related R&D subsequent to the UN resolution. The last US direct-ascent systems (Program 437 Thor missiles) were deactivated in 1975. The FY 1980 Arms Control Impact Statement on Space Defense carried the following comment:

> The Johnston Island system was initially a response to Soviet threats to deploy orbital weapons of mass destruction. The system was deactivated because this threat was never deployed (and the Outer Space Treaty prohibited its employment), and because a low altitude (deleted) + would probably damage US satellites (deleted) as well as the targeted Soviet Satellite. (32)

+ The first deleted phrase is in all likelihood "nuclear explosion".

3. US Antisatellite Programs +

The first test of any US antisatellite device took place on October 13, 1959, as part of a program called Bold Orion. A developmental Air Launched Ballistic Missile (ALBM) was fired from a B-47 aircraft at the Explorer VI satellite and apparently came within four miles of its target, but it is uncertain if there were any subsequent tests. In November-December 1960, after three years of preliminary studies the more ambitious Satellite Interceptor (SAINT) project was approved. The projected cost for four "target" satellites and four Intercept-inspector satellites was $56 million. A more or less direct-intercept technique was envisioned to take place at the target's second pass. The intercept satellite was to have an array of sensors including radiation sensors for inspection, to approach the satellite to within 50 feet, and to have the ability to change its orbit. Later operational versions were expected to include a kill-capability. This Air Force program was to be overseen by the Advanced Research Projects Agency (ARPA) of the Dept. of Defense. Ballistic Missile Defense (BMD) was the executive agency, and the new Aerospace Corporation was given technical responsibility for SAINT as its first major program. Feasibility demonstration was scheduled under conditions offering the greatest chance of success; no orbital change was required even though it would be necessary in an operational version.

The Air Force also proposed and studied mechanisms to destroy or intervene with satellites. It funded studies for nuclear kill-mechanisms and obtained DOD funding as early as 1962 for a satellite-borne laser to disable infrared or optical sensors on other satellites. In June 1962, the USAF proposed a new set of studies, in addition to similar ones being carried out in the larger Dyna-Soar vehicle program, for designs, missions and sensors for a "Manned Saint", a manned satellite inspector. It was "to be able to destroy potentially hostile satellites, and defend itself and unarmed American satellites" in addition to the inspection mission. All through 1962, Air Force officials emphasized that the highest priority in the military space program should be given to a capability to inspect — and destroy if necess-

---

\+ The references for this section — except for those for the most recent events — are being omitted due to their very large number. In conjunction with this section also, see the list of major decision points or study inputs to them for US antisatellite programs summarized in Table I, pgs. 67-70 ary — hostile satellites. The Air Force exerted a constant pressure to accelerate programs and to have DOD accept new ones, mostly involving manned military space vehicles, programs that DOD consistently rejected on the grounds that the proposals did not have a "demonstrated military requirement".

The other services were not remiss in offering satellite-intercept plans, but both the Army and the Navy proposals involved direct-ascent intercept techniques. The Army suggested the Nike-Zeus and the Navy first the Sea Scout and then, in a 1960 proposal called "Early Spring", the Polaris missile. The Polaris variant was to have terminal guidance and to home on its satellite target after being launched into its pathway. The Navy also carried out two tests of launching a space vehicle from an F-4 aircraft in 1962 in its "Hi-Hoe" program, whose secondary purpose was to test the use of an aircraft as an antisatellite launching platform.

In May 1962 Secretary McNamara and DDR&E Brown approved the Army's Nike-Zeus missile as the first US direct-ascent ASAT development program, designated Program 505. The missile carried out its first successful intercept test a year later, in May 1963. One month after that, in June 1963, DOD approved the development of the second direct-ascent system, the Air Force Thor missiles, designated Program 437. This provided a capability to reach satellites at somewhat higher altitudes, perhaps 400 miles, compared to the more limited Zeus altitude capability of 100-150 miles. The Army's missiles were established at Kwajalien Island in the Pacific. Both missiles were to use a warhead of somewhat less than one megaton, and the nuclear warhead was tested. In 1962 as part of another unrelated research program the United States had detonated a 4 megaton nuclear explosion an an altitude of several hundred kilometers over the Pacific Ocean. This test, known as Starfish, destroyed several satellites, some belonging to the United States, and some to the USSR. (33)

In December 1962, the Air Force "reoriented" the SAINT program. The project had run into technological problems and had spent over $100 million, several times the amount of funds that had been publicly reported at the time. The test flights were cancelled but SAINT was to continue as a stretched-out program. The ultimate effect was to end the program. If SAINT's purpose were only to demonstrate rendezvous, it was redundant since the NASA-DOD Gemini program would demonstrate the basic rendezvous techniques before the first

SAINT test. In addition, the program had undergone a series of changes in its goals, and NORAD, The North American Air Defence Command in the Air Force, which would have operated satellite inspectors had they become operational, was critical of the program, including its basic concept. If the US intended to launch a satellite inspector every time the USSR placed an object, or even a category of objects, in orbit, NORAD held that any opponent could bankrupt the system by deploying a large number of inexpensive decoys. NORAD also criticized the program because the satellite inspector carried no means to "neutralize" a satellite once it identified it. Furthermore, reliability studies done by the Aerospace Corporation for the four proposed flights indicated very low chances of successful rendezvous. Aerospace Corporation then recommended that contract funding be increased to increase the chances of success. The US Air Force suggested that the satellite's test equipment might be transferred to the Dyna-Soar program, since satellite rendezvous, inspection, and destruction had also been one of the missions under study in 1960-1961 during the "Step 2B" phase of the Dyna-Soar program. That proposal was rejected after some study, which led to the final decision to curtail the program.

The Space Systems Division of the Air Force Systems Command then transferred its hopes for a satellite-inspector program to the Blue Gemini program: "Rendezvous and inspection will be achieved to some degree in the Blue Gemini program. This program differs from the basic Gemini mission in that it will be designed to approach, capture and disable an uncooperative satellite." In addition, the Titan III's Transtage, which could be attached to a Gemini capsule, provided the space maneuverability thought necessary for the rendezvous and inspection of other satellites, particularly any that could themselves evade. Nevertheless, the Space Systems Division gave the designation "Program 706" to a reoriented SAINT program.

The position of the Office of the Secretary of Defense was that there was no positive military threat from hostile satellites. Nevertheless, in January 1963 the USAF Systems Command announced that it still saw satellite rendezvous and inspection, space station development and communications satellites as the three "space programs of prime military necessity". When the Secretary of Defense omitted both the Blue Gemini program and the Manned Orbital Development Station (MODS) from the FY 1964 DOD budget request, the Air Force continued its planning, hoping subsequently to combine the two programs. It was at this same time that Secretary McNamara and DDR&E Brown indicated that they had sent the Dyna-Soar program back to the Air Force for review. At the FY 1964 (i.e. around January 1963) hearings, McNamara refused to state any judgment until the Air Force review studies were completed, but he said that he felt that NASA's Gemini program would demonstrate Dyna-Soar's objectives several years before Dyna-Soar was scheduled to fly, and that the budget could not support both programs. One or the other would have to be chosen. Some two weeks before testifying, Secretary McNamara instituted an agreement with NASA on his own initiative for greater DOD participation in the Gemini program.

In April 1963, Secretary McNamara rejected a new series of Air Force proposals for manned space programs that he found "outlandish", and the Air Force response was described in the aerospace press as "the mood... of a service approaching a fight for its existence." In July 1963, there were indications that DOD would agree to at least one manned space R&D program to test what man could do in space. The Air Force still divided its space interests into two groups, satellite programs that enhanced military capabilities, and the development of "a military patrol capability for the protection of US interests in space." The Air Force now unified its efforts towards the second goal in proposals for an orbiting space station. In the meantime, the revised SAINT, Program 706, was to continue. It was becoming clear that development of an operational on-board radar guidance package for such intercept vehicles was quite expensive and would be cancelled. In October 1963 DDR&E Harold Brown made a public address which indicated that for a given booster surface-launched intercept vehicles would have greater accuracy and payload than would space-based systems. He also indicated that a considerable amount of the identification mission could be done from the ground at much less cost. In May 1964, the Program 437 Thor direct-ascent system made its first successful satellite intercept test, and both direct-ascent systems were apparently considered operational soon after. On September 17, 1964, as part of a presidentical campaign speech, President Johnson announced the existence of the two systems, and Secretary McNamara provided some further detils the next day. Each missile had had at least two successful tests, both required a nuclear warhead to kill, and both were situated on Pacific islands over which USSR satellites would pass within a few orbits of being launched. The number of missiles in each program was small, perhaps no more than half a dozen. In later years, it became known that there were actually only two launch pads at the Johnston Island-Thor missile facility (34) and the missiles had a relatively low-altitude intercept capability. The Army's Nike-Zeus missile had even a lower altitude capability and was decommissioned by 1968, and might therefore be considered somewhat of a stop-gap or even a token deployment. However, though "these would not have met all possible needs, ... over the course of some days (they could have intercepted most satellites in sustained low orbit. " (35) (This assumes of course that the facilities survived attack themselves, either by nuclear or conventional weapons.) Secretary McNamara stated that the hostile nature of a satellite to be intercepted could be established. The cost of the program had been $80 million. An R&D program to develop a non-nuclear warhead for the Thors was underway and the Navy's Early Spring proposals were also reactivated, with the inclusion of a non-nuclear warhead that would spread a screen of metal pellets in the path of a satellite. These various R&D programs were continued into the 1970's at very low levels of expenditure.

USAF Systems Command again began in-house studies into methods of "intercepting, capturing and recovering passive non-cooperating satellites." The Air Force may have been heartened by the deployment of some ASAT capability of any sort, and the presumption that this would make follow-on systems likely, perhaps even ones based on different technology. Alternatively, it may have been a last-ditch attempt to introduce manned systems into the mission. The USAF Titan 3 Integrate-Transfer-Launch (ITL) facilities that had been built at Cape Kennedy, were still in operation. They had been designed on the assumption derived from Project Phoenix studies of 1960-1961 "that US military crews eventually would be required to fly into space frequently and on short notice to intercept, examine, and possibly destroy hostile space vehicles", and represented sunk costs that the USAF could apply to any relevant development program for which it could obtain approval.

The last Air Force avenue to a manned satellite inspection role was through the Manned Orbiting Laboratory, MOL (although satellite inspection was not among its main stated objectives). The political pressures for the MOL were very great.

> One suspects that the motivation for continuing MOL at all would be political: to prevent an "uprising" by the Air Force and its supporters — similar to the "revolt of the Admirals" over the B-36 — if the MOL were cancelled and the Air Force's desire to obtain control over a real manned military space station were frustrated once again by the Secretary of Defense.
> .....

> The MOL program, which is apt to involve development of extensive orbital maneuvering capability, either by the entire vehicle or by the Gemini capsule, or by a remote maneuvering unit, is expected to provide the major realistic assessment of whether or not orbital inspection and interception schemes are indeed feasible.

there is little question but that MOL — which would itself be cancelled by June 1969 — absorbed the manned satellite inspection mission.

As early as 1965, Arthur Kantrowitz, director of the Avco Corporation, made the first proposals for use of particle beam weapons for satellite defense. The first indications of DOD work on "satellite survivability" and defense measures for satellites appeared in 1966. Work on an attack sensor, on decoys, and on Electronic Counter Measures (ECM) to protect US satellites were all under contract. Conceptual studies continued on ground-based antisatellite weapons and on orbital antisatellite weapons, and the Army was asked to study the antisatellite capability of the Nike-X ABM system (later Spartan) should it be deployed. Soviet FOBs (Fractional Orbit Bombardment) tests began in November 1966 and by October 1967 they had produced sufficient pressure for the Office of the Secretary of Defense to accede to the requests of the Joint Chiefs to add another mission to the Nike-X ABM system, to contain a capability to intercept any de-orbiting satellite vehicle. Nevertheless, "the decision to deploy a "thin" Nike-X (did) not change the Air Force's position that an operational antisatellite system is still required."

In 1967, the Army's Program 505 ASAT missiles in the Pacific were deactivated. The system had been tested on at least eight occasions between May 1963 and its deactivation. The Program 437 Thor missiles were tested on sixteen occasions between May 1964 and 1970. (36) None of these tests involved a nuclear warhead detonation. In 1974, it was reported that "on occasions in recent years, US satellites have been damaged by nuclear testing in the atmosphere." (37) These were presumably Chinese atmospheric nuclear weapon tests which had inadvertently provided the US with data on the vulnerability of satellites to various weapon effects. The Navy's Polaris-related direct-ascent Early Spring and Skipper R&D programs were apparently still in development, and Program 922, the designation for the follow-on for the Air Force's Thor missiles, was in Advanced Development. Program 706 (SAINT) had been dropped at the end of 1965. Apparently referring to Program 922, Secretary McNamara told Congress in January 1968 that "we are exploring the development of a non-nuclear surveillance or destruction capability against hostile satellites." The warhead concept for Program 922 was for a conventional munition, similar to the Navy's, and it was to be provided with infrared terminal homing. There was by this time apparently also highly classified work on antisatellite satellites involving incapacitation of hostile satellites by laser energy, and some suggestion that because of such work, DOD thinking was beginning to shift to the possibility of replacing ground-based systems by satellites. In 1968/69 the Dept. of Defense projected the retention of the Program 437 Thor missiles for the coming five years.

> As described in previous years, we have a capability to intercept and destroy hostile satellites within certain ranges. The capability will be maintained throughout the program period. (38)

The first USSR ASAT test series began in October 1968, and consisted of seven tests running until December 1971. US response was noticably restrained and modest, and there was little or no official comment on the USSR tests. One apparent early internal response seems to have been the funding of USAF studies on the use of space-based laser radiation to destroy or damage targets in space. Program 922 reportedly had two unsuccessful test launches in 1971, though it has not been possible to confirm these. Studies were accelerated for equipping early warning and communications satellites at synchronous orbit altitudes with proximity warning sensors and impact sensors. In 1972, the Air Force once again initiated studies for unmanned satellites capable of intercepting, inspecting, and destroying hostile satellites. A detection sensor for nuclear weapons had already been developed in previous studies, and an infrared homing sensor as part of Program 922. DDR&E John Foster testified that "... we in the Department of Defense are not very clear in our own minds about what we ought to do. We have looked at this matter for a number of years. It has never been clear that we ought to go out and develop a system that would costs hundreds of millions of dollars... We are now in the process of thoroughly reworking this whole basic question." (39) Foster referred to the Soviet ASAT tests, the increasing use of reconnaissance satellites for tactical purposes, and the growing dependence on satellites in the future as factors that might change DOD perceptions. New improvements for satellite surveillance systems were sought, and the notion that some of these might be space-based made its re-appearance. R&D on satellite survivability increased, including hardening of solar cell arrays against nuclear radiation. R&D also began on warning devices that would warn military satellites that they were being illuminated by ground-based radar or laser tracking sensors. +

By 1973-1975, in the period between the first and second USSR test series, the core of the passive defensive measures included in the US satellite survivability R&D program were evident. All the items in the following list represented active US R&D programs in the middle 1970's and some, items in procurement:

- sensors to detect an approaching satellite, and to initiate evasive maneuvers;
- sensors to detect and report an impact, or illumination by laser;
- decoys to confuse attacking satellites;
- jam proofing of communications satellites, utilizing ECM;
- laser reflective coatings for satellites, and other devices to prevent laser damage;
- hardening of solar cell arrays against nuclear radiation;
- replacement of solar cell arrays with satellite nuclear power sources;
- replacement of infrared horizon sensors that provide satellite stabilization and attitude control but which are also vulnerable to nuclear effects and to lasers, by satellite gyroscopes;
- development of computer software for a satellite attack warning system for the NORAD control center;
- improved capability for the Spadats satellite detection and tracking system, to altitudes of 23,000 nm. and with spaceborne Long Wave Infrared (LWIR) optical sensors.

New US space satellite programs in their planning stages during 1973-1974 were required to incorporate appropriate survivability measures as design specifications. More recently, hardening the small number of ground-based US satellite launching facilities and the USAF Satellite Control Center at Sunnyvale, California, against nuclear attack has become an important addition to this program.

In 1975, the US however removed from operational status, its remaining ground-based and minimal direct-ascent ASAT system the Air Force's

----

+ The US itself had a program dating from 1965 at the Cloudcroft, New Mexico, facility in which USSR photo-reconnaissance satellites could be illuminated by laser instrumentation to determine the nature of the satellite's optics. The USSR presumably developed similar instrumentation not long after. The process produces a visible effect on the reconnaissance satellite's film, but apparently does not interfere with the satellite in any other way, and is accepted by both nations.

Program 437 Thor missiles. This was several years after the end of the first USSR test series, and before the start of the second, but during a period when Soviet ground tests of portions of its ASAT test system were reportedly observable. It is interesting to speculate whether this move on the part of the US was a direct and tacit suggestion to the USSR that it forego any further ASAT testing. During 1979, there were references in administration testimony on the SALT negotiations, both in public but more particularly in private, that several gestures of unilateral restraint on the part of the US had not been met by the USSR with parallel restraints. It is possible that the dismantling of the US direct-ascent ASAT missile launchers in the Pacific in 1974 was one of these.

At the same time, R&D was again undertaken on conventional kill-mechanisms with terminal guidance for direct-ascent systems. The technology selected was apparently an adaptation of designs developed in the US ABM R&D program. What would appear in 1984 as the Prototype Miniature Air Launched System (PMALS) was thus begun in the early 1970's with full-scale development initiated in 1977 (40). It had been felt that a nuclear warhead — with which the Thor missiles had been armed — would be used only in case of an all-out nuclear war. Therefore, efforts were again begun in 1974-1975 on developing a non-nuclear warhead for ASAT use. These R&D efforts did not, however, become publicly known until 1977, a year after the initiation of the second USSR test series. In 1975, DDR&E Malcolm Currie offered the assessment that "over the next ten or fifteen years, space is not going to remain the unmolested territory, the sanctuary, that it is today. This issue must be addressed explicitly... The question of warfare in space... inevitably will arise."

The USSR resumed its satellite intercept tests in February 1976. At least through the end of 1976 DOD response in public was again low key, perhaps because a substantial number of the tests were failures: "... there seems to be uncertainty as to the success of the Soviet tests and its ultimate aims. 'We're not pushing the panic button' says one Pentagon official, 'but we're not shrugging them off either.' (42) Satellite survivability R&D received increased funding, and it was reported that a substantial portion of ARPA's high-energy laser research in recent years had been "redirected towards outer-space applications — largely against other satellites." At the Congressional Hearings early in 1976 (for FY 1977) ARPA's director reported on the research program focusing on hydrogen-flouride lasers for possible spaceborne defense.

At the policy level, however, things were apparently somewhat less relaxed. A classified report from Malcolm Currie to Congress in January 1977 on both the USSR and US antisatellite programs stated that the new US ASAT program was intended to make its first tests in 1980 and be operational in 1982. (42) This was apparently the Vought Corporation homing intercept technology warhead, described in detail in information released in February 1978. It was also reported that one of the several important end-of-term decisions made by the outgoing Ford administration's National Security Council was to permit the Air Force to release requests for proposal for the new ground-launched direct-ascent anti-satellite system. (43) This was a decision to initiate system development of the R&D work that had been in process since 1974-1975, and, from subsequent budgetary indications, it may have been a decision sharply to accelerate and expand the project. The decision was apparently accepted by the incoming Carter administration. On October 4, 1977, Secretary of Defense Brown made the statement that the USSR — despite its recent series of test failures — "had developed the operational capability to destroy some American satellites in space." (44) In his FY 1979 report to Congress he said:

> The Space Defense program attempts to deal comprehensively with the threats posed by Soviet satellites and anti-satellite systems. The program is a balance between near-term procurement, advanced development and basic R&D. Last year our commitment to this effort was increased significantly.
>
> The reasons for a comprehensive program are two-fold. On the one hand, we credit the Soviet Union with having an operational and anti-satellite interceptor that could be intended for use against some of our critical satellite systems. Not only are they improving their orbital ASAT interceptor, they are also engaged in other programs, including activities which appear to be ASAT related. We estimate that in the absence of an agreement effectively limiting their efforts, their ASAT capability will be substantially improved by the mid-1980's. On the other hand, we see the Soviets making increased use of satellites for tactical purposes that could include the targeting of U.S. ships. Their satellites represent a unique threat in the broad ocean areas where the Soviets lack alternative surveillance assets. In sum, it now seems possible that activities in space could become more competitive, and that we might have to take steps to deter attacks on our satellites, to deal with attacks should they occur, and to have the capability to destroy Soviet satellites if necessary. As the President has clearly stated, it would be preferable for both sides to join in on an effective, and adequately verifiable ban on anti-satellite (ASAT) systems; we certainly have no desire to engage in a space weapons race. However, the Soviets with their present capability are leaving us with little choice. Because of our growing dependence on space systems, we can hardly permit them to have a dominant position in the ASAT realm. (45)

The statements on Department of Defense Activities in Space and Aeronautics for FY 1977 and FY 1978 contained the statement: "Our space defense R&D efforts are organized into the categories of space surveillance and satellite systems survivability". The same statement for FY 1979, with a public release date of March 8, 1978, added a third program to the same statement: "... and our Anti-Satellite Program." (46)

The US Presidential Decision Memorandum on US space activities, released on June 20, 1978, set the following policy position:

> The United States finds itself under increasing pressure to field an anti-satellite capability of its own in response to Soviet activities in this area. By exercising mutual restraint, the United States and the Soviet Union have an opportunity at this early juncture to stop an unhealthy arms competition in space before the competition develops a momentum of its own. The two countries have commenced bilateral discussions on limiting certain activities directed against space objects, which we anticipate will be consistent with the overall U.S. goal of maintaining any nation's right of passage through and operations in space without interference.
> While the United States seeks verifiable, comprehensive limits on anti-satellite capabilities and use, in the absence of such an agreement, the United States will vigorously pursue development of its own capabilities. The U.S. space defense program shall include an integrated attack warning, notification, verification, and contingency reaction capability which can effectively detect and react to threats to U.S. space systems. (47)

Eight months later, the Presidential Decision Memorandum was described in US Senate testimony by a Dept. of Defense official as "This was the key point in our program... Up to this point in time we did not have a very vigorous anti-satellite program". (48) The actual decision, however, would appear to have been taken at the end of 1977, and even this does not take into account the Currie report at the end of the previous administration, in January 1977. In a sense the Carter administration had reaffirmed the decision of the Ford administration, after a more thorough review. The timing is quite interesting, as we will see in a later section of this study that the Carter administration had proposed ASAT negotiations with the USSR early in 1977, and may only have made these decisions when progress seemed lacking.

US ASAT R&D programs were broadened and accelerated. (49) They reportedly fell into several separate groupings:

- the terminally guided metal cannisters of the Vought homing intercept technology;
- a new nuclear warhead;
- laser radiation.

In addition, other destructive mechanisms, involving pellets or other materials were also under investigation. The working concepts at the time reportedly were that the antisatellite missile would be launched either from ground-based launchers or from F-15 aircraft, which could theoretically give the US an antisatellite capability wherever F-15 aircraft are deployed. The US tests would be aimed at actually destroying their target vehicles, which USSR tests did not do. In June 1979, the Air Force granted contracts for ASAT test targets and a presidential decision on the first flight tests was expected as early as April 1980. President Carter took an important step in making the decision that the US could in fact test antisatellite weapons, since US policy prior to that decision reportedly was that there should be no testing of ASAT weapons. (50) This seems somewhat puzzling in view of the proposals and decisions made earlier by the Ford administration, but presumably final Presidential approval would only come at an appropriate later stage in the development program, particularly as ASAT negotiations were concurrently in progress with the USSR. These negotiations were, however, broken off in January 1980, and in March 1980 the Dept. of Defense secretly informed the Congressional Armed Service Committee that Presidential approval had been given for ASAT testing. It was stated hopefully that these could take place in Fiscal Year 1982. The information was rapidly compromised, and whether this, or the breakdown in negotiations, the failure of SALT, or other factors contributed to the Soviet decision to resume its ASAT testing program is not known, but the USSR resumed ASAT tests on April 18, 1980, after a moratorium of two years.

It is interesting that when US defense planners sought the most feasible plan for a rapid ASAT development and development effort in the 1976-1978 period, they once again chose a direct-ascent intercept vehicle, rather than a satellite that enters an earth orbit to rendezvous with its target, as the USSR ASAT systems do. Thus, they made technological choices similar to those made roughly 15 years earlier, in 1963-1964, although this time with the addition of making the direct-ascent vehicle air launchable.

In addition to direct antisatellite R&D, other areas of R&D and procurement related to "Space Defense" continued, such as the several programs related to satellite survivability and the upgrading of the satellite tracking and identification systems. All of these systems, but primarily the US ASAT developments, received some attention in the administration's Arms Control Impact Statements. (51) However, the ASAT statements were probably the most heavily deleted ones in the entire volumes and were noteworthy for their ambiguity. There was much emphasis on the "bargaining chip" notion that US programs might provide the USSR with an incentive to negotiate a settlement and cease their own programs and testing. The assessments did not recommend any hesitation in the programs, and subsequent statements prepared by the Congressional Research Service did not comment on them. (52)

The Five Years Defense Guidance prepared by the Reagan administration in 1982 and partially disclosed in the public press apparently envisioned "space based" fighting with antisatellite weapons. (53) (There was apparently even mention of nuclear weapons in space.) In this expectation the administration therefore planned to obtain an operational ASAT system by 1987, and to avoid any international agreement that would limit the possibility of obtaining such a system.

In harmony with the tenor of the Reagan administration there were again heard proposals for a manned military "command center" in space (54), and the evaluation by the Air Force of the conceptual design of a Maneuvering Reentry Research Vehicle (55). There was also a return to the bravura phrasing of "space control" reminiscent of the late 1950's by senior Air Force advocates of military space operations, for example a remark by the Deputy Chief of Staff of the newly formed Space Command:

> "If this nation is able to control space in the future, then there is no doubt in any mind that we are going to be able to control events on earth.... I know of no better way to ensure peace on earth for the next fifty years, hundred years, for as long as you want it, if the free world will take control of the space environment." (56)

At the same time the Space Command was described as having responsibility for the "Satellite negation function", providing a new euphemism for ASAT operations (57). The first US ASAT test — an attempt to direct the missile to a point in space rather than to destroy a target — was expected to take place in late 1983 or early 1984.* Plans call for the procurement of 112 ASAT missiles by 1987, 28 modified F-15 aircraft and 56 missiles would be based on the US East coast, in Virginia, and a second group of aircraft on the West coast, in Washington state. The F-15 aircraft could theoretically be deployed to any other US Air Force base worldwide that can service the F-15. The Air Force has projected a cost of $3.6 billion for the system, while a classified report of the US General Accounting Office to Congress has reportedly predicted that the cost could rise to $15 billion or more, or as described in another report "tens of billions of dollars". (58)

It is difficult to arrive at a firm figure of how much the US has spent on ASATs and ASAT-related programs since their inception. It is possible to find the phrase "Space Defense" in DOD budget categories back to FY 1961. However, it seems that such category designations have contained different program elements for different years, and are thus not directly comparable. The phrase "Space Defense System" was consistent in meaning at least for fiscal years 1974-1980. "Space Defense" apparently is still not to be understood as a total, overall funding category, but it does include spending for ASAT development programs, as well as all programs such as hardening and satellite survivability that contribute to the defense of one's own satellites as well as space surveillance. ("Space Defense" officially includes "Space Surveillance, Satellite System Survivability, and Anti-Satellite Program".) The funding in all of these categories showed sharp increases in the late 1970s as is indicated in Table 3. (Budgeting for these systems has increased even more since 1980, but those data have not been collected here.)

4. <u>The USSR Antisatellite Test Program, 1968 to the Present</u>

Several useful studies of the USSR ASAT development are available and only a short synopsis is presented here to support the discussion of the relevance of the USSR program to subsequent US decisions. (59) Little or nothing can be said about the earliest R&D phases on the USSR side — at least from the open literature — and even less about its planning and decision elements. It has been suggested that the USSR began its planning for satellite programs in the years 1953-1954, while comparable planning in the US did not take place until 1957-1958. (60) However, in a situation similar to ICBM development, US military satellite programs developed at a more rapid rate than those of the USSR in the early 1960s, once they were begun. The USSR certainly established a satellite surveillance system, and some of its radar systems as well as an optical observation program contributed to this capability. (61)

As was indicated in an opening section of the paper, early statements from important USSR officials referred to space weapon threats, discussed relevant US programs and USSR perceptions of them, or made threats of their own. The important 1963 USSR volume by Marshall Sokolovskii, <u>Soviet Military Strategy,</u> has an extensive discussion of proposed US "space defense" programs, anticipated "space weapons" — including <u>US</u> orbital nuclear weapon delivery — antisatellite weapons, and estimated US satellite launches under these programs through 1975. (62) His claim that

> "American military leaders continue to take significant measures for antimissile and antisatellite defense, from the viewpoint that the side which first develops a defense against missiles and space weapons can threaten war or even initiate it without fear of strong retaliatory blow,"

is an exact mirror image of the statements of those in the US who called for the development of US ASAT systems. (63) In February 1963, USSR Defense Minister Malinovsky announced that the defense forces had been assigned the task of "combating... an aggressor's ... attempt to reconnaitre our country... from space", and in 1964 a special "anti-space" unit of PVO Strany, the air-defense branch, was established and was designated the Protivo-Kosmicheskaya Oborone, or PKO. (64) This would imply an operational unit, though there are no public sources which indicate operational USSR tests or capability at the time. (It was not until Sept. 1982 — some eighteen years later — that a Space Command was established by the US Air Force.) There are several possibilities as to what the operational responsibilities of the PKO division may have been in 1964:

- to oversee the design of the orbital rendezvous ASAT systems that the USSR would begin testing in 1968;
- to develop analogues to the US Program 505 and 437 direct-ascent systems using portions of the USSR ABM system. Though such USSR systems were apparently never tested, such a possibility was always assumed by the US Dept. of Defense and the US Air Force at the time;
- to assume control of the military manned space program of the USSR which began space system launches in the Soyuz program in 1967 and which has continued ever since.

The PKO and its work were briefly referred to in several other USSR publications in 1965 and 1966. (65)

The US aerospace literature was quick to note those aspects of the Soviet space program, manned and unmanned, that had military significance: the first USSR satellites that showed some maneuverability in space; the Polet, or Polyot, satellites in 1963 ; co-planar rendezvous; any suggestion of cross-course intercept techniques with manned vehicles; launching or ejection of a second vehicle from a satellite in parking orbit, such as in the early USSR Venus probes; long-duration manned flights; and extra-vehicular activity. (66) Many of these same space vehicle capabilities were also demonstrated at roughly the same time in the US manned space program, but they are not ordinarily considered when discussing US ASAT development programs per se, or operational capabilities. A major implication of this study is that such early US manned space R&D programs as Dyna-Soar, Blue Gemini, and MOL, most of which were totally abortive or were cancelled at very early stages, may nevertheless have affected USSR decisions over the years to develop its own ASAT programs. There is no way to know if this is so or not, but it seems plausible in view of the degree to which the original conception of these programs were concerned with ASAT roles, which is demonstrated in some detail in the appendixes. If such an assumption is justifiable, then the corresponding manned USSR systems which were not only carried through R&D but have been operational in some form over most of the period since 1968 become perfectly relevant to an assessment as to what the overall conception and nature of the Soviet ASAT program may have been. The USSR's Salyut-Soyuz manned military space flights are, in fact, the analogue to the Blue Gemini-MOL concepts, and these have been available to the USSR on a continuing basis since 1968.

Without evidence and reasoning solely on logical grounds, the Soviet military manned space programs could have been relevant to ASAT considerations even if the US programs had not been. That one has parallel evidence from the US programs simply makes such an assumption that much more plausible. (67)

The USSR ASAT test program proper began in October 1968, if one uses as a criterion the first actual intercept test. (68) Obviously R&D dedicated to the program had to begin at least several years earlier. Seven tests were carried out between October 1968 and December 1971, a period of just over three years. The test program then halted until February 1976, although it is clear from the tests in the second period and from various ground tests that R&D on the system continued between the two periods of space intercept testing. Only the last test in the first group, in December 1971, involved interception of a target below 160 miles, at low reconnaissance altitude levels. Satellite interception increases in difficulty as the altitude of the target decreases. All other intercept tests had been at altitudes ranging between 360 and 550 miles. All USSR tests, as well as those in the later series, were carried out against their own satellite targets. No target vehicle was ever destroyed in a test, though the interceptor vehicle was often destroyed in orbit some time subsequent to the test, by explosion, or programmed to return to the ground for recovery. Though a number of these tests were failures, no US information was provided during this first test series to indicate which tests were assumed to be successful. Success would be judged by the closeness of approach achieved by the two vehicles. The US Air Force considers a Soviet ASAT test a success if the weapon approaches to within five miles of its target. Nor did any statement ever indicate whether certain of the tests should be considered tests of inspection rather than destruction vehicles and, if so, which test might be which, or which interceptors might have both capabilities. The literature on the USSR ASAT testing program quite frequently speaks of "inspection", but no author has ever indicated any evidence as to why the capability is inferred, or what would lead one to assume such a capability. (69) The miss-distances in both the first and the second test series, as well as the absence of any indication of terminal homing, suggested at first that the destruction mechanism might be a nuclear weapon, despite the frequent explosion of the interceptor vehicle in tests. However, in 1983 the US Dept. of Defense disclosed that the Soviet ASAT "... is designed to destroy space targets with a multi-pellet blast." (70)

The second phase of the Soviet test program began in February 1976, and ended on May 19, 1978, only two weeks before ASAT negotiations began with the Carter administration in June 1978. These tests showed more sophistication and variety than the first test series, making it apparent that R&D continued between the two test series. (71) Three target satellites and four interceptors were used in 1976, the same in 1977, and a single interceptor in mid-1978. The USSR test program experimented with four different methods of satellite interception. These are:

- perigee matching, in which the interceptor makes a fast swoop past its target at the perigee (lowest point) of the target's orbit;
- co-orbiting, in which the interceptor approaches more gradually while in a circular orbit similar to its target;
- apogee matching, in which the interceptor by-passes its target at the apogee (highest point) of its own first orbit; and the latest
- "pop-up" mode, first attempted in 1977, in which the interceptor enters an orbit much lower than its target and is then accelerated to target altitude.

During the second test series, official US sources provided information on their estimates of the success and failure rate of the USSR tests. The estimates did not always agree with each other, but indicated a success rate of around 50 percent for eleven to fifteen tests, depending on when the estimate was given. (72)

None of the tests were against maneuvering targets; all targets remained passive. No interceptors attempted to match more than one target. Most of the intercepts took place at altitudes of about 500 km., and all have been at orbital inclinations of between 62^{o} and 66^{o}. All of the USSR intercept missiles are launched from a single site, by a rocket known as the F-LV, an adaptation of the USSR's SS-9 ICBM.

> The most important limitation exhibited in the tests is that it appears to be necessary for the interceptors to be launched at the same orbital inclination... as the target, which limits the chances of intercepting hostile targets once they have been adequately located with respect to Soviet launching sites. (73)

None of the USSR intercept tests were carried out at the orbital inclinations of any US satellite systems (see figure 2; p.79). They were, however, at altitudes of some USSR satellite systems (see figure 3; p.79). The inclinations and altitudes were closest to those used by Chinese satellites, and next close to the orbits and altitudes of the USSR's own satellite programs.

Several hypotheses for this pattern are possible:

- it is the easiest way for the USSR to carry out its tests;
- it is the least provocative way for the USSR to carry out its tests;
- it indicates a primary intention of the system against Chinese satellites;
- it indicates a primary role against any interceptor (presumably US) attempting to intervene with a Soviet satellite by entering the orbits used by USSR military satellites:

Finally, both the SIPRI and the Freedman studies have pointed out that — in addition to the very close matching of the orbital angles and altitudes of the Soviet ASAT tests to those of Chinese satellite launches — the occasions of these tests have — at least until 1979 — matched the Chinese launches, by following them, more frequently and more closely than would be indicated by coincidence.

> Tests of these satellites followed both of the first two Chinese launches in April 1970 and March 1971. There were then no more Chinese launches until 1975, when there were three — in July, November and December. Considerable progress was indicated by the first recovery of a satellite capsule. These launches were followed by the 1976 resumption of tests of the Soviet interceptor satellites, the first since 1971. (74)

Official US spokesmen have never sought to explain the pattern or purpose of the USSR tests, except to indicate that they would threaten various US satellite capabilities. They have never referred to the interpretations of the USSR tests as being aimed at Chinese satellites or meant to defend USSR satellites against interference, and neither of these suggestions have been taken up by any US civilian analyst.

In regard to the US, the Soviet system seems more likely to be intended to deny the US use of its satellite resources during wartime — and hence to be intended for use — rather than to threaten them during any peacetime situation. The USSR has never admitted that it is carrying on a satellite intercept test program — or even that any of the tests in the series have been of that nature — at any time during the past sixteen years of the program, including during the period of ASAT negotiations with the US in 1978-1980. The announcement of the Cosmos flight that was the first of the USSR ASAT tests stated, "The satellites carry scientific equipment to continue research in outer space", and subsequent USSR test announcements usually repeat that the "scientific investigations" of the flight have been completed. (75)

In the second half of the 1970's, the USSR also initiated several space programs about which knowledge is sparse, ambiguous or classified, and that may have dealt all or in part with ASAT roles, or lent themselves to allegations of such a role. In 1976, the USSR began a series of tests of a lifting body vehicle of the type the US had tested in the early 1960's (see Appendix 3;p 96) (76). The appearance of this vehicle is similar to the designs of the cancelled US Dyna-Soar program of the 1960's, and may be the antecedent to a Soviet space-shuttle development. The tests have continued through 1983 (77). In 1980 there were also press reports that "An authoritative intelligence estimate produced by the Carter administration has concluded that the Soviet Union has developed a ground-based laser weapon that could be used to destroy orbiting US satellites." (78) Its power was allegedly sufficient to destroy lower altitude orbiting reconnaissance satellites. In 1981 there was the allegation that the USSR's Cosmos 1,267, a large vehicle which had docked with the Salyut 6 space station, was an "antisatellite battle station in orbit", capable of threatening higher altitude US communications and early-warning satellites. (79) In March 1979 the US Dept of Defense stated that the USSR had "... several efforts under way to improve upon and complement... (its existing) operational capability against our satellites." (80). Whether this referred to any of the preceeding, or to the major identified USSR ASAT program is unknown, but in April 1980 the USSR resumed ASAT testing with a third test series. (81) There have been four tests in this last series as of December 1983, making a total of 20 tests since 1968 (see table 6;p.76).

It has sometimes been questioned whether specific US space or satellite programs contributed to the resumption of USSR ASAT testing in 1976, particularly the US Space Shuttle system or the Navstar system. There seems no satisfactory way to answer this question, though the Navstar systems satellites are located at altitudes not presently reachable by the USSR's ASAT's. The USSR routinely criticizes US developments related to ASAT development programs as being very "dangerous", and it has repeatedly charged that the US Space Shuttle will have ASAT capabilities. (82) The USSR also embellished these charges with claims of the Space Shuttle serving as a "space bomber" to deliver nuclear weapons and as part of a "first strike" capability. (83). The US Dept of Defense has just as regularly denied that the Space Shuttle would be used against Soviet satellites, a position which is uniformly accepted by US arms control specialists.

However, it was recognized for many years that the Shuttle "could be used to test Defense Dept. technology that would be involved in active US anti-satellite systems", and an early mission of the Shuttle was precisely such tests under the Talon Gold laser R&D program. (84) In 1983, the US Dept. of Defense was considering proposals

> "... to use the space shuttle and begin within two years technology demonstrations in orbit for spacebased weaponry to defend US satellites. ... Validator could result in the final phase of flight test in space of a demonstration of a high-energy later or kinetic energy hit-to-hill weapon against spacecraft targets." (85)

Such a test may be years away from realization but these ASAT-related R&D uses of the shuttle do not make it any simpler to deny the USSR charges, and as early as 1978 the US Dept. of Defense was also looking at the vulnerability of the Shuttle to attack by Soviet ASAT's.

Evaluations of the threat involved in the ASAT system represented by the USSR test program demonstrates its limitations:

> Although the orbits of interceptor satellites can reach altitudes of 2,000 km., all interceptions have taken place at altitudes of less than 1,000 km. Current American reconnaissance, electronic intelligence, meteorological, ocean surveillance and Transit navigation satellites are thus all threatened by the Soviet system. The time between the launch of the interceptor and the interception is very short (1-2 hours). Because the number of American satellites normally operational for these purposes at any one time is usually small (15) the number of interceptors needed is not great...
>
> There are, however, important limitations to the Soviet ASAT system. It is still impossible to reach the NavStar GPS satellites, which will orbit at 20,000 km, or the US communications and early-warning satellites, which are in geostationary orbit at 36,000 km. The interceptors cannot change their orbital plane and therefore can only be launched when the launch site lies in the orbital plane of the target satellite, and this only happens twice a day. But in only a fraction of these passes can the target satellite be reached by the interceptor within a few hours, since in the majority of cases when the orbital planes coincide the distance between target and interceptor is too great. Thus an interceptor launch is possible only once in several days. This has the important consequence that, whereas a single satellite might be intercepted by surprise, degrading a satellite system which uses several spacecraft might take a matter of weeks. (86)

General David Jones, Chairman of the US Joint Chiefs of Staff, has stated that the effectiveness of the USSR ASAT system is quite limited "both in terms of the number of ASATs they can launch and the types of US satellites they can go against. (87). A similar assessment by the US Joint Chiefs was given several months later:

> Senator Glenn. On their antisatellites... Would you want to comment on the effectiveness of their antisatellite system as they have tested it so far?

> General Jones. Yes, go ahead.
> General Allen. The system that they have tested so far has the potential of being effective against our low-altitude satellites. It was tested in that kind of a mode, and it has had some successful tests. On the other hand, it is difficult to assign it a very high degree of credibility because it has not been a uniformly successful program and they have changed parameter with many of the different launches they have made.
> ....
> Senator Glenn. Have they deployed any antisatellite systems yet?
> General Allen. They have the systems that are more or less at the ready. It is not a very quick reacting system. The systems that are at the ready are located in the missile test areas. So, I think our general opinion is that we give it a very questionable operational capability for a few launches. In other words, it is a threat that we are worried about, but they have not had a test program that would cause us to believe it is a very credible threat. (88)

In the USSR ASAT "tests between 1968 and 1971 70 percent of the flights appear to have been successful: in those between 1976 and 1981, the success rate was 72 percent for two-orbit attacks but only 40 percent for one-orbit sorties." (89) "Radar-homeing interceptors have experienced a 30 percent failure rate, and more recent tests using a heat seeking sensor have experienced a 100 percent failure rate." (90) The tests have been only held against a very narrow range of orbital inclinations, none of which corresponds to those of low altitude US satellites, and it appears as if the USSR is continuing to "search for a satisfactory guidance system and a more direct intercept trajectory."

5. US - USSR Negotiations for ASAT Control, 1977-1979

The internal policy debate of the Carter Administration on what kind of agreement it wanted to negotiate with the USSR regarding ASAT weapons provided substantial information on the opinions of various branches of the government regarding the development of US ASAT programs.

A treaty that permits full development and bans only deployment of anti-satellite weapons is far less satisfactory than one that provides more assurance that the weapons would not be ready for use in case of a crisis. Should nuclear war between the US and the USSR ever erupt, such agreements would not be likely to be honored. In Richard Garwin's words:

> Naturally, such a treaty (not... to deploy weapons in space) cannot be depended on in time of war; however, it does control activities in time of peace (just as the ABM treaty prevents deployment in peacetime and prevents certain testing of ballistic missile defenses), so a ban on space weapons, would ban a lot of things and reduce the capability one could surreptitously create for use in war. (91)

This is not to say that in the case of a major US-USSR war, antisatellite operations will be a certainty, but only that the determination by either side whether to initiate them would not be based on whether or not a treaty existed. It would be based on the calculation of the likelihood of one's own satellite forces being left unmolested and the desire to remove the advantages supplied to the enemy by his operational force. The more satellites become involved with actual operations of strategic nuclear systems, the more they are likely to come under attack. In addition, if one side initiated ASAT operations, it is highly unlikely that the other side would abstain from them. What lessons there are from other weapon systems — primarily chemical warfare — indicate that the relation between restraints of international law and decisions to use or not to use a constrained weapon are extremely complex, and are very dependent on the state of supplies, training, readiness, and possible use by the opponent of the weapon system in question. (92) International legal restraints affect a decision to initiate use to the degree to which they have affected prior preparations and readiness of a particular system. If the system is fully operational and deployed, the decision to use or not will be made purely on the basis of military utility or disadvantage, regardless of legal prohibitions.

In March 1977, during Secretary of State Vance's trip to Moscow, the US suggested to the USSR that negotiations be held banning satellite interception and destruction weapons. President Carter informed the press that he had suggested "... that we forego the opportunity to arm satellite bodies and also... forego the opportunity to destroy observation satellites." The USSR reportedly indicated its willingness to participate in such negotiations, and in subsequent months, asked the US on at least one occasion when the US position would be formulated. (93) The USSR also continued its 1977 satellite intercept testing program. In the fall of 1977, Marshall Shulman, special advisor on Soviet affairs to the Secretary of State and head of the administration's Interagency Committee on Soviet policy, disclosed that the administration was preparing proposals to be submitted to the Soviet Union as part of an antisatellite arms control agreement. (94) It was hoped that the negotiations would proceed early in 1978. In the interim, relevant US weapon development programs would continue.

Various government branches involved in the administration's deliberations differed in their approach to the proposed negotiations. The Department of Defense was concerned that the negotiations might impede US developments and did not want to stop the planned US testing program. It also expressed concern as to the feasibility of verifying Soviet adherence to such a treaty, and intensive US studies were undertaken on the verification question. Finally, the Department of Defense also reportedly wanted US-USSR talks postponed until the National Security Council completed its ongoing space policy study. The Department of State was in favor of initiating US-USSR talks prior to the completion of the NSC study, but agreed that the negotiations preceding an agreement should have no effect on US development of satellite intercept and destruction systems. The Arms Control and Disarmament Agency advocated a ban on ASAT tests, but this position was defeated by opposition from the Department of Defense and other unidentified government branches. Continued development provides precisely the circumstances under which verification of a deployment ban would be most in doubt, a condition to which the US Deparment of Defense claims high sensitivity. Nevertheless, the Department of Defense was opposed to a ban on <u>development</u> that would jeopardize its own antisatellite weapon development programs. This choice — to prefer the continued development of one's own systems at the cost of permitting the continued development, and perhaps deployment, of the enemy's — is exactly analogous to the history of the US Department of Defense and particularly the Joint Chiefs of Staff in the long history of inter-departmental debate in US government decisionmaking on a Comprehensive Test Ban Treaty.

On March 18, 1978, the administration disclosed that it had asked the USSR to initiate discussions in April. (95) It then became known that the

Department of Defense had strong objections to beginning negotiations with the USSR until the US had developed satellite intercept capabilities similar to those already exhibited by the USSR. This would clearly have meant a delay of at least several years. The Office of the President decided in favor of proceeding with negotiations, but at that time the administration had not yet decided on what the goals for the negotiations were.

USSR agreement to begin the negotiations was reported to Washington by March 31, 1978. (96) A brief negotiating session was held in Helsinki, from June 8 to June 17, 1978, with ACDA director Paul Warnke heading the US delegation. (97) Fourteen months had passed since negotiations had been suggested in March 1977; nevertheless the talks were still described as being "preliminary". When the agreed date for the talks was first reported in May, US State Department spokesmen had indicated that they were only expected to last two to three days. (98) The US position at the talks was reportedly still <u>not</u> to seek a ban on ASAT testing:

> Because of the verification problem, the Pentagon favors banning the use of ASAT weapons, but not their development or deployment. The Soviets reportedly took a similar position at Helsinki. (99)

Defense Secretary Brown also told a Congressional Committee: "Of principal concern is the lack of verification methods to provide assurance that the USSR does not retain or increase an antisatellite capability." (100) On October 4, 1977, however, Secretary Brown had already stated that the Soviet ASAT capability was operational. The Department of Defense position in favor of permitting both testing and deployment would allow the USSR to retain and increase its ASAT capabilities. The US goals were in substantial contradiction to one another.

The actual negotiations comprised about two hours of talks a day for eight days. The USSR delegation apparently did not acknowledge during any time in the talks that the USSR was testing an operational antisatellite system. (101)

On June 20, 1978, the administration released its new Presidential Decision Memorandum on US space policy, the first US space policy declaration made since President Kennedy's in 1961. The Memorandum stated that "While the United States seeks verifiable comprehensive limits on antisatellite capabilities and use, in the absence of such an agreement the US will pursue development of its own capabilities vigorously. The US space defense program shall include an integrated attack warning, notification, verification, and contingency reaction capability that can detect and react to threats to US space systems." (102) Both before and after the June negotiations unidentified White House spokesmen "talked tough" to the press regarding prospective US developments in the ASAT weapon area: "I don't think the Soviets want to force us into the antisatellite business... Because with the programs we have under way, we could clean up the sky in 24 hours." (103)

After an interval of seven months, the second round of negotiations took place on January 23, 1979. (104) As these drew near, further important aspects of the US negotiating position became known. Agency coalitions reportedly consisted of ACDA, Department of State and NSC on one side, and DOD and other executive agencies on the other. Reportedly, the State Department-ACDA group proposed

> ... that the US commit itself to a policy of comprehensive "noninterference" with Soviet military satellites. The term "noninterference" in the context of an anti-ASAT treaty tends do take on extremely broad meaning. At stake are prohibitions against jamming hostile satellites, inspecting them by visiting Space Shuttle crews, hindering their operation by placing foreign objects in the paths of their transmissions and their fields of view, incapacitating them in various ways — such as overheating or overloading their sensors with ground-based high-energy lasers — and either "pirating" them through electronic means or causing them to "self-destruct" through spurious command signals.
>
> The Defense community — whose views at this writing seem to have greater leverage in the White House than do ACDA's views — believes that a space-weapons treaty should be treated as a two-step process. During the initial phase — possibly a protocol period similar to the one envisioned for SALT II — a certain number of ASAT tests would be permitted, thus enabling the United States to catch up with the Soviets. This is considered essential — and has been received sympathetically by the White House — since Soviet pledges to dismantle that nation's ASAT hardware are totally unverifiable and largely meaningless.
>
> Once there is parity, provisions that limit both sides' capabilities within verifiable bounds could be drawn up to provide the framework for the second, permanent phase of such an accord. (105)

When President Carter was asked in a January 30, 1978, press conference about "reports that the Soviets have or will soon have the capability to disrupt sending of military orders by satellite", he replied that "such reports were not accurate." (106) In January 1978, a US administration spokesman had said: "We have the goal of a very comprehensive space arms control agreement with the Soviets. We want maximum pacification of space."(107) According to the same report, space arms control questions were "broken off... for immediate presidential action" from the other space policy issues then being considered by the Presidential review group. However, as we have seen, this certainly did not produce any rapid progress on the negotiating front. As the January 1979 talks began, a report stated that President Carter was still in the process of deciding whether the US position in the talks "should be to begin hard negotiating toward killer-satellite limits, or take a more informational approach." (108) This hardly indicated a resolution of the differing positions in the administration. The US and the USSR were to provide each other with answers to questions put in the first session in June 1978. The talks ended on February 16, 1979, with twelve sessions having been held. No results or information on what took place have been provided. (109)

Negotiations were resumed again from April 23 to June 15, 1979. It was now reported that three main negotiating objectives had been set by the President: a ban on antisatellite tests, a requirement that the USSR dismantle the launchers already deployed for ASAT weapons, and provisions for verification. (110) The last two objectives would certainly be difficult to obtain. The US also suggested a limited agreement to ban any ASAT tests until January 1981, to be signed at the USSR-US SALT summit in June 1979. The USSR rejected this proposal. (111) Three additional major difficulties emerged. The USSR did not want satellites of China or of NATO nations to be protected by the agreement. It also wanted to exempt from protection any satellite performing "hostile or pernicious acts that enfringe on national sovereignty or otherwise damage the environment," an extremely ambiguous proposal that would be open to wide latitudes of interpretation. Finally, the USSR claimed that the US Space Shuttle should be considered a potential antisatellite weapon and be subject to termination, or limitations of its activities — particularly satellite rendezvous — as part of an ASAT limitation treaty. The US has constantly claimed that it has no intentions or plans to use the Space Shuttle as an antisatellite weapon, and that it would be foolish to use these vehicles in such a role, despite their ability and planned use to retrieve US satellites from space. This position was somewhat compromised by the disclosure that the Space Shuttle would carry equipment for tracking USSR satellites, and that it "might also inspect but would not destroy Soviet Space Weapons." (112). It is puzzling why this should have been considered necessary or desirable, considering the major uses planned for the Shuttle and its own great vulnerability and cost. Once having been stated, however, such a role leaves much to interpretation, and depending on its application, could be seen to involve the Shuttle as an part of an ASAT system.

There was no significant progress at this third and — as it turned out to be — final session. The various considerations introduced by the USSR, particularly the second one, did not appear to indicate any great desire for achieving a rapid and total ban on ASAT's. It is particularly notable that the USSR, which is usually favorable to moratoria and frequently suggests them during negotiations, rejected the US suggestion for an interim moratorium on ASAT testing despite the fact that the USSR was itself effectively observing a two year unannounced moratorium (or interruption) in its ASAT test program at the time. It was later suggested by unidentified American officials that the USSR's primary interest in the ASAT talks was to enhance the chances of achieving a SALT II agreement with the United States. (113) ~~The US interrupted the negotiations, as it did all other arms control negotiations with the USSR, after the USSR's invasion of Afghanistan in December 1979. (114)~~ The USSR resumed ASAT testing in April 1980, and the Carter administration never resumed the negotiations again. In August 1981, the USSR presented a draft treaty to prohibit weapons in space, which was considered inadequate by Western observers.

, be revised

The Reagan administration has shown no interest in ASAT negotiations with the USSR despite mounting pressure from the US Congress in 1982 and 1983.(115) In March 1982, President Reagan urged the development of a US orbital defense system capable of destroying attacking ballistic missiles. In the following months, Yuri Andropov urged a general US-USSR ban on weapons in space. There was no reply from Washington. In July 1983 the US Senate Committee on Foreign Relations approved a resolution urgeing the Reagan administration to negotiate a prompt moratorium on ASAT tests, followed by a "mutual and verifiable ban" on ASAT's, and finally by a more general prohibition on all spacebased or directed weapons systems. (116)

In August 1983, the USSR tabled a new draft treaty on ASAT's and reportedly undertook unilaterally not to be the first to launch anti-satellite weapons:"

> "The USSR assumes the commitment not to be the first to put into outer space any type of anti-satellite weapon, i.e. imposes a unilateral moratorium on such launchings for the entire period during which the other states, including the USA, will refrain from stationing in outer space anti-satellite weapons of any type." (117)

The statement is, however, full of ambiguities, and it is not at all clear what it means. It is not clear if it implies a halt to USSR ASAT testing — which could then presumably resume with the first US test — or if it is at all relevant to the existing ASAT systems that either the US or USSR presently have developed, since neither of these are stationed in outer space. On the face of it, it is a declaration not to station in space new kinds of ASAT systems that both nations have under further development, and seems closer to suggestions that have been made that an initial US-USSR ASAT agreement could leave both nations with its existing minimal systems but ban new systems. However, the USSR's August 1983 draft treaty contains bans on all space-based weapons of any kind, and a ban on all types of anti-satellite weapons.

US Congressional concern increased as the start of the US ASAT testing program approached. The Senate voted 91 to 0 in adopting an amendment which:

> "... requires the President to certify to Congress that the United States is endeavoring in good faith to negotiate with the Soviet Union a mutual and verifiable ban on antisatellite weapons before proceeding with tests against targets in space for such weapons. It also bars such testing unless not doing so would pose irreparable harm to United States national security." (118)

The first two US ASAT tests were not to be fired against actual targets but at a point in space. A Congressional appropriations conference committee also directed that the first procurement funds for long-time items in the ASAT system.

> "... may not be obligated as expended until the administration has submitted a report to Congress on US policy on arms control plans and objectives in the field of ASAT systems." (119)

The report must be submitted to Congress by March 31, 1984

III. DISCUSSION AND ANALYSIS

The decision points regarding US ASAT systems were numerous and stretched over many years. There were decisions to develop primary ASAT systems, as well as other space systems that included satellite interception, inspection and destruction as one of several missions. The latter might be termed "secondary" ASAT system. There were the decisions to cancel most of these programs. There were also numerous studies and committees from 1958 onwards that reviewed the requirement for or status of ASAT programs.

Studies for the SAINT, Satellite Inspector, program began in 1957 and the demonstration phase began in 1960. The necessity of a satellite tracking and monitoring system was understood, and a program for attaining it was implemented. By 1960, the concepts for ground-based systems, which eventually became the deployed ground-based direct-ascent intercept Programs 505 and 437, were already available.

A dominant factor in the pre-1962-1963 technical approaches to the ASAT mission was the Air Force's desire for a military manned space program. Satellite intercept was just one mission harnessed to that goal. Reduced to its crudest from, one can say that the Air Force wanted a manned space mission first, and an ASAT second, not the other way around. The ASAT mission was constructed to include satellite inspection prior to satellite destruction, and inspection was assumed to require a man in space. The Air Force persistently tried to meld the satellite intercept mission with manned space vehicles and its desire for a military manned space role. This pressure produced the chain of sequential programs involving manned space vehicles and missions, in which R&D for a new program was approved and initiated as the previous one was cancelled, all containing the satellite inspection mission. Satellite destruction was always the implicit follow-on step, although for political reasons the latter stage was not always expressed in the program definition agreed to by OSD (though it was certainly assumed by the Air Force).

SAINT and Dyna-Soar development were approved in 1960, only to be cancelled several years later. Both faced continual technological problems and extravagant cost growth; neither was able to solve its technological problems. In both cases they were supplanted by other technologies that would achieve all or most of their purposes before they could even be tested, creating a clear case of redundancy. It is a bit more difficult to say what would have happened if either or both programs had been technologically successful. When Dyna-Soar was dropped, components or its intended capabilities were transferred to other development programs:

- satellite intercept went to the ground-based ASAT Programs 505 and 437;
- the hope for a military manned space role went to MOL;
- the vehicle and technology studies went to the START program;
- as both radar and electro-optical technology improved, the inspection role was also taken over by ground-based elements that were added to the Spadats capabilities under the SOI (Space Object Identification) program.

Even though a particular project might be dropped, its goals were transferred to other programs. In this way, satellite rendezvous and inspection was passed from SAINT to Dyna-Soar to Blue-Gemini to MOL. Other objectives of the original SAINT (and Dyna-Soar) programs were realized as part of NASA space programs, although not necessarily in low-earth orbit: demonstration of rendezvous, orbital change and cross-course maneuvering, and even visual inspection of other satellites in Gemini experiments early in 1962-1963.

The accretion of technological developments between 1960 and 1968 probably explains the relative success of the USSR test series in contrast to the difficulties of the US SAINT program. By the time the USSR ASAT programs came along, more of the technological capability had been developed in other aspects of their space and satellite programs. The earlier US programs were making far greater demands of technology then available. When costs rose and predictions of failure rates in the four-vehicle SAINT program were too high, this was sufficient to lead to the cancellation of the projects before extensive testing. The early USSR testing programs proceeded despite very real and visible high failure rates. This may indicate, among other things, that USSR decision-makers in the military R&D programs are more tolerant of expensive failures, once a development program has been initiated — or it may indicate the greater military value of an ASAT capability for the USSR.

If one looks at the drive for an ASAT capability in general on the part of the US military services in this early period, and particularly of the Air Force, there was clearly no evidence of the development of a specific

ASAT capability on the part of the USSR. The capability for the USSR to place a nuclear weapon in orbit was, however, certainly there. There was no discussion by Air Force spokesmen of the possibility that US ASAT developments might provoke comparable systems in the USSR, but such systems were stated to be exceedingly dangerous if they should appear in USSR hands. At the same time Air Force spokesmen all but invoked the USSR systems in maintaining that a US "space control" capability was the only way of protecting US assets, in space and elsewhere.

When the "inspection" concept, and other of its sophisticated components — "capture", "convey", "dismantling" of the enemy satellite — were set aside and the system requirement was reduced to "destruction", the several political factors vis-à-vis USSR capabilities discussed below, plus the pressure resulting from the imminent cancellation of Dyna-Soar, produced the decision in 1962 in the Office of the Secretary of Defense to build the simpler direct-ascent ground-based intercept systems. The Army's Nike ASAT was approved in 1962 and the USAF's Thor in 1963. With the decision to procure these from "off-the-shelf" and available components, each of the two systems was operational a year after approval for them had been given, and at a low cost, in comparison to the slippages, technological problems and heavy cost overruns of SAINT and Dyna-Soar.

Both the Army's Nike ASAT, deactivated in 1968, and the USAF's Thor, deactivated in 1975, were token deployments. The Army may have been more satisfied with a "symbolic" system, which gave it a mission role in space and which might not have been particularly functional from an operational military viewpoint, than would the Air Force. Both systems required the use of a nuclear warhead. Both systems had a limited number of missiles. The times and details of their tests were given extremely little public attention; neither the US nor the USSR released any information on the US tests. Subsequent, more complicated tests for Program 922 in the mid-1960s, a follow-on system for the Thors intended to provide a non-nuclear warhead, reportedly failed, and 922 was eventually cancelled. Concerning technology, it is interesting that the US Department of Defense apparently came to similar conclusions in favor of direct-ascent systems in 1962, 1975 and 1977 with different policy-makers in key positions, and after the demonstration of the USSR satellite intercept tests.

It is clear that there were several major inputs to the US decisions in the 1962-1963 period. Decisions to approve particular systems were also often decisions to cancel other programs, and the roles and determination of Secretary of Defense McNamara and DDR&E Harold Brown were crucial to these. The interest and partiality of the new President, Lyndon B. Johnson, contributed to the approval of MOL as it also politically facilitated the decision to cancel Dyna-Soar.

The intercept of orbital nuclear weapons, rather than satellites per se, was the context in which nearly all US public ASAT debate within and without the administration was phrased in the 1960-1963 period. Though the decision to develop and deploy the US ASAT system was taken before the October 1963 UN resolution on avoiding the placement of nuclear weapons in orbit, the program was subsequently described as serving some assurance should the USSR subsequently deploy orbital weapons. It was understood that if the USSR were to announce that it had placed a nuclear weapon in space orbit that this would not be of much military significance, but would primarily be a "psychological weapon". However, should that happen, US political leaders wanted to have their own psychological weapon, i.e., the ability to destroy the Soviet weapons. In this sense, the US capability was far more a political one than a "military" one.

A similar, primarily political, function is expressed in Air Force Secretary McLucas' statement that Secretary McNamara was concerned that the "US needed assurance that if the Soviets... started playing around with our satellites, we should have the ability to do likewise." Though McLucas is clearly referring to a US antisatellite role unqualified by any special category of target vehicle, the very limited nature of the US deployment that followed again suggests that the capability was intended to supply an essentially political need. Regarding both these political roles, it is important that Secretary McNamara himself ordered the approval of the Air Force's Project 437, apparently with strong White House support, if not initiative.

A third major factor that entered into many of the ASAT-relevant decisions surrounds the question of manned space missions; their technical feasibility, the need or lack of need for them, and their cost. Secretary McNamara was not remiss in constantly referring to his effort to control the budget of the Department of Defense. He repeatedly stressed the principles of "... sound management and prudent planning":

> The best expression of those principles that I have yet heard were the instructions given to me by President Kennedy and re-emphasized strongly by President Johnson. They were:

> First, find out what we need, and determine this without regard to predetermined budget ceilings. Second, having determined the need, procure and operate the required military forces at the lowest possible cost. (120)

He was trying to reduce the defense budget, and he was not being successful in that effort. The Air Force's manned space proposals were extravagant and costly programs by the standards of the time. There is substantial evidence to indicate that the Dept. of Defense during Sec. McNamara's tenure did not always follow the cost-conscious dicta that he liked to emphasize, but it was nevertheless an important argument that could be used when it was decided to cancel a program. In addition, the Secretary did not trust the technical feasibility of the Air Force's manned space proposals, and neither did most of his civilian advisors. It was finally felt that man was not necessary for carrying out the functions for which manned systems were being proposed. (121)

It is in this light that it seems apparent that at least several of the positive decisions in favor of R&D on ASAT-relevant systems, and the decisions to deploy the two similar direct-ascent intercept systems, were made by the Office of the Secretary of Defense under very strong institutional pressures, as a compensation for other decisions that had been against the continuation of programs. These negative decisions comprised several categories. Some projects were never advanced by the OSD from research to development, and some were cancelled after several years of development work. Finally, in some cases the OSD prompted the development of an alternative capability to allow cancellation later of projects at the same time as a tangible, and more feasible, alternative was approved. It apparently was not possible for the OSD to say "no" in all decisions relevant to ASATs as a category. Approval of something was politically necessary, and the two direct-ascent systems were the easiest and least expensive alternatives. Approval for development and deployment was given, but since no extensive system was ever built, clearly no great military urgency or need for the systems was seen by OSD. They served to take the edge off further demands for an orbiting satellite ASAT capability. The decision was defended by DDR&E Harold Brown on the cost-effectiveness grounds typically used throughout the McNamara years: a ground-based system could do the job better than a space-based intercept. Accuracy was better, payload could be larger, and cost was lower. There was no strong identifiable lobby within the Air Force itself for the direct ascent ASAT, It should also be pointed out that though the advocacy for manned space programs was often strong, there was no indication of uniformity on the question on the part of the military services or of the JCS, and not even uniformity within the Air Force. NORAD had even opposed Program 437 as an antisatellite system. The technological problems and futuristic aspects of many of the manned programs reduced their credibility, which in turn reduced Service advocacy for them. After 1963, the pressure for manned programs subsided, even with the approval of MOL.

There was a fourth and final major contributing policy factor, the expressed concern of Secretary of Defense McNamara, Deputy Secretary Gilpatric and DDR&E Brown to avoid an arms race in space. Information is not publicly available to determine whether the Office of the Secretary of Defense was using cost-effectiveness arguments in this case as a proxy for an implicit and unexpressed arms control interest — limiting US ASAT capabilities in order to avoid an arms race in space — or for the equally unexpressed reason of maintaining maximum free use of US satellite systems. In at least one case, under the Eisenhower administration, it was explicitly claimed that the choice to inhibit US programs was based on the realization that the development of a US ASAT capability would be likely to promote a USSR capability which would threaten US satellites. It was judged that it was more desirable for the US to be able to operate its own military satellite systems at will than to be able to threaten USSR satellites.

> The Air Force also strongly promoted the idea that we should undertake on an urgent basis the development and deployment of a "satellite interceptor", to be known as SAINT. The President himself, in recognition of the fact that we didn't want anybody else interfering with our satellites, limited this program to "study only" status and ordered that no publicity be given either he idea or the study of it. The other two military departments independently promoted the same idea and volunteered their services for its accomplishment. (122)

The President's Science Advisor at the time, Dr. Kistiakowsky, took the same position:

> During the period covered in this diary there was considerable occasional pressure to develop anti-satellite missiles. I opposed these proposalt successfully using the arguments that for us the satellites were far more important than for the Soviet Union... (123)

However, since the programs were at their earliest and pre-hardware stages during the Eisenhower administration, and technology development in relevant areas had not yet gone very far, the decision to hold a low profile was probably easier to make and to hold at this time. This position was to some degree reversed in the Kennedy administration. ASAT-relevant programs were approved, and they did obtain publicity. Nevertheless, under the Kennedy administration, development programs were also actually cancelled, althrough, that very process led to the pressure for replacements.

It would be important to be able to evaluate to what degree the desire to avoid an arms race in space or to maintain uninterrupted use of space by the US for its military satellite programs — or both — were the determining policy factors in several successive administrations between 1957 and the present time. (124) One has a tendency to answer "yes" by default, since there was no large US ASAT program deployed. York and Kistiakowsky make the explicit, if very brief, claim for such a policy in the Eisenhower administration. The problem becomes more difficult in subsequent years. There were significant decisions adverse to ASAT development programs, and a few in favor of them, but there is no unclassified administration statement available that states such a policy. The US was following a restrained course : was it restrained on purpose, or coincidentally due to a failure of very expensive and misdirected programs such as Dyna-Soar? In the case of nuclear weapon delivery from orbit, though the OSD was very strongly opposed to any such US systems on technological grounds, Deputy Secretary Gilpatric's statement explicitly invoked the effect that a deployment of such a system would have on USSR development of similar weapons in orbit. If one wants to make the case for an analogous basis for US policy determination on ASATs, one is forced to do so on circumstantial evidence, pointing to the absence of a program, as well as the absence of information on such a policy. Perhaps the post-1968 situation after the initiation of the Soviet ASAT tests, is the most relevant test of this hypothesis. US military use of its satellite programs was growing constantly and one can speculate that it was judged desirable not to enter a competition that threatened to intervene in that situation in any way. Although there was a series of DOD decisions in the early 1970s to begin ASAT developments of various sorts, the effort was small and not a crash program until 1977. Clearly, US policy then changed.

In a study prepared for the US Dept. of Defense in 1981 one finds the following assessment:

> "At the present time there is a modest but significant technological momentum in the development of ASAT systems. Whereas the United States at one time consciously avoided such system, the inability to achieve an ASAT agreement and the continued testing of the Soviet low attitude system has led to a desire to eliminate the current technological assymetry in such systems... The distinct US advantage in the exploitation of space for military purpose argues for limits on ASAT systems..." (125) (Emphasis in the original)

The statement that "... the United States at one time consciously avoided such systems"..is at the least a partial gloss on history. It is only because the US direct ascent Program 437 ASAT missiles were dismantled in 1975 that administration statements in subsequent years could state that "... the United States has no capability to intercept or negate Soviet satellites or anti-satellite vehicles." (126) The 25 year history of these systems can be briefly summarized as follows:

- The United States began development of ASAT systems quite early, in the late 1950's. Rudimentary direct-ascent ground launched missiles were first deployed in 1963, and remained deployed until 1975.
- The United States rejected development of orbital nuclear weapon delivery systems, and negotiations with the USSR in 1962 and 1968 presumably resulted in the removal of the threat that the USSR could do so.
- The USSR began its first orbital ASAT test series in 1968, having begun relevant R&D some years before. In addition from 1968 onwards it maintained operational manned military space systems with capabilities analogous to programs that were initiated in the US some years before that were intended to include ASAT capabilities but which were all cancelled.
- In 1976 (a year after the removal of the US missile systems), the USSR initiated a second ASAT test series, and in 1976-1977 the US accelerated development of a new direct ascent air-launched ASAT with warhead technology derived from ABM R&D.
- Three unhurried ASAT negotiating sessions were held between the US and USSR between 1978 and 1980. Neither side displayed any great hurry to achieve an ASAT ban. The negotiations lapsed with the end of the Carter administration.
- The USSR initiated a third ASAT test series in 1980, and the US testing program rapidly approached towards the end of 1983. No further negotiations have been held.

Whether the change in US policy in 1977 was due to

- the threat posed by the second USSR ASAT test series, and the desire to protect the increasingly important US military satellite systems by deterrent counter-threat

- the desire by the US Navy for tactical military reasons to be able to destroy the low altitude USSR Radar Ocean Reconnaissance satellites (RORSAT's)
- a desire to begin development of ASAT systems to be used as a "bargaining chip" in negotiations with the USSR

or parts of all of these (and of others) reasons combined is not known. If there was any "modest but significant technological momentum" in 1981, there was not — or very much less of it — in 1976-1977, and whatever there was in 1981 was the result of the political decisions made in 1976-1977.

This paper is concerned with US weapon system decisions. However, one would always like to know to what degree such decisions can be judged to have prompted developments in the USSR, as well as the reverse, since the outcome may clearly produce a second cycle. The first USSR ASAT tests were in 1968, five years after the first US ground-launched tests (not counting the single air-launched test in 1958), and four years after the US Air Force announced that it would use Gemini capsules for satellite inspection experiments. It was also four years after the deployment of the two components of the US direct-ascent intercept system. It seems a reasonable guess that R&D for the USSR program might have begun around 1963. Until 1976 it also seems plausible to suspect that the USSR had carried out only seven ASAT tests and although the test system was of a different design than that of the US, it can be said to have been as minimal as the US program to that date. The Soviet ASAT test program may not have come until their strategic defense priorities could afford it, i.e., not until their sharp increase in ICBM production rates after 1965 was well under way.

It therefore does not seem surprising that the USSR began R&D in the early 1960's and initiated testing of an ASAT program. It seems very likely that the USSR was "led" by the extensive US discussion of the mission; the entire US development history of ASAT-intended systems from 1958 on would have fed into the USSR proclivity for more extensive defensive systems, as demonstrated in such other areas as air defense. The USSR had no way of knowing that the earlier and far more ambitious US programs would be abortive, and there are other instances, for example the US B-70 bomber, in which the USSR developed more than one air defense system in response to the expected deployment of a US system that then never materialized. At the very least, the ground-based minimal US system was in place, and a development program to improve it was in process. This possible sequence of events would not, however, explain the resumption of USSR ASAT testing in 1976 focused on a direct satellite interception and, presumably, destruction capability. Judging from these tests, there was probably no "inspection" involved at all; only the co-planar tests would indicate enough time for the insertion of an inspection period before destruction was attempted. Since the US had no orbital nuclear weapon program, and the USSR did not profess to doubt that, inspection would not be particularly necessary, and other kinds of satellites would be the presumptive targets. The USSR program was not directly imitative in this case, at least not of the US direct-ascent systems. It is more closely related to, but more ambitious than, the earlier US proposals for the co-orbital SAINT program. Soviet experimentation with several different orbital intercept techniques can be seen as an attempt to find one that works a satisfactory number of times. The Department of Defense did not apparently find the first USSR 1968-1971 test series very provocative and the first DOD assessment of the second USSR series were apparently not much different. Ambiguities in the USSR test program such as the orbital inclinations of the USSR tests have been little discussed, and the USSR tests are being used as the rationale for developing a US ASAT program.

The ASAT negotiations with the USSR — along with all the other arms control negotiations with the USSR that were underway during the Carter administration — were a casualty of the USSR's invasion of Afghanistan and the transition of administrations. The draft treaties that had been proposed by the USSR in this period were relatively unsatisfactory and it was not until a first test of the US air-launched ASAT was imminent that the USSR offered a more satisfactory draft treaty in August 1983. The USSR's own test program has continued since 1980 with one ASAT test even carried out as part of a single synchronized launching of ICBM, SLBM, ABM and ASAT systems. The US Miniature Homing Vehicle weapon system grew out of a low-level R&D program that had first been conceived in the early 1960's and was developed in a relatively low level R&D program, with components under constant gradual development as a technology usable both in ASAT and in ABM systems. The air launched missile is an "off-the-shelf" system, as is the already proposed follow-on to it.

The purpose of this study was to elucidate the early R&D decisions of the United States concerning anti-satellite systems. (127) The early 1980s paradoxically found some US Air Force devotees again speaking of "control of space" and using the exact phraseology of some 22 years before. The Commander of the new USAF Space Command was quoted in a BBC interview in 1983 as predicting "peace for 50-100 years if the free world takes control of space". The "threat" image presented was also again very similar: the commander of the US Strategic Air Command suggested in 1982 that unless the US was willing to operate weapon systems in space "The Soviets will eventually be able to deny us use of space as a support medium and use it as a high ground to launch attacks on US targets". "Space denial" was that back — as an alleged threat, as well as "the high ground". This latter euphemism for weapon systems in space was further extended: The "High Ground" of 1958-1960 became the "High Frontier" in 1982-1984.

REFERENCES and NOTES

A Note To The Reader

Sections I and II of this paper were written entirely from published and unclassified sources. Section III, the Discussion and Analysis, benefits from correspondence and interviews with former US Department of Defense officials who served in the 1960s and had been involved in varying degrees with the programs being discussed. Their insights and suggestions are greatly appreciated and were an important benefit to the author. However, all the interpretations presented in the paper are the author's alone.

Several of the people interviewed made remarks which taken together provide a very important message concerning the difficulty of obtaining an accurate picture of defense policy process and decision making at the highest levels, from unclassified sources, and in fact from interviews. It was stated that:

- One would not find in the open literature a definitive statement of a final decision and why it had been taken.
- Such information sometimes exists on paper, but when it does, it is unobtainable. At other times, it is simply not written down.
- Further, such documentation, if it were obtainable, would most often be misleading, since the "real reasons" are not stated. Several examples were provided.
- A participant, even a central one, does not always know of all the aspects and considerations going into a decision.

(As a comfort to the reader, several of these officials felt that the present study was a thorough, comprehensive and close approximation of what had happened in this case.)

1. L.L.Kavanau, "The Military Space Program in Perspective", US Department of Defense, News Release No. 718-63, May 21, 1963, 18 pp. mimeographed; Harold Brown, "DOD Space Programs", Astronautics & Aeronautics 2:6 (June 1964): 68-71.

2. L.L.Kavanau, op. cit., p. 4

3. "Satellite Countermeasures", Time, 3 May 1954.

4. "USAF Launches Anti-Satellite Program", Aviation Week & Space Technology 73:20 (November 14, 1960): 26.

(54

5. US Senate, Committee on Armed Services, Hearings: Inquiry into Satellite and Missile Programs, November-December 1957, January 1958, 85th Congress, Washington, D.C.: US Govt. Printing Office, 1958, p. 506.

6. Ibid., pp. 1217-1218.

7. US Senate, Committee on Aeronautical and Space Sciences, Hearings: NASA Authorization for Fiscal Year 1960, April 1959, 86th Congress Washington, D.C.: US Govt. Printing Office, 1959, pp. 646-655.

8. US House of Representatives, Committee on Science and Astronautics, Hearings: Defense Space Interests, March 1961, 87th Congress. Washington, D.C.: US Govt Printing Office, 1961, pp. 111, 125, 147.

9. Dr. George B.Kistiakowsky, A Scientist at the White House: The Private Diary of President Eisenhower's Special Assistant for Science and Technolo(Cambridge, Massachusetts: Harvard University 1976, pp. 334.

10. US Congress, Hearings: Space Posture, 1963 (6), p. 228; see also, V.Van Dyke, Pride and Power, The Rationale of the Space Program, Urbana: University of Illinois Press, 1964, pp.42-59.

11. For references on "Space Denial" concepts, see Appendix 5, or the following sources:

    T.D.White, Gen. "Space Control and National Security", Air Force Magazine 41:4 (April 1958): 80-81.
    J.C.Cooper, "Self-Defense in Outer Space... and the United Nations", Air Force/Space Digest 45:2 (February 1962): 51-56; D.Cole, "Response to the 'Panama Hypotheses'", Astronautics 6:6 (June 1962): 36-39, 76-80; A. Frye, "Breaking the Cold War Stalemate: A Proposal", Air Force/Space Digest 45:7 (July 1962): 53-55; "Space Denial, An Amplification", Air Force/Space Digest 45:10 (October 1962): 54-56; C.C.Abt, "Space Denial: Costs and Consequences", Air Force/Space Digest 46:3 (March 1963): 45-55.

12. "USAF Launches Anti-Satellite Program", op. cit.

13. Edgar Ulsamer, "Secretary McLucas Looks at Pressing Air Force Needs", Air Force Magazine, January 1974, pp. 38-44.

14. FY 1962 Hearings on Military Posture and HR9751, p. 3709, 3774. See also General Lemay in FY 1963 Posture Hearings, p. 1172.

15. US House of Representatives, Committee on Science and Astronautics, Defense Space Interests, op. cit., p. 111

16. P.J.Klass, "USAF Halts Saint Work, Shifts to Gemini", Aviation Week & Space Technology 77:24 (December 10, 1962): 36.

17. P.J.Klass, "Value of Bombardment Satellites Debated", Aviation Week & Space Technology 73:2 (July 11, 1960): 26-27.

18. John Prados, The Soviet Estimate, US Intelligence Analysis and Russian Military Strength, New York, The Dial Press, 1982, p. 172

19. Raymond C. Garthoff, "Banning the Bomb in Outer Space". International Security, 5 (3), Winter 1980/81, pp. 25-40.

20. F.G.McGuire, "McNamara Spells Out AF Gemini Role", Missiles & Rockets 12:13 (April 1, 1963): 15.

21. Klass, "Value of Bombardment Satellites Debated", op. cit.

22. Moscow. — The commander in chief of Soviet strategic rocket forces said today the Russians can launch rockets from satellites at a command from earth.
In a radio Moscow interview commemorating the fourth anniversary of the Soviet Army and Navy February 23, (1963) Marshall S.S.Biryuzov also claimed that the Soviets have developed an antimissile missile.
"It has now become possible at a command from earth to launch rockets from satellites at any desirable time and at any point of the satellite's trajectory", he said..."
US Senate, Committee on Armed Services, Hearings: Military Procurement Authorization, Fiscal Year 1964, February-March 1963, 88th Congress. Washington, D.C.: US Govt. Printing Office, 1963, p. 347.
The form of Marshall Biryuzov's statement quoted above is a type of USSR statement that has caused problems of interpretation in other cases as well. The phrases "... can launch rockets from satellites..." and "It has now become possible..." can be read and could have been intended to mean, that such capabilities are now possible in the abstract, that is, that it was now feasible to design and to deploy such systems. It did not necessarily mean that an operational system was flying in space, or that the USSR itself possessed such an operational system. Such interpretations however, depend on common language usage in the West. On the other hand for most of the post-WWII period, the most senior USSR military and political spokesmen have used exactly such ambiguous phraseology to describe technical weapon systems capabilities that the USSR did possess. Finally, one reaches the third level of analysis: in this particular case, even if the statement was in fact intended to mean that the USSR had such a system operational, it was not the first time that USSR officials had laid claim to operational capabilities for which there was no available or subsequently available evidence, particularly in the period of the late 1950s to early 1960s. That is, the claim was apparently false. No Soviet tests of any such system was reported other than the return of satellites to earth for recovery — and the first Soviet FOB's test, which might be considered more relevant, did not take place until late in 1966.

23. "That Orbiting Bomb Again", Air Force/Space Digest 46:10 (October 1963): 64-65. (Excerpts from an address by Assistant Secretary of Defense Eugene Fubini).

24. Deputy Secretary of Defense Roswell Gilpatric, South Bend, Indiana, September 5, 1962, DOD News Release No.1426-62, mimeographed, pp. 3-4. Also published in Congressional Record, September 21, 1962, pp. A7007-A7009, and US Arms Control and Disarmament Agency, Documents on Disarmament, 1963, Washington, D.C.: 1964?, pp. 536-537. See also ref. 19 above.

25. US Arms Control and Disarmament Agency, Documents on Disarmament, 1962, Vol. II, Washington, D.C.: 1963 (?), pp. 1119-1124.

26. US Arms Control and Disarmament Agency, Documents on Disarmament, 1963, op. cit., p. 523.

27. Ibid., pp. 528-529.

28. "Kennedy Denies Space Arms Ban", and "President's Press Conference", New York Times, October 9, 1963.

29. "Anti-Satellite Weapons", Aviation Week & Space Technology 79:16 (October 14, 1963): 25.

30. "Kennedy Denies Space Arms Ban", op. cit.

31. US Senate, Committee on Foreign Relations, Hearings: Treaty on Outer Space, March-April 1967, 90th Congress, 1st Session. Washington, D.C.: US Govt. Printing Office, 1967, pp. 84-85, 89, 92-100.

32. US Senate, Committee on Foreign Relations and US House of Representatives, Committee on Foreign Affairs, Fiscal Year 1980 Arms Control Impact Statements, Joint Committee Print, 96th Congress, 1st Session, Washington, D.C.: US Govt. Printing Office, March 1979, "Space Defense", p. 64.

33. Dr. Richard L. Garwin, "How to Avoid Nuclear War", Erice-Trapani, Sicily, Aug. 20, 1983, mimeographed, 20 pages.

34. Fiscal Year 1980 Arms Control Impact Statements, op. cit., p. 64.

35. US House of Representatives, Committee on Science and Technology, United States and Soviet Progress in Space, Summary Data Through 1977 and a Forward Look, "Statement by C.S. Sheldon II, January 23, 1978", Washington, D.C.: US Govt. Printing Office, April 1978, p. 39.

36. Paul R. Stares, "Dêjã vu: The ASAT Debite in Historical Context", Arms Control Today, 13 (11), December 1983, p. 2-3.

37. Clarence A. Robinson Jr. "US Shifts Emphasis on Missile Defense", Aviation Week and Space Technology, 100 (18) May 8, 1974, p. 44.

38. Sec. of Defense Clark M. Clifford, The 1970 Defense Budget and Defense Program For Fiscal Years 1970-74, Jan. 15, 1969, pg. 64.

39. US Congress, House, Committee on Appropriations, Dept. of Defense Appropriations for 1973, Hearings, Part 4, Research, Development, Test and Evaluati 92th Congress, 1972, pg. 813.

40. John Pike, "Anti-Satellite Weapons and Arms Control", Arms Control Today, 13 (11), December 1983, p. 4. See also ref. 37 above.

41. See, among others: D.Shapley, "Soviet Killer Satellites; US Ponders a Response", Science 193:4256 (September 13, 1976): 865-866; J.W.Finney, "Pentagon Fearful of Soviet Effort to Develop Hunter-Killer Satellites", New York Times, November 24, 1976; "Satellite Killer, Now a New Arms Race in Space", U.S. News & World Report, November 14, 1977, p. 28; B.Weinraub, "Brown Says Soviet Can Fell Satellites", New York Times, October 5, 1977; and, R.C. Aldridge, "Saints and Killers, Who Will Shoot First in Space", Nation, March 25, 1978, pp. 333-335.

42. A copy of the report found its way to the Los Angeles Times. The newspaper wrote an article on the basis of it, which was subsequently verified by DOD sources. Los Angeles Times, March 30, 1977, and "US Satellite Killer Program Confirmed", Los Angeles Times, July 7, 1977.

43. "Antisatellite Effort Decision Awaited", Aviation Week & Space Technology 106:4 (January 24, 1977): 19; see also, "Guidance Satellite",Aviation Week & Space Technology 105:14 (April 10, 1976): 13.

44. Weinraub, Oct. 5, 1977, op. cit.

45. Harold Brown, Secretary of Defense, Department of Defense Annual Report, Fiscal Year 1979, Washington, D.C.: DOD, February 2, 1978, p. 125.

46. The Department of Defense Activities in Space and Aeronautics, Annual Statements of the Director (and then Under Secretary of Defense) Defense, Research and Engineering:
FY 1976 — March 11, 1975
FY 1977 — March 3, 1976
FY 1978 — March 9, 1977
FY 1979 — March 8, 1978
FY 1980 — March 15, 1979

47. Presidential Decision Memorandum, Washington, D.C.: White House, June 20, 1978.. Mimeographed, 3 pages.

48. Dr. Seymour L. Zeiberg, US Congress, Senate, Committee on Armed Services, Dept. of Defense Authorization for Appropriations for FY 1980, Hearings Part 6, Research and Development, March 1979, p. 3008.

49. See the following sources as well as those in references 50 and 61 below: "U.S. Funds Killer Satellite Effort", Aviation Week & Space Technology 108:6 (February 6, 1978): 18-19; C.Covault, "Military Efforts in Space on Increase", Aviation Week & Space Technology 108:18 (May 1, 1978): 53-54; C.Covault, "US Pushes Antisatellite Effort", Aviation Week & Space Technology 109:3 (July 17, 1978): 14-15; "Military Space", Aviation Week & Space Technology 110:13 (March 26, 1979):17; "AVCO Mins USAF Award for Antisatellite Targets", Aviation Week & Space Technology 110: (June 29 1979): 23; E.Ulsamer, "Defense Technology, Moving Into Space", Air Force Magazine 62:6 (June 1979):46-51; US Air Force, FY 1980 Budget Estimates, Research and Development, Test and Evaluation, "Statement by Lt.General T.Stafford, pp. VII-2, II-37 to II-41.

50. "Soviets Encrypting Space Links', Aviation Week & Space Technology 110:18 (April 30, 1979): 26

51. US Senate, Committee on Foreign Relations and US House of Representatives, Committee on Foreign Affairs, Fiscal Year 1979 Arms Control Impact Statements, Joint Committee Print, 95th Congress, 2nd Session, Washington, D.C.: US Govt. Printing Office, June 1978, "US Anti-Satellite Systems", pp.101-106; US Senate, Committee on Foreign Relations and US House of Representatives, Committee on Foreign Affairs, Fiscal Year 1980 Arms Control Impact Statements, "Space Defense", op. cit., pp.70-71.

52. US Senate, Committee on Foreign Relations and US House of Representatives, Committee on Foreign Affairs, Analysis of Arms Control Impact Statements Submitted in Connection With the FY 1978 Budget Request, Joint Committee Print, 95th Congress, ist Session, Washington, D.C.: US Govt. Printing Office, April 1977, 414 pp.:
US House of Representatives, Committee on International Relations, Evaluation of FY 1979 Arms Control Impact Statements: Toward More Informed Congressional Participation in National Security Policymaking, 95th Congress 2nd Session, Washington, D.C.: US Govt. Printing Office, January 1979, 185 pp.

55. "Skantze Sees Possibility of Aerospace Plane", Defense Daily, Dec. 14, 1982.

56. Panorama, BBC-1, TV, September 5, 1983.

(16.4.)
57. Colonel Gerald May:(Director of Space Operations, Space Command) One of the functions that we perform here or will perform here in the future is our negation function.
Mangold: Satellite negation?
May: Satellite negations
Mangold: Negation — that means killing?
May: That means damaging or causing a spacecraft to no longer function properly. And it doesn't mean that we necessarily have to destroy the spacecraft. In the future we will have a capability to either retaliate if we are attacked or we can use it as a device for a deterrent. Using the F-15... with the two stage missiles slung beneath it we will be able to negate a space craft system by physical impact when we're directed to do that by the national command authorities.
Mangold: And presumably the Soviets will then respond in the same way?
May: Well, ours is a defensive capability and we would use that for — if deterrence fails we will use it to retaliate.

58. Charles Mohr, "Preparing for Conflict on Orbititing Battle Fields", New York Times, June 5, 1983; William J. Broad, "Weapon Against Satellites Ready for Test", New York Times, Aug. 23, 1983; Robert C. Toth, "Anti-Satellite Missile to be Tested by US", Los Angeles Times, Dec.12, 1983. See also John Pike, ref. 40 above.

59. The most thorough description of the USSR's space and satellite program is the encyclopedic series of volumes by Dr. Charles S. Sheldon II:

US Congress, Senate, Committee on Aeronautical and Space Sciences, Staff Report: Soviet Space Programs, 1962-1965; Goals and Purposes, Achievements, Plans, and International Implications, 89th Cong., 2nd Sess., 30 December 1966, Washington, DC: US Govt. Printing Office, 1966.

US Congress, House, Committee on Science and Astronautics, Report: Review of the Soviet Space Program, 90th Cong., 1st Sess., Washington. DC: US Govt Printing Office, 1967.

US Congress, Senate, Committee on Aeronautical and Space Sciences, Staff Report: Soviet Space Programs, 1966-1970, 92nd Cong., 1st Sess., Document no. 92-51, Washington, DC: US Govt. Printing Office, 1971.

US Congress, Senate, Committee on Aeronautical and Space Sciences, Staff Report: Soviet Space Programs, 1971. A Supplement to the Corresponding Report Covering the Period 1966-70, 92nd Cong,, 2nd Sess., Washington, DC: US Govt. Printing Office, April 1972.

US Congress, Senate, Committee on Aeronautical and Space Sciences, Staff Report: Soviet Space Programs, 1971-75. Volume I: Overview, Facilities and Hardware, Manned and Unmanned Flight Programs, Bio-astronautics, Civil and Military Applications, Projections of Future Plans, 94th Cong., 2nd Sess., 30 August 1976, Washington, DC: US Govt. Printing Office, 1976.

US Congress, Senate, Committee on Aeronautical and Space Sciences, Staff Report: Soviet Space Programs, 1971-75. Volume II: Goals and Purposes, Organization, Resource Allocations, Attitudes Toward International Cooperation and Space Law, 94th Cong., 2nd Sess., 30 August 1976, Washington, DC: US Govt. Printing Office, 1976.

US Congress, Senate, Committee on Commerce, Science and Transportation, Soviet Space Programs: 1976-80. Supporting Vehicles and Launch Vehicles, Political Goals and Purposes, International Cooperation in Space, Administration, Resource Burden, Future Outlook, 97th Cong., 2nd Sess., Washington, DC: US Govt. Printing Office. December 1982.

See also, H.L. Sawyer, "The Soviet Space Controversy, 1961 to 1963", PhD Thesis, Fletcher School of Law and Diplomacy, Tufts University, Medford, Mass., May 1969, 259 pp. Among other sources see: "The Soviet Interceptor Programme", World Armament and Disarmament, SIPRI Yearbook, 1978, Stockholm International Peace Research Institute. London: Taylor & Francis, 1978, pp. 108-114, and analogous sections in subsequent SIPRI Yearbooks, such as pages 134-137, and 284-285, 292, in the SIPRI Yearbook 1981; L. Freedman "The Soviet Union and 'Anti-Space Defense'", Survival 19:11 (January-February 1977): 16-23; C.S.Shelden II, "The Soviet Interceptor Program", TRW Space Log,16 (1977): 2-10,G.E.Perry, "Russian Hunter-Killer Satellite Experiments", The Royal Air Force Quarterly, 17 (Winter 1977): 324.
See also several of the recent studies listed under reference 127.

60. Kavanau, "The Military Space Program in Perspective", op. cit., p. 7.

61. "Soviet Optical Observation Program", Aviation Week & Space Technology 78:7 (February 18, 1963); "Soviet Surveillance of Orbiting Objects", in Stockholm International Peace Research Institute, op. cit., pp. 124-127.

62. V.D.Sokolovskii, Soviet Military Strategy, RAND Corporation Translation, Englewood Cliffs, N.J.: Prentice-Hall, 1963, pp. 171, 176-182. ("Space defense" and "space weapons" are sometimes used to cover both anti-ballistic missiles and antisatellite weapons, while at other times, anti-satellite weapons are spoken of separately.) See also ref. 66, below.

63. Ibid., p. 182 It is quite interesting that when official Soviet "arms control" consultants were queried in 1978 on the purposes of the USSR ASAT test program, their sole reply was "antisatellite technology started as American research during the Lyndon Johnson Administration, so don't blame us." (Moscow, December 13, 1978, in Harlan Cleveland, "Moscow Diary", mimeographed, p. 28.)

64. Freedman, op. cit.; G.E. Perry (ref. 42) quotes a 1965 Russian military dictionary

> ... defining the anti-cosmic component (PKO) of the antiaircraft branch (PVO). This was said to be "a component part of air defence", designated for destroying the enemy's means of fighting which are used for military purposes (in the capacity of a carrier of nuclear weapons, for carrying out reconnaissance, etc.) in their flight orbits. "Special spaceships, satellite fighters, and other flying apparatuses, armed with rockets and radio-electronic apparatuses, are the basic means of the PKI."

65. Sheldon has suggested that some of the USSR's Galosh ABM system may have been delegated to this unit. It would have been technically possible to configure it to intercept hostile satellites to about the same degree that the United States could have from its mid-Pacific installations. However, it took the United States eighteen months to establish this capability and the US never reported any such Soviet development and apparently did not assume that it had taken place.

66. In the more general public media, the USSR Vostok flights in August 1962, in which the two vehicles came to within three miles of one another, were used to predict both Soviet satellite interceptor capability and manned orbiting USSR space stations armed with nuclear weapons. "Space, Tone and Pace", Time, August 31, 1962, pp. 9-10; "If Space Becomes a Battlefield, Will the US Be Ready", U.S. News & World Report, September 3, 1962, pp. 35-37.

67. The US aerospace literature concerning various of these Soviet programs discussed their possible or potential ASAT relevance. Of course, no USSR literature does that concerning their own manned space programs. Descriptions of military hardware in Soviet books on military technology are nearly always in terms of Western systems. Soviet discussion of military space in terms of US systems does not necessarily mean that their own R&D and deployed programs are simply "reactions" to US systems. This may sometimes be the case, or perhaps even often so. For example, USSR military analysts formulating technological or military intelligence assessments would have been reading about such US programs as SAINT, etc., in the open US literature in the early 1960's. (A Soviet volume published in 1971 demonstrates this to have clearly been the case: Antimissile and Space Defense Systems, Ivan Ivanovich Anureyev, Moscow, 1971, translation, JPRS 57378, October 31, 1972) However, foreign military technology and systems are also the vocabulary used in the USSR for open discussion of issues concerning the USSR's own military systems. In addition, beginning in 1967-69, the USSR deployed, and has maintained ever since, in the Soyuz-Salyut systems the equivalent to the US military manned space program such as MOL which was discussed, but which was never developed. The timeing,expenditure,and continuity of these systems USSR suggests something more than simply a reaction to proposed or real US R&D programs. It is thus often virtually impossible to determine cause and effect from the outside concerning USSR weapon development decisions vis-à-vis analogous US systems.

68. The USSR began its ASAT test series after the Outer Space Treaty had gone into effect. It also initiated its FOB tests in late 1967. Both the FOBs tests and the first USSR ASAT test series ended in 1971, and it is possible that the halt was called in coincidence with the negotiations of the first SALT agreement, perhaps in order not to imply any threat to space-based "national technical means of verification", which were not to be interfered with according to the treaty. The FOBs tests were never renewed.

69. The only suggestion has been that USSR ASATs that approach their targets on more circular orbits, and hence at a slower bypass, in contrast to those with more eliptical orbits and a faster bypass, were the ones that contained an "inspection" capability of some sort. See Deborah Shapley, "Soviet Killer Satellites: US Ponders a Response" Science, 193:4256, September 3, 1976, pp. 865-66. As late as 1982 Berman and Baker speak of "Soviet... Interceptor and Inspector Satellite Launches".

70. Soviet Military Power (2nd Edition, March 1983), US Dept. of Defense, pg. 65. Other sources refer to a "shower of skrapnel".

71. "Satellite Killers", Aviation Week & Space Technology 104:25 (June 21, 1976). See also reference 72 below.

72. US Senate, Committee on Commerce, Science and Transportation, Hearings: NASA Authorization for Fiscal Year 1978, Part 3, March 1977, 95th Congress. Washington, D.C.: US Govt. Printing Office, 1977, p. 1636. See also Shapley, op. cit.; "Third Soviet Failure: Anti-Satellite Satellite Falls", Washington Post, July 24, 1976; see also, "Soviet Anti-Satellite Mission Fails to Reach Its Target", Aviation Week & Space Technology 105:5 (August 2, 1976): 24; and Finney, op. cit.:

Aldridge, op. cit.; A.Tucker, "Russians Seek Killer Satellite", The Manchester Guardian, September 20, 1976; Weinraub, "Brown Says Soviet Can Fell Satellites", op. cit.; "Soviet Union Outpaces US in Preparing for Possible Wars in Space, Brown Says", Wall Street Journal, October 5, 1977; "Satellite Killer: Now a New Arms Race in Space", op. cit. According to Sec. of Defense Harold Brown, the USSR carried out 8 ASAT tests in the 1976-1979 period.
Not only the failure rate but the actual number of USSR ASAT tests was reported differently by the best sources available. ACcording to SIPRI data as of January 1, 1979, seven targets had been subjected to ten intercepts of four different kinds over a period of nine years, and the final test in 1978, used an earlier target vehicle. ("The Soviet Interceptor Programme", op. cit.) Sheldon listed — as of the end of 1978 — sixteen interceptor flights against fourteen targets; C.S.Sheldon II, "Soviet Space Activities in 1978", Air Force Magazine 62:3 (March 1979): 86

73. SIPRI, "The Soviet Interceptor Programme", op. cit. See also "US Funds Killer Satellite Effort", Aviation Week & Space Technology 108:6 (February 6, 1978): 19.

74. SIPRI, "The Soviet Interceptor Programme", op. cit.; and Freedman, op. cit.

75. Perry, op. cit., pp. 328-329.

76. C. Covault, "Soviets Build Reusable Shuttle", Aviation Week & Space Technology 108s12 (March 20, 1978): 14-15; "Soviets Reveal Orbital Space Plans", Aviation Week & Space Technology 110:15 (April 9, 1979); "Soviet Re-Entry Tests: A Winged Vehicle", Spaceflight, , May 1980, pg. 213-214.

77. "First Photos of Soviet Space Shuttle", Ny Teknik (Sweden) June 16, 1983. This particular test led to the release of a suggestion in Washington that the Soviet space vehicle "... may have been a space-borne atomic weapon built to attack aircraft carrier task forces in the Indian Ocean, according to some sources in US space intelligence". Thomas O'Toole, "Soviet Spacecraft May Have Been Atomic Weapon, US Sources Say", International Herald Tribune (from the Washington Post), March 18, 1983.

78. Richard Burt, "US Says Russians Develop Satellite-Killing Laser", New York Times, May 22, 1980, (also in International Herald Tribune, May 23, 1980). Both before and after this report there were various rumors and allegations that USSR had damaged different US satellites on occasion by ground based laser, for example a SeaSat in October 1978 and a photo reconnaissance satellite in February 1983. Aviation Week and Space Technology also alleged in 1981 that the USSR's Cosmos 1,267 satellite was an "antisatellite battle station in orbit".

79. Aviation Week and Space Technology, ; "Soviet Satellite-Killer Looms Large", Christian Science Monitor, December 7, 1981.

80. The Dept. of Defense Activities in Space and Aeronautics, FY 1980, March 15, 1979, p. III-41.

81. Richard Burt, "Russians Again Test A 'Killer Satellite'", New York Times, April 19, 1980, (International Herald Tribune, April 21, 1980) "US Intelligence Indicates Russia Tests Satellite Arm", International Herald Tribune, February 7-8, 1981; "Gains by Soviet Reported in Test to Kill Satellites", New York Times, March 19, 1981.

82. "Soviets See Shuttle As Killer Satellite", Aviation Week and Space Technology, 108:16 (April 17, 1978) : 17

83. "... there is talk about the installation of anti-satellite arms... laser or missile weapons... the creation of a device for scattering space mines. Possibilities are being explored for using Columbia as a kind of space bomber with nuclear weapons on board", quoted in Defense Daily, October 6, 1981, p. 156; "Washington was now discussing the contribution of space weapons to the development of first strike capability. A major role in this was assigned to the reusable space shuttle transport system", "An Abuse of Human Endeavor", Soviet Weekly, November 7, 1981. Tass and Soviet television reporting on the flight of the Shuttle in the spring of 1981 portrayed the new spaceship as primarily an instrument for testing laser weapons and 'Killer Satellites' in space". Anthony Austin "Brezhnev Hints He Wants Talks on Space Arms Curbs", New York Times, April 18, 1981.

84. "Soviets See Shuttle as Killer Satellite", op. cit.; "Space Shuttle Due to Test Laser Sight, Sources Say", Baltimore Sun, January 7, 1980

85. Clarence A.Robinson Jr. "Shuttle May Aid in Space Weapon Test", Aviation Week and Space Technology, October 31, 1983) p. 74

86. The Strategic Survey, International Institute of Strategic Studies, 1978 London" 1979, pp. 25-27.

87. Quoted in "The High Cost of Confusion: The New Military Budget", The Defense Monitor 8:6 (May 1979): 4.

(88.) US Senate, Committee on Foreign Relations, The SALT II Treaty, Hearings, Part I, July 11, 1979, pp. 423-424. 96th Congress.

89. Robert P. Berman and John C. Baker, Soviet Strategic Forces: Requirements and Responses, Washington, D.C., The Brokings Institution, 1982, p.150-153.

90. John Pike, "Anti-Satellite Weapons and Arms Control", Arms Control Today, 13:11 (December 1983) p. 4-5.

91. Richard L. Garwin, "How to Avoid Nuclear War", Erice-Trapani, Sicily, Aug. 20, 1983, mimeographed. p. 11

92. Fredric J. Brown, Chemical Warfare, A Study in Restraint, Princeton, Princeton University Press, 1968.

93. "Killer Talks", Aviation Week & Space Technology 107:22 (November 28, 1977): 13.

94. "Anti-Satellite Bid", Aviation Week & Space Technology 107:10 (November 7, 1977).

95. Richard Burt, "US Asks Soviet to Begin Talks on Banning Anti-Satellite Weapons," New York Times, March 19, 1978.

96. David K. Shipler, "Soviet Said to Agree on Satellite Talks", New York Times, April 1, 1978. The USSR had carried out its last intercept test on May 19, 1978, the ninth in the series of tests which began in 1976 and the fifth since the US had suggested negotiations in March 1977.

97. "First Talks Concluded on Killer Satellites", New York Times, June 18, 1978

98. "US-Soviet to Begin Talks on Killer Satellites", Baltimore Sun, May 9, 1978

99. H.S.Bradsher, "Administration Hasn't Worked Out Approach on Anti-Satellite Weapons", Washington Star, June 6, 1978. See also A.Bates, Col. (Ret.). "Satellite Killers", The Retired Officer, January 1979.

100. "ASAT Talks", Aerospace Daily, May 15, 1978, p. 86.

101. "US Optimistic on Killer Satellite Ban", Aviation Week & Space Technology 108:26 (June 26, 1978): 20.

102. Presidential Decision Memorandum-37, Washington, D.C.: The White House, June 20, 1978, mimeographed, 3 pp.

103. Burt, "US Asks Soviet to Begin Talks on Banning Anti-Satellite Weapons, op. cit.: "Soviet Warned on Killer Satellites" (AP), June 20, 1978.

104. "Killer Satellite Talks to Resume", Washington Post, January 11, 1979

105. E. Ulsamer, "Space Treaty Rift?", Air Force Magazine 62:1 (January 1979): 14 Ulsamers phraseing is ambiguous at one point and it is not clear if he is implying that the USSR did in fact offer to "pledge" to dismantle its ASAT systems in the course of negotiations to date.

106. R.D.Lyons, "Carter Favors Ban on Atomic Reactors in Earth Satellites", New York Times, January 31, 1978.

107. C. Covault, "Unified Policy on Space Readied", Aviation Week & Space Technology 108:1 (January 2, 1978): 14; see also, B.Jasani, "The Military Use of Satellites: The Quest for a Comprehensive Outer Space Treaty", Bulletin of Peace Proposals 4:3 (1978): 222-226.

108. "Antisatellite Talks", Aviation Week & Space Technology 110:4 (January 22, 1979): 13.

109. "US and Soviet Adjourn Meeting in Bern on Killer Satellite Output", New York Times, February 21, 1979.

110. "Chinese Space Gains Hamper Antisatellite Limitation Treaty", Aviation Week & Space Technology: (July 9, 1979): 18-19; Richard Burt, "US Seeks to Curb Killer Satellites", New York Times, April 10, 1979.

111. R.C.Toth, "Progress is Slow on Discussions by US, Kremlin on Satellites", Washington Post, July 15, 1979; "ASAT Treaty Apparently Stalled", Air Force Magazine 62:7 (July 1979): 14; Richard Burt, "Soviet Said to Ask Space Shuttle Halt", New York Times, June 1, 1979.

112. Walter Pincus, "Space Shuttle Seen as Way to Track, Not Destroy Satellites", Washington Post, June 5, 1979.

113. "In the view of American officials in Washington, Moscow entered those talks despite its commanding lead in space weaponry because it wanted to improve chances of including a new strategic arms limitation treaty covering missiles and bombers." Anthony Ausin, "Brezhnev Hints He Wants Talks on Space Arms Curbs", New York Times April 18, 1981. (There is actually nothing in Brezhnevs public remarks at this time to justify the New York Times article caption.)

114. US Congress, Senate, Committee on Foreign Relations, Subcommittee on Arms Control, Oceans, International Operations and Environment, Hearing: Arms Control and the Militarization of Space, 97th Cong., 2nd Sess., 20 September 1982, Washington, DC: US Govt. Printing Office, 1982.

115. The Committee on Foreign Relations held hearings again in May 1983, but those have not yet been published.

116. R.Jeffrey Smith, "Administration Resists Demands for ASAT Ban", Science 222:- (October 28, 1983) 394-396.

117. "Andropov Offers Accord On Banning The Use of Anti-Satellite Weapons", New York Times, Aug. 19, 1983; John Pike, "Soviet ASAT Initiative rebuffed by Administration", FAS Public Interest Report, 36 (October 1983):6

118. Joe Moakley, "Space Weapons and Congress", Arms Control Today 13:11 (December 1983) 8-9; Charles Mohr, "Conferees Debate Effort For Anti-Satellite Arms", New York Times, Nov. 17, 1983.

119. "Space Weapons and Congress", op. cit.

120. R.S.McNamara, Secretary of Defense, "Remarks, Chicago, September 18, 1964", Department of Defense News Release, No. 670-14, September 18, 1964, p. 1.

121. For a discussion of some of these aspects, see W.W.Kaufman, The McNamara Strategy, New York: Harper & Row, 1964, pp. 232-235.

122. Herbert York, Race to Oblivion, A Participant's View of the Arms Race, New York: Simon & Schuster, 1978, p. 131.

123. G.B.Kistiakowsky, A Scientist at the White House, Cambridge, Mass.: Harvard University Press, 1976, p. 334.

124. The development of United States policy on maintaining the free use of its developing satellite reconnaissance systems is examined in a recent study by Dr. Gerald Steinberg, Satellite Reconnaissance. The Role of Informal Bargaining, New York: Praeger, 1983.

125. Integrating Arms Limitation and Defense Procurement Planning, Science Applications Inc. McLeon, Virginia, July 27, 1981, pp. 5-20. (Study prepared for DARPA; Defense Advanced Research Projects Agency).

126. Gen. David C.Jones, United States Military Posture For FY 1980, March 1979, p. 30.

127. The following recent publications will serve to bring the interested reader up to date on the issues surrounding ASAT developments and arms control:

- Special Issue on Anti-Satellite Weapons, FAS Public Interest Report, 36:9 (November 1983) 16 pages.
- Stephen M.Meyer, "Anti-Satellite Weapons and Arms Control: Incentives and Disincentives from the Soviet and American Perspectives", International Journal 36 (Summer 1981): 460-484.
- Michael M.May, War or Peace in Space, Discussion Paper no.93, Santa Monica, Calif.: California Seminar on Arms Control and Foreign Policy, March 1981.
- Donald L.Hafner, " Averting a Brobdingnagian Skeet Shoot: Arms Control Measures for Anti-Satellite Weapons", International Security 5 (Winter 1980/81): 41-60.
- Raymond L.Garthoff, "Banning the Bomb in Outer Space", International Security 5 (Winter 1980/81): 25-40.
- Herbert Scoville, Jr., and Kosta Tsipis, Can Space Remain a Peaceful Environment? Occasional Paper 18, Muscatine, Iowa: The Stanley Foundation, July 1978.
- Thomas H.Karas, Implications of Space Technology for Strategic Nuclear Competition, Occasional Paper 25, Muscatine, Iowa: The Stanley Foundation, July 1981.
- Gerald Steinberg, "The Implications of New Technological and Political Developments in Anti-Satellites", Technology Review, (October 1981)
- Donald L.Hafner, "Outer Space Arms Control: Unverified Practices, Unnatural Acts?", Survival 25 (November-December 1983): 242-247
- Richard L.Garwin, "Banning Space Weapons", 12 May 1983, mimeographed, 16 pages
- Richard L.Garwin, "Weapons in Space", 26 April 1983, mimeographed, 7 pages
- Svein Melby, Anti-Satellite Weapons, the Strategic Balance and Arms Control, NUPI Rapport, no. 69, Oslo: Norsk Utenrikspolitisk Institutt, June 1982.
- Bhupendra Jasani, ed. Outer Space; A New Dimension of the Arms Race, London, Taylor and Frances, Ltd. 1982. The papers by Bhupendra Jasani, Donald Hafner, J.W.Scheffers, Donald M.Kerr Jr., Walter B.Slocombe, Marcia S.Smith, Regina Veraguth, K.Gottfried in this volume directly pertain to ASAT questions.
- Union of Concerned Scientists, Anti-Satellite Weapons: Arms Control or Arms Race? Cambridge, Mass. 30 June 1983.
- Thomas Karas, The New High Ground, Systems and Weapons of Space Age War, New York: Simon and Schuster, 1983. (Chapt. 6, re ASAT's)
- Colin S.Gray, American Military Space Policy. Information Systems, Weapon Systems and Arms Control, Cambridge, Mass: Abt. Books, 1982.
- David Baker, The Shape of Wars to Come, New York: Stein and Day, 1981. (Chapt. 5, re ASAT's)

TABLES AND FIGURES

TABLE 1

LIST OF MAJOR DECISION POINTS OR STUDY INPUTS FOR US ANTISATELLITE PROGRAMS

1. 1957: First USAF studies of a satellite intercept vehicle.
2. Spring 1958: ARPA establishes the basic elements of Spadats (Space Detection and Tracking System); the two detection networks, USAF's Spacetrack, US Navy's Spasur, and a central computation center.
3. April 1960: Dyna-Soar development formally begins; first USAF-funded studies had been in 1954 and industry proposals requested in late 1957.
4. October 1960: USAF, Air Force Systems Command, established the Air Force Space Study Committee, a panel under Trevor Gardner, to review USAF space activities; suggested seven development plans.
5. November 1960: approval of SAINT.
6. Around January 1961: Military space systems; a separate classified portion of the "Report to the President Elect of the Ad Hoc Committee on Space," known as the Wiesner Report.
7. 1961: Development of optical devices which would permit ground-based systems to perform satellite identification are initiated. Ground-based radar analogues of these systems, later to be grouped in the Space Object Identification (SOI) program, begin in the mid-1960s.
8. September 1961: Air Force Chief of Staff Lemay orders an Air Forve review to establish a unified plan of its military space program (including manned), by the Keese Committee. It prepared a projected ten-year Air Force space plan.
9. November 1961: Air Force Scientific Advisory Board meets on military role in space.
10. November 1961: Air Force position is presented to Sec. McNamara.
11. Around December 1961: Institute for Defense Analysis completes a special study on the same question.
12. January 1962: DDR&E prepares an assessment of the military potential of manned, maneuverable space vehicles for the Secretary of Defense, DOD accepts a "partially accelerated" schedule for Dyna-Soar (but rejects a major speed-up) and comes to an agreement with NASA on additional cooperation in projects on manned space flight and rendezvous.
13. May 1962: DOD approves development of US Army's Program 505, Nike-Zeus direct ascent satellite intercept and destruction system.
14. June 1962: DOD asks the Air Force to translate its ten-year plan into a five-year program including specific projects and specific costs in dollars.

Study completed in September 1962 and presented to Secretary McNamara in November.

15. August 1962: DOD review of the military space program.
16. December 1962: SAINT program "reoriented," with the Air Force deciding to press for a Blue Gemini program to demonstrate rendezvous techniques.
17. December 1962 and January 1963: DOD asks USAF to review and reassess the Dyna-Soar program.
18. January 1963: DOD deletes both USAF Blue Gemini and Manned Orbital Development System, (MODS) proposals from FY 1964 funding request. Secretary McNamara initiates Gemini DOD-NASA cooperation agreement.
19. Early 1963: DOD approves development of USAF Program 437, Thor direct ascent satellite intercept and destruction system.
20. April 1963: Secretary McNamara rejects a group of USAF manned spacecraft proposals.
21. April 17, 1963: Following McNamara's rejections, Secretary of the Air Force Zuckert and Air Force Chief of Staff Lemay empanel Project Forecast, reportedly to press for the Air Force's military manned space program, hoping to produce effects similar to those that resulted from the Von Karman committee many years before. The panel in the end did not produce recommendations primarily focused on the space program, and that portion of its intentions failed.
22. May 1963: First successful intercept test by Program 505.
23. Fall 1963: ARPA study shows that ground ascent intercept systems are feasible.
24. October 1963: DDR&E Harold Brown states that ground-based systems will perform both identification and intercept better than space-based systems when measured in cost-effectiveness terms.
25. December 10, 1963: Dyna-Soar cancelled.
26. December 10, 1963: MOL approved.
27. January 1964: A series of improvements begun for the Spadats system to provide extremely accurate satellite orbits as inputs to an antisatellite program.
28. May 1964: Program 437 makes its first successful intercepts, and both direct ascent systems considered operational soon after.
29. September 17-18, 1964: President Johnson and Secretary of Defense McNamara announce the existence of the two direct ascent systems.
30. 1965: Program 922, the follow-on to Program 437, is initiated.

31. May 1966: DOD carrying out a study on satellite defense, to be completed before submission of the FY 1968 budget.
32. October 1967: DOD adds the mission of intercepting a deorbiting satellite to the Nike-X ABM system as an anti-FOB's program (October 1968 to December 1971: first USSR antisatellite test series, of seven tests).
33. February 1972: DDR&E restudying space defense program.
34. 1973-1974: The number of satellite survivability R&D studies increases, and DOD requires all satellite programs still in R&D stages to include new survivability components.
35. 1974: Program 437 is decommissioned from operational status, and USAF initiates new contracts to develop a conventional direct ascent ASAT system. R&D on Homeing Intercept Technology initiated.
36. February 1976: USSR initiates a second antisatellite test series. The first three tests in 1976 are failures but the test series continues into 1977, and a single test in 1978.
37. December 1976: NSC approves USAF plans to initiate development of a new (ground-based) direct ascent antisatellite system, but the plan is held over for decision by the new administration. (The decision was apparently later approved by the incoming administration).
38. January 18, 1977: DDR&E Currie sends Congress a detailed report on USSR space weaponry, and on the US ASAT program. The first test of the system is planned for 1980, and the system's operational status for 1982.
39. 1977-1978: Carter Administration debate accompanying US suggestions of negotiations with the USSR on antisatellite weapons.
40. End of 1977: President Carter approves decision to initiate a US ASAT development program. The statements on Department of Defense Activities in Space and Aeronautics for FY 1977 and FY 1978 contained the statement: "Our space defense R&D efforts are organized into the categories of space surveillance and satellite systems survivability". The same statement for FY 1979, with a public release Date of March 8, 1978 added a third program to the same statement: "... and our Anti-Aatellite Program"
41. June 20, 1978: Presidential Decision Memorandum on space includes statement on US antisatellite development. Eight months later this was described in US Senate testimony by a Dept. of Defense official as "This was the key point in our program... Up to this point in time we did not have a very vigorous anti-satellite program". As indicated in entry 39, however, the decision must have been taken towards the end of 1977, and this statement does not seem to take into account the Currie report at the end of the previous administration, in January 1977.

42. June 1979: The Air Force grants contracts for ASAT test targets.
43. March 1980: The Dept. of Defense secretly informs Congressional Armed Service Committee that (Presidential) approval has been given for ASAT testing, it is hoped in FY 1982. The information is rapidly compromised.
44. April 18, 1980: The USSR resumes its ASAT testing after a moratorium of two years. The last proceeding USSR rest had been carried out precisely at the initiation of negotiations. Another test is held on March 18, 1981 and additional tests followed.
45. 1982: The "Five year war plan" prepared by the Reagan administration and partially disclosed in the public press apparently envisioned "space based" fighting with anti-satellite weapons. The United States should therefore obtain an operational ASAT system before 1987, and should not agree to any international agreement that would limit the possibility of obtaining such a system.
46. 1983-1984: First US ASAT test of the F-15 aircraft launched prototype Miniature Air-Launched System (IMALS), using the Miniature Homing Vehicle (MHV) to take place at end of 1983 or early 1984. Test takes place on 21 January 1984, not against a target.

GLOSSARY

SAINT, or "Satellite Inspector or Interceptor", Programs 621 and 706. US satellite interceptor development program 1957-1963, cancelled, no flight demonstration, after a cost of over $100 million.

Dyna-Soar, the X-20, research and development program for an advanced manned, winged, orbital aerospace vehicle, 1960-1963. Contained many preliminary studies and designs , 1954-1960, all with their own program acronyms. Cancelled after cost of $405 million.

SPACETRACK, US Air Force satellite detection and tracking system.

SPASUR, (Space Surveillance System), US Navy satellite detection and tracking system.

SPADATS, (Space Detection and Tracking System), overall NORAD satellite detection and tracking system, continually modified and uprated. Contains worldwide radar, optical, and electro-optical sensors.

SOI, Space Object Identification Program.

Skipper, Early Spring, US Navy ASAT research and development programs, early 1960.

Program 505, US ground-launched direct-ascent ASAT. ASAT missiles based on the Army's Nike-Ajax missiles. Deployed, based on Kwajalien Island in the Pacific, from 1964 to 1968.

Program 437, US ground-launched direct-ascent ASAT missiles, based on the Air Force's Thor missiles. Deployed at Johnson Island in the Pacific from 1964 to 1974.

Blue Gemini, an Air Force R&D proposal for a manned vehicle, never approved.

Program 922, R&D follow-on to the Air Force's Program 437 Thor missiles, in the middle and late 1960s.

MOL (MODs), The Air Force Manned Orbiting Laboratory R&D program, 1964 to 1969. Cancelled after a cost of $1.491 billion.

Space Shuttle, the Department of Defense and NASA's "Space Transportation System", a winged, manned, multiorbital aerospace vehicle.

TABLE 3

	Fiscal Year 1970	Fiscal Year 1971	Fiscal Year 1972	Fiscal Year 1973
64406F; Aerospace Defense Program	4.67(part)	7.82(part)	10.0	11.8(?)
64737F; On-Board Sensors	---	---	3.0	---
64405F; Surviv-able Satellite	---	---	6.0	---
3326; Aerospace (deleted) Weaponry	---	1.80	2.7	10.1
6.22.04F, 7760; Space Surveillance and (deleted) Technique	---	1.30	1.1	1.3
"Missile and Space Defense Concepts"	---	---	2.1	8.1
"Space Defense System"	---	---	5.4	10.1

(Spacetrack, FY 1971, $38.6 million)

[It was not possible to find a funding figure for Project SPIKE (621B), a grouping of eight space defense programs, FY 1973.]

SOURCE: Various Department of Defense Annual Appropriations Hearings

FUNDING

["Then year" dollars, in millions]

	1978 and prior	Fiscal year— 1979	1980	1981 (estimate)	1982 to completion
Space defense systems (PE 64406F):					
Development	62.8	73.0	80.5	108.6	(1)
Procurement [2]					
Satellite survivability (PE 63438F):					
Development	20.3	23.2	30.0	35.0	(1)
Procurement [2]					
Space surveillance technology (PE 63428F):					
Development	95.8	36.1	42.1	56.0	(1)
Procurement [2]					
Spacetrack (PE 12424F):					
Development	8.9	6.9	6.2	2.7	2.3
Procurement	42.0	15.2	11.9	7.1	(1)
Construction	2.0	0	5.4	13.0	(1)

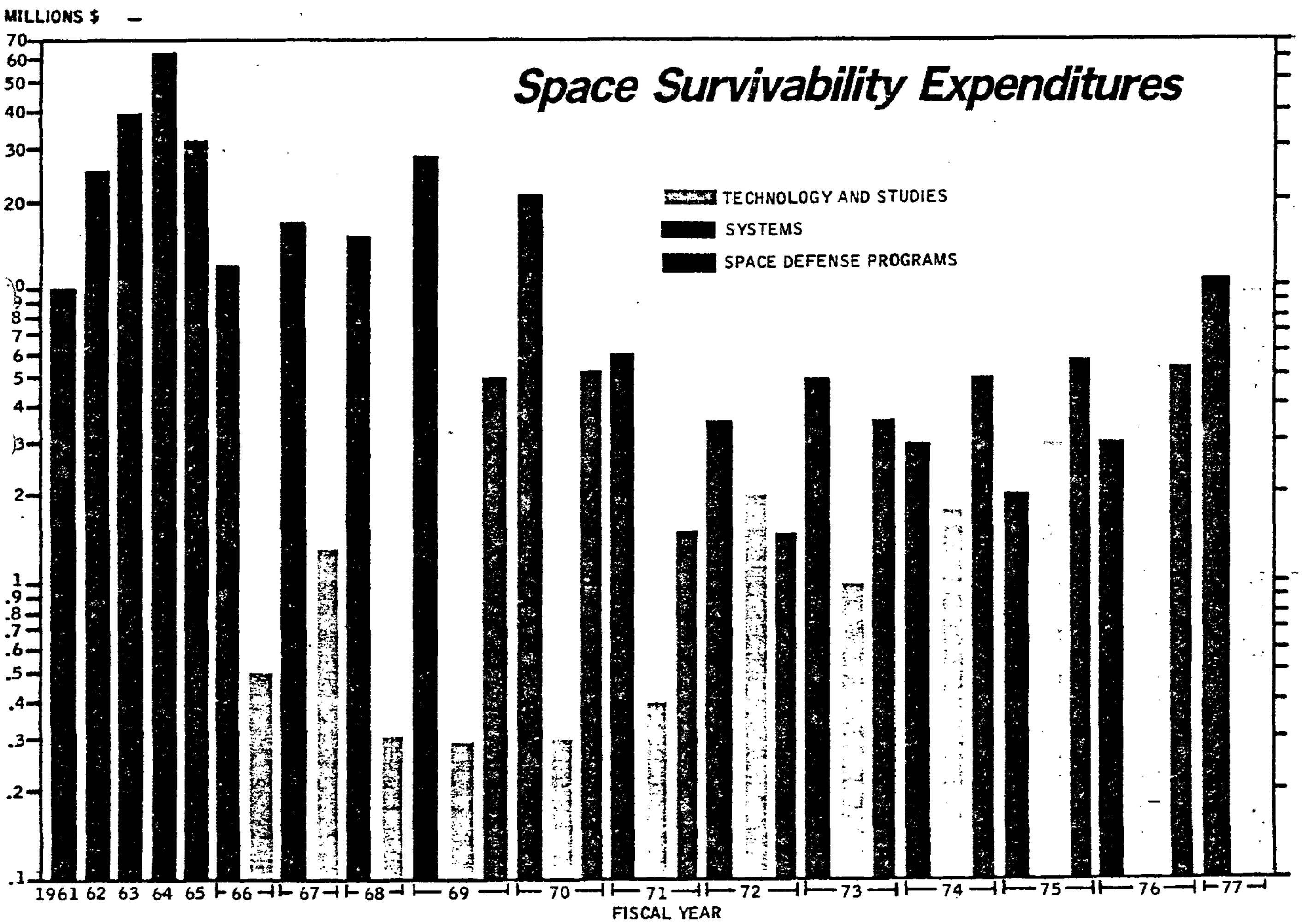
[1] Continuing.
[2] Not applicable; this is an R. & D. program only.
[3] To be determined.

SOURCE: FY 1980 Arms Control Impact Statements, p. 65.

Funding for "Space Defence System."

FY 1972	5.4 million
" 1973	10.1 "
	total 1977 and prior: 21.2 mn.
" 1978	41.6 "
" 1979	73.0 "
" 1980	80.5 "
" 1981	108.6 "

Table 4



Funding trends for military space survivability fall into three categories of expenditures. For the current fiscal year, survivability funding in technology and studies is $10 million, plus another $10 million in space defense programs category. Funding for systems, under which system program offices incorporate survivability features in communications and early warning satellites, for example, is shown only through 1976. The satellite inspection (Saint) program accounts for heavy funding during 1960s.

Source: Aviation Week & Space Technology 106:13 (March 28, 1977):53.

NOTE: The ordinate is in log scale.

Table 5

Program Name	Date When Service Studies Begin	Date When DOD Approval Given	Date Program Operational	Date Program Cancelled	Total Program Costs
Dyna-Soar X-20	1954	(1957 or 1960)	---	Dec. 10,1963	$405.0 mn
(US orbital weapon studies)	(1958-59 to 1963)	---	---	---	
SAINT	1957	1960	---	Dec. 3, 1962 "reoriented"	100(+) mn.
"Blue Gemini"					
Project 437 (USAF)	(USN; "Early Spring", 1960)	(May)1963	May 1964	1974 (or 1975)?	80.0 mn.
Project 505 (US Army)	1960(?)	May 1962	Aug 1963	1968 ~~(1970?)~~	
START		1964			
MOL	1957	Dec. 10,1963	---	June 1969	$1,491.9 mn
Satellite Inspector				Jan. 1965(?)	
Project 922	1968(?)	1968		?	
newest US programs		June 1972 summer 1975 Jan. 1977			
USSR FOB's tests	Nov. 1966 to 1971	---	---	---	---
USSR ASAT tests	10/68-1971 2/76-5/78 4/80-?	---	---	---	---

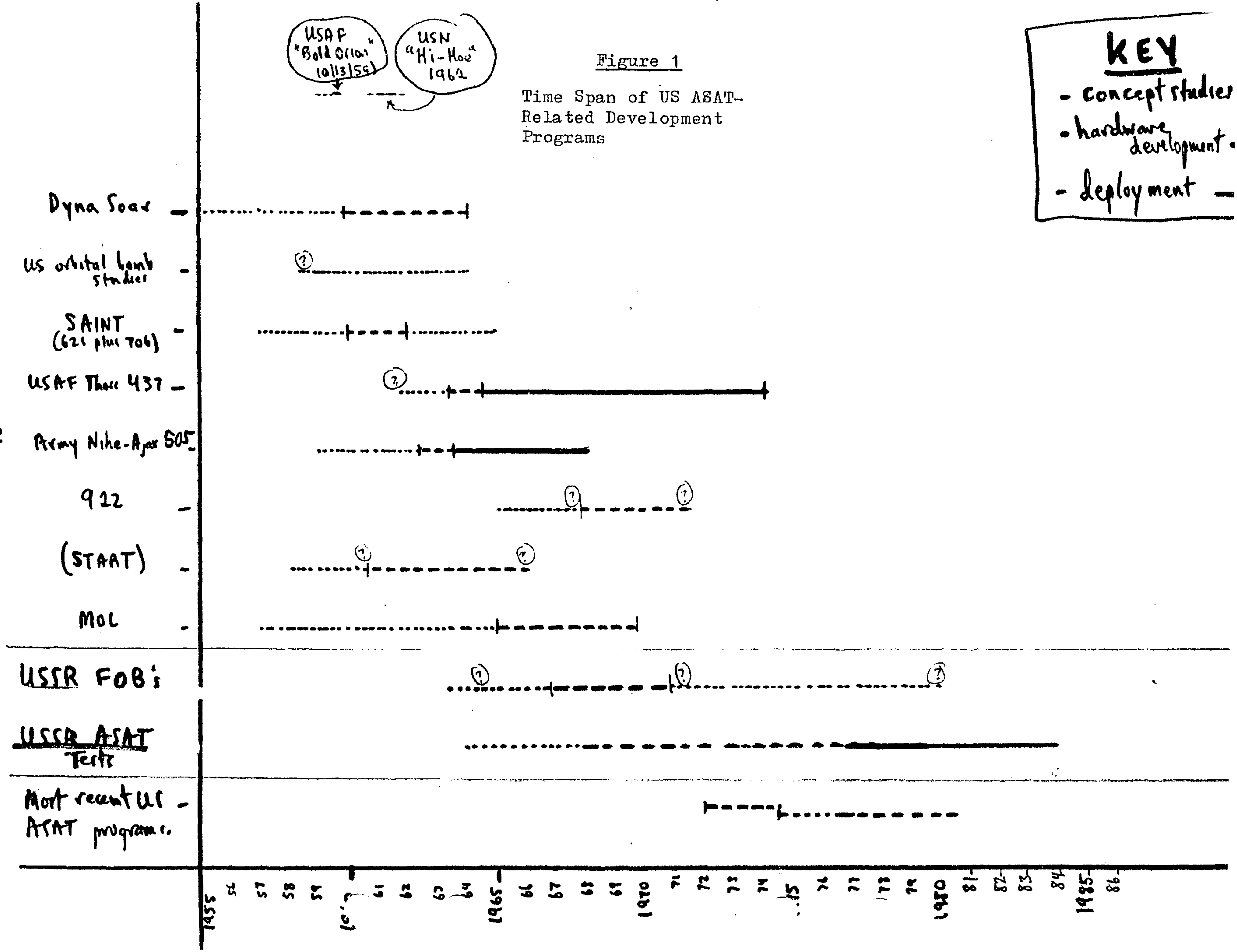


Figure 1

Time Span of US ASAT-Related Development Programs

Table 6. Launchings of Soviet Interceptor and Inspector Satellites, 1968–81

Kosmos number[a]	*Year launched*	*Status*[b]	*Time to intercept (hours)*[c]	Result
249	1968	Exploded	3.0	Failure
252	1968	Exploded	3.0	Success
374	1970	Exploded	3.0	Failure
375	1970	Exploded	3.0	Success
397	1971	Exploded	3.0	Success
404	1971	Returned	3.0	Success
462	1971	Exploded	3.0	Success
804	1976	Returned	11.0	Failure
814	1976	Returned	1.5	Success
843	1976	Returned	1.5	Failure
886	1976	Exploded	3.0	Success
910	1977	Returned	1.5	Failure
918	1977	Returned	1.5	Success
961	1977	Returned	3.0	Success
970	1977	Exploded	3.0	Failure
1009	1978	Returned	3.0	Success
1174	1980	Exploded	1.5	Failure
1234	1981	Returned	3.0	Success
1258	1981	Exploded	3.0	Success

Sources: Lawrence Freedman, "The Soviet Union and 'Anti-Space Defense,' " *Survival*, vol. 19 (January–February 1977), p. 19; David Baker, "Killer Satellites," *Flight International*, October 15, 1977, pp. 1129, 1130; "Soviet Space Programs, 1971–75," Senate Aeronautical and Space Sciences Committee, vol. 1, August 30, 1976, p. 425; Stockholm International Peace Research Institute, *World Armaments and Disarmament: SIPRI Yearbook 1978* (London: Taylor and Francis, 1978), p. 110; *Aviation Week and Space Technology*, April 28, 1980, p. 20.

a. Radar sensors were used by Kosmos 249–918; optical sensors were used on Kosmos 961–1258.

b. Satellites exploded in space are possible interceptors; those returned to earth are possible inspectors.

c. Antisatellite missiles are believed, like reconnaissance satellite missiles, to be capable of a quick enough launching to be in orbit in 90 minutes.

Table 7. Soviet Target Satellites for Interceptor and Inspector Satellite Launches, 1968–81

	Target satellite	
Target type and altitude	*Kosmos number*	*Year launched*
Reconnaissance, 150 nautical miles	291	1969
	450	1971
Elint,[a] 350 nautical miles	248	1968
	373	1970
	394	1971
	752	1975
	803	1976
	959	1977
Navigation, 600 nautical miles	400	1971
	421	1972
	839	1976
	909	1977
	967	1977
	1171	1980
	1241	1981

Sources: Same as table D-1.

a. Electronic intelligence.

Source: R.P. Berman and J.C. Baker, Soviet Strategic Forces: Requirements and Responses, Washington, DC: The Brookings Institution, 1982, pp. 152-153.

Table 8. . SOVIET SATELLITES VULNERABLE TO AMERICAN ASATS

	1983				1989			
	photo recon	radar recon	early warning	all orbits	photo recon	radar recon	early warning	all orbits
SOVIET SATELLITES	2#	2	9	92	2#	2	3	67
CURRENT ASAT								
Early ASAT	2	2	—	—	2	2	—	—
PMALS	2	2	9	26	2	2	—	10
RESIDUAL ASAT								
Homing Overlay	2	2	—	(59)	2	2	—	(22)
Space Shuttle	2	2	—	(59)	2	2	—	(22)
ADVANCED ASAT								
Advanced MALS	2	2	9	80	2	2	—	26
Trident MHV	2	2	9	92	2	2	3	67
Ground Laser	2	2	—	59	2	2	—	22
Space Laser	2	2	9	92	2	2	3	67

AMERICAN SATELLITES VULNERABLE TO SOVIET ASATS

	1983				1989			
	photo recon	radar recon	early warning	all orbits	photo recon	radar recon	early warning	all orbits
AMERICAN SATELLITES	4	12	3	94	2*	14	3*	141
PRESENT ASAT								
FLV ASAT	4	12	—	29	2?	14	—	24
RESIDUAL ASAT								
Galosh ABM	4	6	—	11	2?	—	—	3
Progress	4	6	—	(11)	2?	—	—	3
ADVANCED ASAT								
DLV ASAT	4	(12)	3	(94)	2?	(14)	3	(141)
Ground Laser	4	12	—	27	2	14	—	22
Space Laser	4	12	3	94	2	14	3	141
Space Mine	—	—	3	59	—	—	3	96

( ) Numbers in parentheses indicate the total number of satellites that the system could attack for systems that have a number of interceptors that is smaller than the number of satellites in the target set.

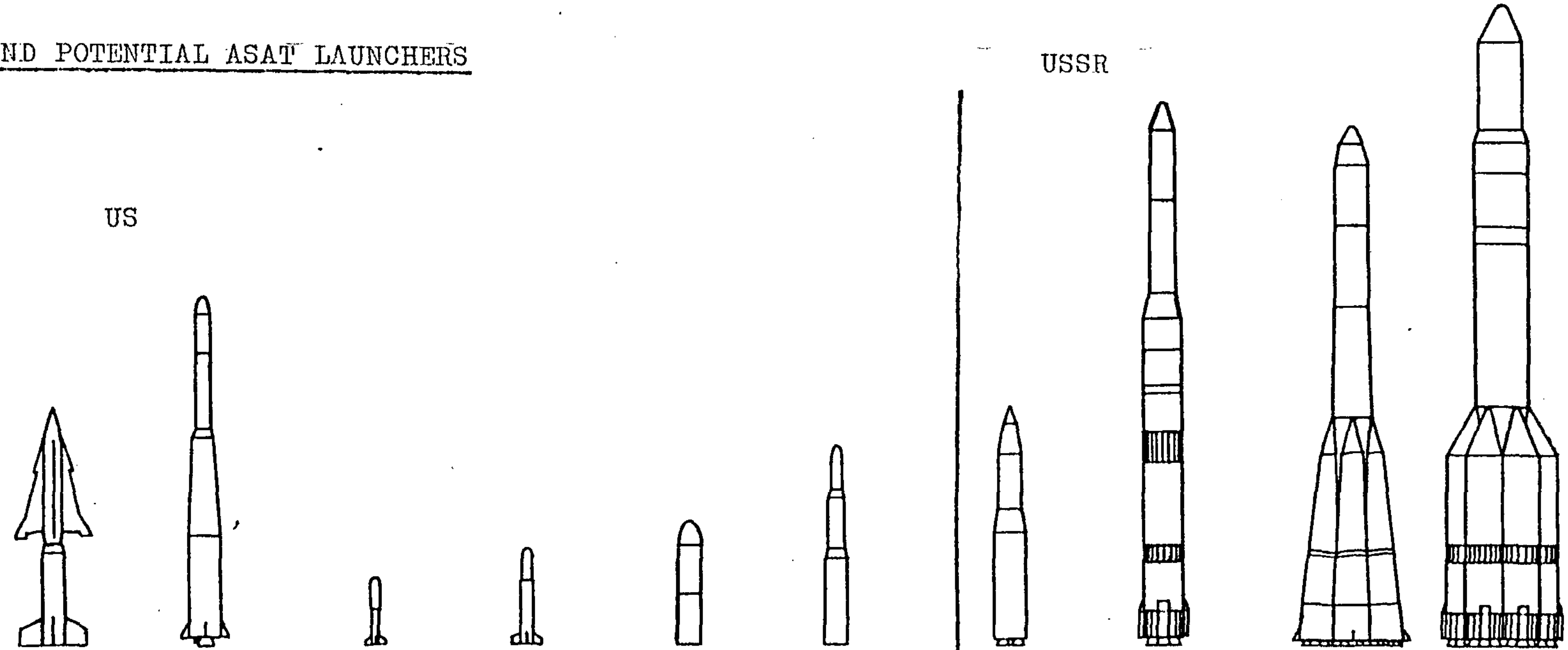
These satellites have demonstrated a very high annual launch rate that suggests a considerable potential for the rapid reconstitution of the on-orbit constellation.

* These satellites will incorporate a very substantial maneuvering capability and on-board attack warning features that will greatly reduce their vulnerability to explosive and impact type ASATs.

? The new KH-12 satellite incorporates a radar-warning system that would degrade the capabilities of the radar-guided Soviet ASAT, but not the passive/optical guided system.

SOURCE: FAS Public Interest Report 36:9 (November 1983): 9.

EXISTING AND POTENTIAL ASAT LAUNCHERS



Designation	505	437	PMALS	AMALS	AMGLS	HOE	Galosh	SUASAT	Progress	Proton
Mission	ASAT	ASAT	ASAT	ASAT	ASAT	ABM R&D	ABM	ASAT	space	space
Operational	1963-67	1964-75	1987	(1989)	199?	1983	1964	1971	1978	1964
Number	5?	6?	112	80?	100?	4+	32+	10	—	—
Launch	ground	ground	air	air	surface	ground	ground	ground	ground	ground
Type	pad	pad	F-15	F-15	various	silo	pad	pad	pad	
Number	2	2	56	80?	100?	1+	64+	2+6?	8?	2+3?
Booster	Nike-Zeus	Thor	SRAM	Castor	Trident	MM-1	ABM-1B	F-LV/SS-9	A-LV	D-LV
Length	19.2m	29.1	5.5m	8.0m	10.3m	16.5m	19.8m	45.1m	42.5m	54.0m
Diameter	1.5m	2.5m	.5m	.8m	1.9m	1.8m	2.5m	3.2m	10.3m	9.2m
Weight	18 tn	63 tn	1 tn	5 tn	15 tn	29 tn	33 tn	230 tn	305 tn	1075 tn
Stages	3	3	2	2	3	3	3	3	3	4
Propellant	solid	liquid	solid	solid	solid	solid	liquid?	liquid	liquid	liquid
Interceptor	50 kt?	1 MT	impact	impact	impact	impact	4 MT	explosive	—	—
Sensor	radar	radar	IR	IR	IR	IR	radar	radar/IR	radar	—
Kill Radius	20 km+	30 km+	.1 m	.1 m	.1 m	10.0 m	50 km+	1-8 km+	—	—
Length	1 m?	3.0 m	.3 m	.3 m	.3 m	2.0 m	—	6.5 m	8.0 m	5.5 m
Diameter	1 m?	1.3 m	.3 m	.3 m	.3 m	1.0 m	—	2.0 m	2.2 m	2.0 m
Weight	300 kg?	750 kg	15 kg	15 kg	15 kg	300 kg	1000 kg?	2300 kg	7000 kg	3000 kg
Trajectory	direct	direct	direct	direct	direct	direct	direct	orbital	orbital	orbital
Flight Time	10 min	15 min	8 min	12 min?	350 min	10 min	12 min	45-180 min	—	350 min
Reach	500 km	2400 km	250 km	500 km?	12000 km	2500 km?	500 km	—	—	—
Altitude	400 km	1200 km	500 km	1500 km?	40000 km	2500 km?	400 km	1800 km	350 km	40000 km

SOURCE: FAS Public Interest Report 36:9 (November 1983): 7.

Figure 2. Comparison of orbits of US satellites of military value with those of Soviet target satellites

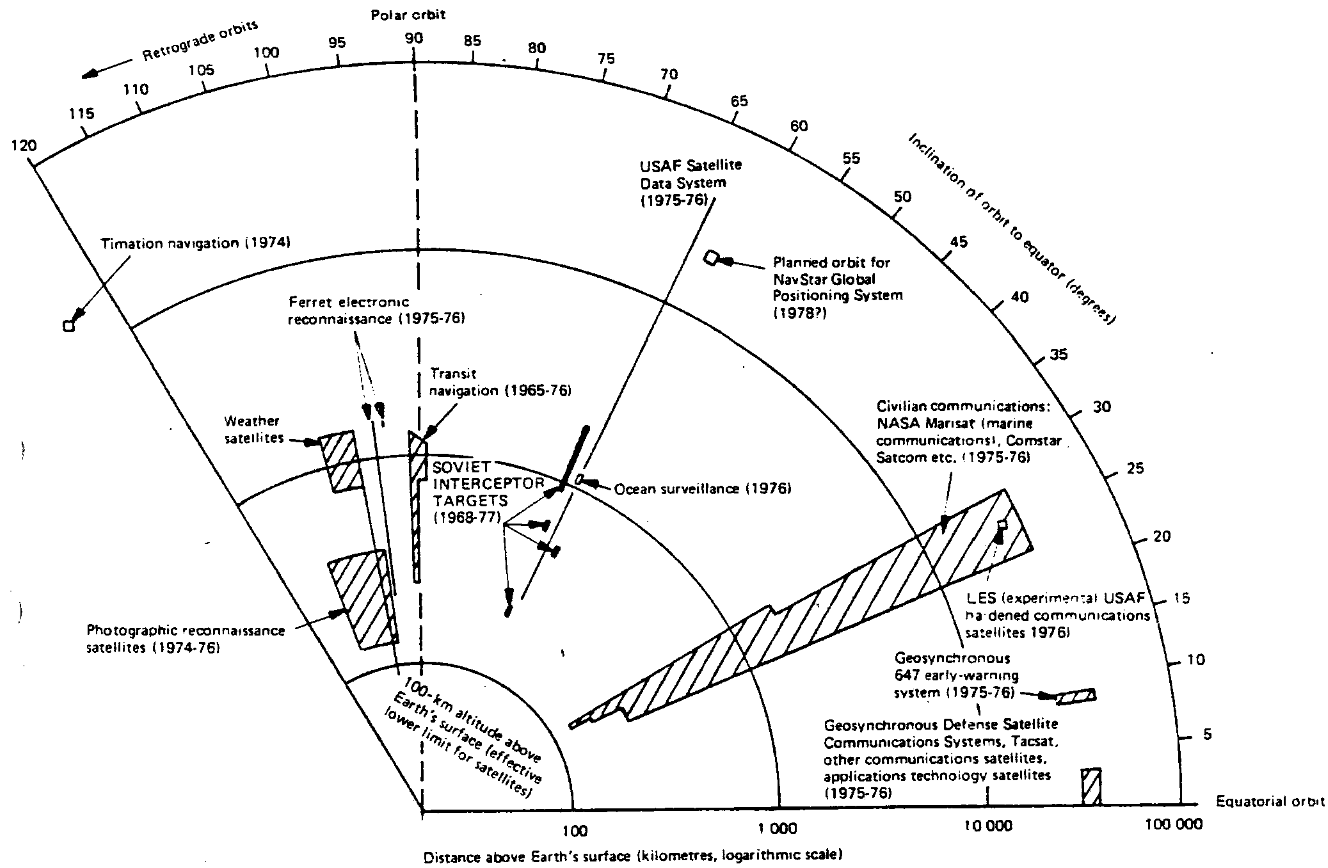


Figure 3 Comparison of orbits of interceptors with those of other Soviet satellites

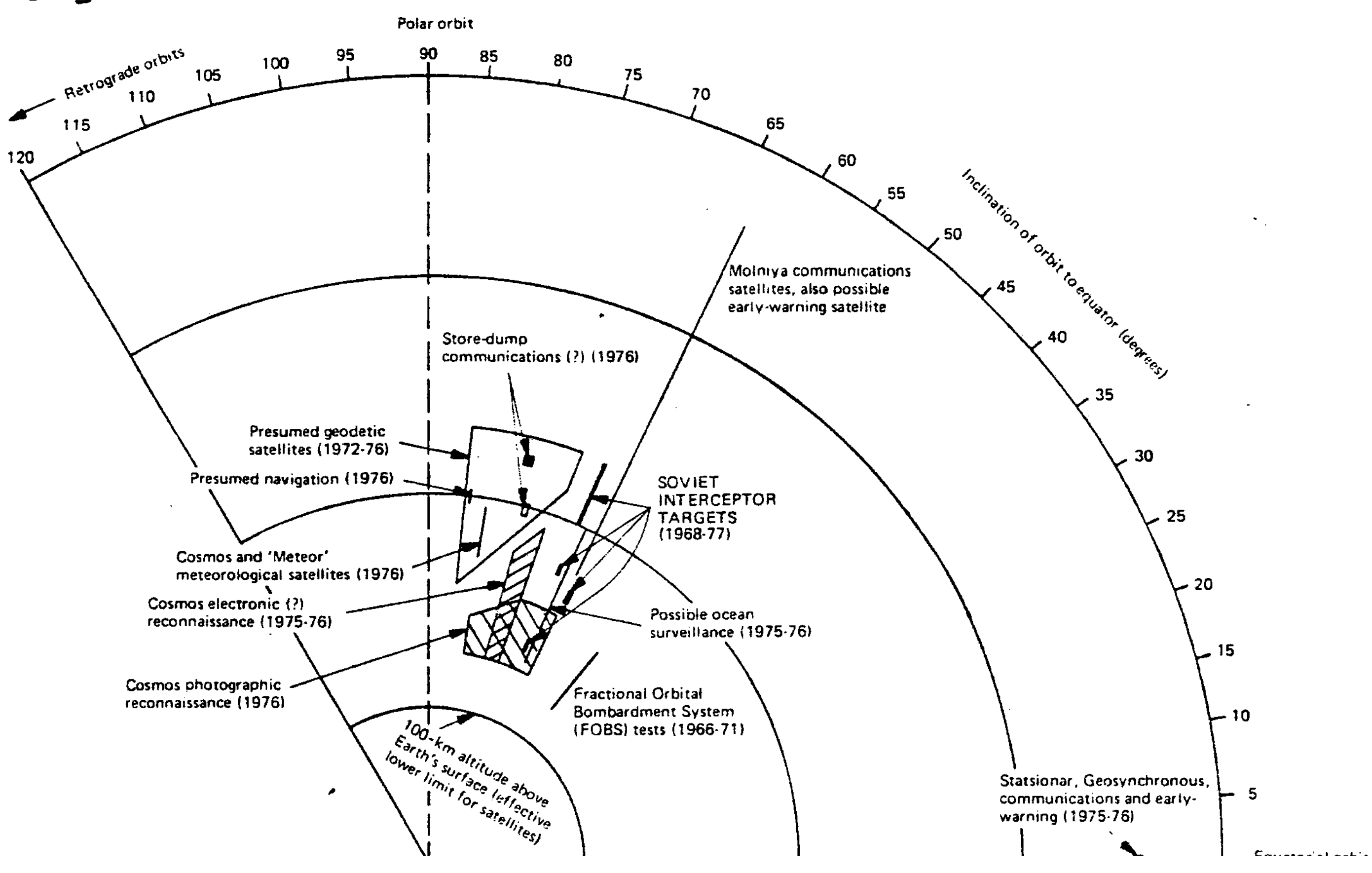
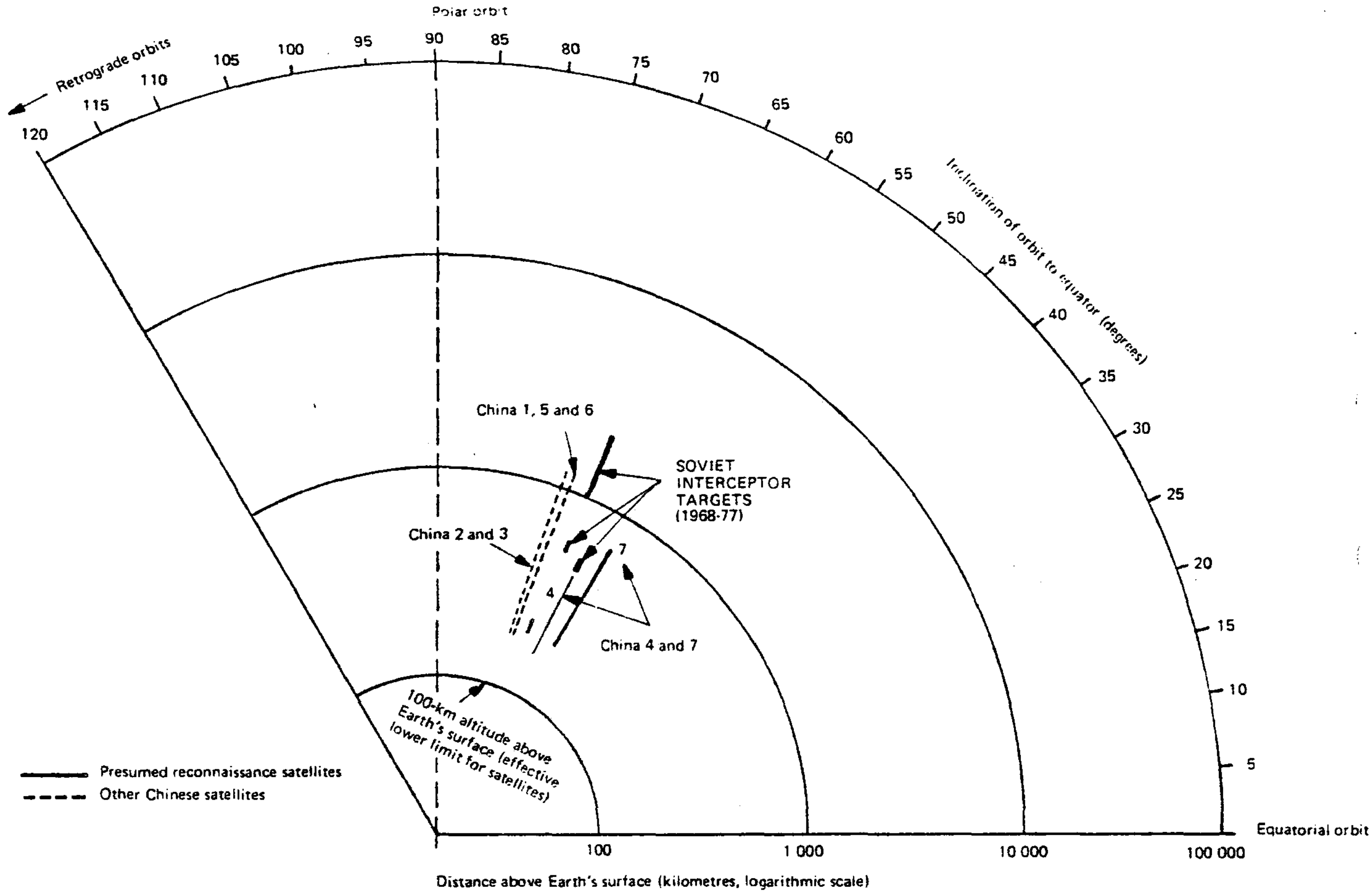


Figure 4 Comparison of orbits of Soviet interceptor targets with those of Chinese military satellites



Source for Figures 2, 3, and 4: <u>World Armaments and Disarmament, SIPRI Yearbook 1978</u>, pp. 111-113.

APPENDICES FOR ASAT CASE STUDY:

1. US Satellite Monitoring and Tracking System
2. The X-20, DYNA-SOAR
3. Other Lifting Body Reentry Vehicles
4. Space Shuttle
5. Space Denial

US SATELLITE MONITORING AND TRACKING SYSTEMS

An essential component of any operational anti-satellite capability or one in development are satellite monitoring and tracking and data systems. The following is a relatively short description of the American systems which were developed to fulfill this role. (1) There is a very substantial literature available on the subject, and only a guide to these systems and their evolution is intended here. The essential point is that it was these monitoring and tracking systems that provided the anti-satellite targeting coordinates for the two land-based satellite intercept systems that the United States deployed from 1963 to 1974, and that would provide the same information for any other operational US ASAT system. Analogous tracking and monitoring systems must have been developed by the USSR.

The basic US system, NORAD's SPADATS (Space Data for Detection and Tracking System), derived from two components, the USAF SPACE-TRACK and the US Navy's SPASUR (Space Surveillance System). They were established in 1958 to deal with a growing satellite population and particularly with unannounced, non-radiating, or "dark" satellites. In addition, all space debris, tankage assemblies, boosters and their segments must be monitored, otherwise there would be no way of knowing which objects were new. All objects thirty inches in size or larger — and some smaller — are tracked, catalogued, have their orbital paths computed, and are assigned a radar signature by NORAD. By far the majority of objects being tracked at any one time are such "space debris", rather than actual US or USSR satellites, operational or dead. This material gradually reenters the earths atmosphere and is thus destroyed but it is continuously replaced by a new and growing population of objects. A single space launcher or its payload can disintegrate into numerous fragments large enough to require tracking. For example, a single US Titan III launch on October 15, 1965 still had 217 fragments in orbit in 1969, and a Soviet Omicron I satellite still had 211 fragments in orbit in 1969.

The USAF SPACETRACK network was established in 1958. Participants were the Air Force's Air Research and Development Command (ARDC), NASA, the Smithsonian Astrophysical Observatory, and numerous domestic and foreign observatories. The first data location, a Filter Center, was established at the Air Force Cambridge Research Center (AFCRC) to receive and process satellite observation data, provide orbit predictions of US and USSR satellites, and prepare observation schedules for various tracking sites. In November 1958, an ARPA order dealing with the surveillance mission changed the Filter Center into the National Space Surveillance Control Center and moved it to Hanscom Field. Soon after AF System Project Office 496 L was established. On April 1, 1960, AFCRC transferred SPACETRACK to the System Project Office. In 1961 (Nov.1960), it was assigned to the Air Defense Command (ADC). Further detail on the evolution of the 496 L SPACETRACK system is included below:

Spacetrack data processing facility established at ESD:	1959
Spacetrack mission assigned to ADC:	1961
Spacetrack data processing facility established at Ent AFB, Colo.:	1961
ISDC established at Cheyenne Mountain, Colo.:	1965
ESD data processing facility shifted to Cheyenne Mountain:	1965
Cloudcroft facility operational:	1965
Hawaii optical tracking facility operational:	1966
Original Elgin AFB facility operational:	1967
Rebuilt Elgin AFB facility operational:	1968
Optical satellite detection system update:	1968
496L (SPACETRACK) and SPASUR systems evaluation by DOD:	1967-68

The sensor components of SPACETRACK are quite varied in type, numerous and of worldwide distribution, from the central Pacific across the Western Hemisphere and in Europe. By 1965, more than 650 sensors sprinkled around the world were providing input to SPACETRACK, and yet others to SPADATS. By 1970, an average of 10,500 satellite observations daily were provided by the system's computers. Some of the radars used are the following:

Surveillance Radar	AN/FPS-17
Tracking Radar	AN/FPS-79
Tracking Radar	AN/FPS-80
Tracking Radar	AN/FPS-85
Optical Surveillance Subsystem	AN/FRS-2

The 416L (SAGE) surveillance radars are part of 496L. In addition, the three large 474L BMEWS radars supply input to SPADATS, as does a Canadian Armed Forces ADC satellite tracking unit, and the Smithsonian Optical Network of Baker-Nunn cameras, as well as the USAF's own Baker-Nunn sites. The Smithsonian network was developed in 1956 and 1957, concurrently with the Minitrack system. The Baker-Nunn cameras actually provided the greatest sensitivity of the systems in use, at least until recently, though their use is severely limited by other constraints to supplying peacetime, non-urgent input.

SPASUR is a far more limited system but is the Navy's counterpart of the USAF SPACETRACK as one portion of the field elements of NORAD's SPADATS. The eleven-station NRL Minitrack radio interferometry system, set up in conjunction with the Vanguard satellite program in 1956 and 1957, was the forerunner of SPASUR and became operational in 1958. On June 20, 1958, ARPA authorized the Naval Research Laboratory (NRL) to construct two tracking complexes, roughly crossing the southern US from east to west. The eastern complex was put into operation on July 29, 1958, less than six weeks after the ARPA order was issued. A Space Surveillance Operations Center was established at the Naval Weapons Laboratory, Dahlgren, Virginia. In October 1969, DOD transferred project control from ARPA to the Navy. On February 1, 1961, the system was placed under operational command of NORAD. In 1965, NORAD was reorganized and in September 1965, the Space Defense Center assumed operational direction of the field systems. SPASUR funding for Operations and Maintainance (O&M) was only about $23 million through FY 1967. The early system consisted of nine field stations; three transmitter sites, and six receiver sites. In 1965 improvements increased the detection range of the SPASUR system and its accuracy in making lower altitude locations. New technology that only required a single receiving station (rather than three) was also instituted, which permitted extension of the network to Pacific and Caribbean islands. The Navy also purchased AN/FPQ-10 radars, which were capable of tracking satellites, and NRL's largest 150-foot radar antenna has also been used to track satellites as have radio telescopes.

When ARPA first established Project Shepherd and the Interim National Space Surveillance Control Center (INSSCC) in 1958, the Army was also involved in the competition for assignment of some operational role in the system. Its entry was the set of three "Doploc" sites, geographically in between the two Navy SPASUR chains. These apparently did not perform well and the Army stations were dropped from the program. Shepherd funding from June 1958 through FY 1960 was approximately $31.5 million.

A combination of optics, more sophisticated ground-based radars and computer software in the SPACETRACK system have gradually been able to supply at least some part of the information that was once sought in a manned or unmanned flyby satellite inspector program. Some of the advanced optical facilities include the two-station Cloudcroft New Mexico satellite photographing and identifying observatory, the POSS (Prototype Optical Surveillance System) AN/FPS-2, updated in FY 1968, a Satellite Optical Surveillance Station (SOSS), and a laser-radar and optical station at Maui, Hawaii. Many of these facilities and programs as well as others are part of the Space Object Identification (SOI) program initiated in 1966. The SOI program includes measurement of radiation signatures in the visible and in the infrared spectrum. The RATSCAT (Radar Target Scatter) system produces a catalog of radar images of possible space vehicle shapes for use in identification as did ARPA's TERF project of 1964-65. The LARIAT (Laser Radar Intelligence Acquisition Technology), a laser system, is used at Cloudcroft for satellite illumination and tracking. (~~Insert: on laser satellite illumination re recon ASAT.~~) The radar portion of the SOI program is dependent on fine signature analysis of radar returns, which vary with satellite geometry and stabilization. By 1970, a pulse-compression ("chirp") millimeter radar was to provide indication of satellite surface feature irregularities six inches apart from one another at ranges of 200-800 miles, and slight perturbations of satellite position also provide indications of satellite geometry.

Development of the sophisticated optical devices, both POSS and others, began as early as 1961. Different systems have different capabilities, some for the highest accuracy (sensitivity and precision of location), others for large numbers of simultaneous observations, others for signature analysis. The twelve Baker-Nunn cameras operated by the Smithsonian Astrophysical Observatory and the five operated by the USAF reportedly can locate a six-inch sphere at 2,400 nautical miles and a basketball-sized object at 500,000 nautical miles. The USAF Naystack radar reportedly can track an object the size of a coin at 1,000 miles. BMEWS resolution is about 4 feet by 8 feet at 3,000 miles. The ranges of most of the radar systems were far below geosynchronous altitudes, but the AN/FSR-2 electro-optical units that became operational in July 1965 had ranges of 20,000 miles or more. Other systems were primarily concerned with volume. The FPS-85 radar at Eglin AFB doubled US satellite tracking ability. In 1967-68 there were about 1,500 objects in orbit at any one time, 25 percent of which were operating satellites, and about 5,000 objects were expected by the mid-1970s. The single radar was to have the capability to track 95 percent of all objects in space at any one time. The computer complex at NORAD's Space Defense Center (SDC) reduces and refines these data and provided the tracking, aiming and intercept instructions via computer-to-computer links to the 437-L Thor ASAT missile sites on Johnston island and to the Army's Nike-Zeus missiles on Kwajalein Island. The Eglin radar was the first DOD space surveillance serviced entirely by uniformed personnel. All the other major sensors of the SPADATS net are maintained and operated by civilian defense industry contractors. SPACETRACK funding in FY 1966 was $40 million, and SPASUR, $6.8 million. In addition, one month after the USSR conducted its second series of ASAT experiments, NORAD decided on December 1, 1970, to provide an Alternate Space Defense Center at the Eglin FPS-85 site. This would require the Eglin facility to provide some or all of the Colorado SDC functions:

- maintain the space inventory catalog;
- issue bulletins to each sensor of target times of arrival and surveillance angles;
- assign priorities for each space object for each sensor;
- provide interceptor coordinates for the 437-L system ASATs (until 1974).

New radars continued to have additional satellite reconnaissance capability. The Cobra Dane AN/FPS-108 radar at Shemya AFB (Alaska) was designed for a performance requirement of simultaneously tracking 300 known and 200 unknown objects. The SAFEGUARD ABM systems PAR radar had some degree of such capability also. The Deep Space Surveillance Radar (DSSR) planned in 1974 was to have a range capability of 22,300 miles. Saturation continued to be a problem as the number of objects in space in 1975 reached to around 4,200. Of 929 new objects in 1975, 151 were payloads launched by sight countries and 778 were debris. As the USSR began its ASAT experiments there was more and more interest in being able to spot such spacecraft as soon as possible after launch, and certainly within its first revolution. Studies and technology development programs were underway in 1974 on new ground-based and satellite-borne electro-optical sensors for this purpose. (2) It was stated that the combined systems accumulated over a fifteen-year period still had limited capability over 3,000 nautical miles altitude and gaps in the coverage below that as well. In 1978, the DOD announced a $33 million program for five new ground-based electro-optical stations, the Ground Electro-Optical Deep Space Surveillance System, or GEODSS. Several of these would again require overseas basing sites, as had other parts of the SPADATS and SPACETRACK systems. One of the new facilities was to be in South Korea and one in the Middle East. (Satellite-borne systems are discussed in the section of the main study on the "US program.")

86

1. There is ample and excellent documentation on US military satellite surveillance and tracking systems in the open literature. Some of the more important sources describing the components, capabilities and performance of these systems are included in the following list:

a) Wilkes, O., "US Surveillance of Orbiting Objects," World Armaments and Disarmament, SIPRI Yearbook 1978, (Taylor & Francis, London), 1978, pp. 114-130.

b) Program 496L (Spacetrack), DMS Market Intelligence Report, Electronic Systems, January 1970, 5 pages.

c) Space Surveillance System: NAVSPASUR, Weapons System 434, DMS Market Intelligence Report, April 1969, 2 pages.

d) Aerospace Defense, Background Information, USAF, 69-6, October 1969, 20 pages.

e) Thomas, P.G., "Space Traffic Surveillance," Space/Aeronautics, 48 (6), November 1967, pp. 75-86.

f) Corliss, W.R., "Spacecraft Tracking," NASA, EP-55, 18 pages.

g) Space Handbook; Astronautics and Its Applications, Staff Report, Select Committee on Astronautics and Space Exploration, U.S. Senate, 85th Congress, 2nd Session, US GPO, 1959, pp. 80-84.

h) Missile and Space Ground Support Operations, 23rd Report by the Committee on Government Operations, 89th Congress, 2nd Session, US GPO, 1966, pp. 22-27.

i) Sections on Tracking and Data Acquisition, Semi-annual Reports of NASA.

j) Avionics Research: Satellites and Problems of Long Range Detection and Tracking, (ed.), E.V.D. Glazier (AGARD Symposium Volume) Pergamon, Oxford, 1960).

k) Gettings, H., "Shepherd Touching Off Interservice Row," Missiles & Rockets, 6 (10), March 7, 1960, pp. 21-25.

l) Booda, L., "Military Space Tracking Needs Outlined," Aviation Week and Space Technology, 74 (5), January 30, 1961, pp. 33-34.

m) Klass, P.J., "Spadats Network Relies on Varied Sensors," Aviation Week and Space Technology, 78 (7), February 18, 1963, pp. 89-93.

n) Hanes, H.A., Major. Gen., "Satellites, Sensors & Space Specialists," Air University Review, 16 (2), January-February 1965, pp. 2-12.

o) "A New Fence in Texas," Naval Research Reviews, 18 (6), June 1965, pp. 13-15.

p) "Spacetrack, Keeping Tabs on What's Out There," Air Force and Space Digest, 48 (7), August 1965, pp. 52-53.

q) Klass, P.J., "Navy Improves Accuracy, Detection Range of Space Surveillance Chain," Aviation Week and Space Technology, 83 (7), August 16, 1965, pp. 56-59.

r) Burnham, F., "New FPS-85 Will Not Help Against FOB," Aerospace Technology, 21 (13), December 18, 1967, pp. 22-23.

s) Jones, D.L.; Tessier, E.A., "The US Naval Space Surveillance System," US Naval Institute Proceedings, 93 (7), July 1967, pp. 142-145.

t) Elson, B.M., "US Space Tracking Capability to Double," Aviation Week and Space Technology, 88 (1), January 1, 1968, pp. 64-

u) Kissell, K.E., "OPOS, Study of the Optical Properties of Satellites," OAR Research Review, 7 (2), February 1968, pp. 4-6.

v) Williams, H.R., "Space Debris, Keeping Track of Space Junk," Air Force and Space Digest, April 1969, 52 (4), pp. 60-61.

w) Anderson, L.J.; Mohlke, B.H., "Radar Analysis Reveals Satellite Parameters," Space/Aeronautics, 51 (6), June 1969, pp. 77-80.

x) "94-GH_2 Radar to 'Picture' Objects in Space," Electronic Design, 17 (14), July 1969, pp. 25-26.

y) "Keeping Track of Earth Satellites," Spaceflight, 12 (1), January 1970, pp. 2-7.

z) Miller, B., "New Roles Grow for Electro-Optics," Aviation Week and Space Technology, 92 (25), June 22, 1970, pp. 155-167.

aa) Klass, P.J., "FPS-85 Radar Expands to Cover SLBMs," Aviation Week and Space Technology, 98 (8), 197 , pp. 61-67.

bb) Moore, O.C., Maj. Gen., "No Hiding Place in Space," Air Force Magazine, 57 (8), August 1974, pp. 43-48.

cc) "Cobra Dane, (AN/FPS-108) Radar System," Signal, #8, May-June 1977, pp. 60-67.

dd) Klass, P.J., "Norad Data System Has 100% Overrun," Aviation Week and Space Technology, 109 (18), 1979, pp. 61-63.

ee) Wilkes, O.; Gleditsch, N.P., "Optical Satellite Tracking, A Case Study in University Participation in Preparation for Space Warfare," Journal of Peace Research, 15 (3), 1978, pp. 205-225.

2. Several sources which provide information on more recent US spacetracking capabilities, such as the GEODDS system, are given in the sources below

a) US Senate, Committee on Armed Services, Hearings, Dept. of Defense Authorization for Appropriations for Fiscal Year 1980, Part 6, Research and Development, March-April 1979, pgs. 3020 to 3025, 96th Congress.

b) "US Upgrading Ground Based Sensors", Aviation Week and Space Technology, 112 (24), June 16, 1980, pp. 239-242

c) "Space Surveillance Deemed Inadequate," Aviation Week and Space Technology, 112 (24), June 16, 1980, pp. 249-254; 259.

d) "Watching the Action in Orbit," Time, March 24, 1980.

e) pages in Owen Wilkes, "The Arms Race in Space," in World Armaments and Disarmament, SIPRI Yearbook 1978, SIPRI, Stockholm International Peace Research Institute, Taylor and Francis, Ltd,

THE X-20, DYNA-SOAR

The Dyna-Soar development program was initiated by the Air Force in mid-1958, after seven years of preliminary studies and investigations by the Air Force, NACA, and industry. It was a "rocket-boosted hypersonic glider representing an advanced stage in the development of a manned orbital vehicle for bombing and for reconnaissance".(1) "Dyna-Soar" was an abbreviation for "dynamic soaring".

The antecedent history of this project is quite intriguing (2-4). The idea had been conceived many years before by Dr. Eugen Sanger in the 1940s in the World War II German rocket development program. It was to be a high velocity rocket boosted lifting body with a range to make it capable of bombing New York City. In 1951, Walter Dornberger, the head of the WW II German rocket program and one of Sanger's colleagues, who had been brought to the US as part of "Operation Paper Clip" and was now working for the Bell Aircraft Corporation first suggested the project to the US Air Force. It was an extended range version of Sanger's idea, with global range. The Air Force became sufficiently interested in the idea in 1954 to begin the funding of a series of studies of rocket boosted hypersonic bombers and reconnaissance aerospacecraft. The first was Project Bomi, followed by the 118 P vehicle, the Brass Bell project, Project ROBO, and the NACA's Hyward's study. Finally in October 1957, after Sputnik, all these studies were merged with studies of aircraft to follow beyond the X-15, and a development plan for an orbital reentry glide vehicle called Dyna-Soar was formulated. The X-15, to which the Dyna-Soar or X-20 was seen as a successor, had itself begun in NACA research in 1952, and approval was given in late 1955 for three X-15 vehicles to be built. The X-15 had investigated the materials, design and pilot problems in the Mach 2 to Mach 6 range. Its design altitude was 50 miles, suborbital, and did not involve reentry. The Dyna-Soar was to go to Mach 12. In December 1957, industry was asked to submit proposals, and a phase I definition contract was let in 1959. As development progressed, the booster selection history for the vehicles was as follows:

1958:	M^2 Cluster	1961:	Titan II
1959:	Atlas-Centaur	1962:	Titan III
1960:	Titan I	1963:	Titan III (redesigned)

For several years, the only justification for the Titan III development program, which was quite expensive in its own right, was as a booster for Dyna-Soar and then for the MOL.

When the Air Force issued the request for Dyna-Soar proposals in 1957, the R&D program objectives were stated as:

1. to demonstrate piloted maneuvering reentry from orbit with conventional glide landing at a precise landing site;
2. to explore full potential of (the) pilot . (5)

Congressional testimony, particularly by Air Force spokesmen, placed very heavy stress on the first objective. The Air Force realized that it could never expect to have an operational ground-to-space-and-return system if it required the kind of extensive involvement of ships and aircraft around the earth foreseen in 1959 as being necessary for the recovery of vehicles in the Mercury and Gemini programs. An operational vehicle would have to be independent once spaceborne, its only requirement being its ability to land at any conventional air base. Hence, the large cross-range reentry and landing capability requirement. These R&D objectives remained the same during Dyna-Soar's six years of program lifetime — but they are only half of the story. They are the only half that OSD testimony on the program discussed in open hearing, with a constantly increasing stress as the years passed on which phases of the program were approved and which were not.

Dyna-Soar is an extremely interesting case of the tension and counterpoint — grounded in counter-purposes — between testimony and statements of the OSD and of the Air Force regarding a system and its purposes, which are discussed below. Military spokesmen hardly missed an opportunity to refer to the hoped-for subsequent operational capabilities of the system, though they may not have specified what they were, when referring to Dyna-Soar. From January to March 1960, "Phase Alpha" studies were carried out, reexamining the L/D configuration of the vehicle. In April 1960, the Dyna-Soar program formally began. It was to have several steps. In Step 1, a Titan 1 launcher was to be used for suborbital flights, since no launcher was yet available with sufficient thrust to put the vehicle into orbit. Step 2A was to explore the R&D aspects of orbital flight. Step 2B was to examine the possible operational use of the vehicle for military and for other needs. Step 3 was to be the development of a complete orbital weapon system for as-yet-undefined missions. Suborbital flights were eliminated in December 1961, and formal selection of Titan 3 as the booster came in February 1962, and release of funds for it in December 1962. In the summer of 1962, the vehicle was re-designated the X-20, "to underscore the experimental nature of the program." The program underwent continuous modifications and rescheduling. As many as twenty air drops from a B-52 were scheduled to begin in early 1965 to familiarize pilots with the vehicle and its operation, and there were to be several unmanned tests of the vehicle at orbital velocities. The first orbital launch was to be in early 1966 with about ten orbital flights to follow. The Air Force had originally hoped to have an operational system sometime between 1966 and 1970.

During 1960 and 1961 the other portions of Step 2, the paper studies on the potential military uses of Dyna-Soar, were being carried out. These were the BOSS (Bomb Orbital Strategic System) and WEDGE (Weapon Development Glide Entry) studies. Parallel studies were also already in process for a follow-on to the X-20, a manned aerospace plane — the Advanced Hypersonic Manned Aircraft — which would have essentially the same flight regimen as the X-20, without requiring a missile for initial launching. The FY 1964 USAF budget included funds for components of this aircraft. An attempt would be made to develop the more difficult components first, before any decision to begin the expensive system development phase. Nevertheless, some of the weapon-mission studies already took this aircraft into account. Some of the missions known to have been studied were bombing, reconnaissance, ferry, support- and satellite inspection and destruction. A description from one of these studies carried in a trade journal ran as follows:

> A Dyna-Soar glider equipped to perform the satellite inspection mission is shown above in an artist's conception closing with an unidentified space vehicle. The equipment bay is open and a sensor module has been extended. During this first phase of the interception, various sensors are used to observe the unidentified vehicle and to check any signals that it might be transmitting or receiving. Later phases of this mission call for possible boarding and/or disabling hostile vehicles. Air Force studies show that a human crew aboard the interceptor vehicle can materially broaden the possible action that can be taken against hostile satellites, will lower over-all vehicle weight to accomplish complex missions, and will improve reliability ... Most of the devices necessary to inspect and disable hostile satellites can be carried in the reentry glider and can be reused. (6)

During roughly the same period of time — late 1961 through 1962 — at least three other separate development study programs produced designs and proposals for <u>manned</u> orbital satellite interceptor vehicles:

- the "manned 621 A", or manned satellite Inspector;
- North American's "Cosmos", an orbital defensive weapon system to be deployed against hostile satellite-based offensive weapon systems;
- Air Force Space System Command's (SSD) "Saint 2". (7)

At least some of the weapon system concepts, particularly the orbital bomber, were distinctly unpopular in the OSD, as the following early quotation amusingly shows.

> ... there is some high-level sentiment in DOD to drop the weapon system requirement on Dyna-Soar — in order to speed its development. Some experts believe the present concept for the space vehicle should be a stepping-stone to a weapon, not an end product. If it were handled strictly as an R&D venture, then a lot of the "garbage" (redundancy, "idiot-proofing", etc.) could be eliminated initially. The hitch, however, is that the Air Force under Administration policy must now justify Dyna-Soar as a weapon, to get the necessary funding. If it drops this requirement, the wolves will move in. (8)

OSD sources, notably Secretary of Defense McNamara and DDR&E Harold Brown repeatedly testified to the drawbacks and inutility of orbital nuclear weapons. They were more expensive, less reliable and far less accurate. In addition, during this period Secretary McNamara repeatedly stated in testimony which was repeated by his subordinates that there was as yet no identified military mission for man-in-space. It was not that the Air Force or its industrial contractors could not "identify" one; it was that the OSD would not agree to the ones they identified, or pointed out that other unmanned satellite systems or weapon systems were performing the specific mission satisfactorily or better.

By the early months of 1962, the Dyna-Soar program became dependent on the Titan III development schedule. Both launcher and vehicle each had development problems, costs rose and development schedules were extended. As this happened, other technology — primarily the Gemini vehicle — also became available. At the time of the FY 1964 Appropriation Hearings, McNamara, Brown and the Air Force all made clear that the OSD had sent Dyna-Soar back to the Air Force for reconsideration. When repeatedly questioned in the Hearings as to whether Dyna-Soar was going to be cancelled, McNamara said that he was not prepared to make his or the Department's recommendation until the Air Force completed its studies. However, he was clearly hinting at his anticipation of that outcome. The fact that the Air Force's hopes for a manned space mission rode on the X-20 — in the same way that it would later ride on MOL but probably to a far lesser degree — did not impress the OSD. McNamara and his deputies clearly were not impressed with the nebulous theories of AF Chief of Staff White (largely derived from Dornberger) of the continuity of air and space, the necessity of Air Force operations in both, of space as the "high ground" and of references to routine "space patrols", opinions that were seconded by Generals Lemay and Ferguson, and strongly supported by Senator Symington. When the Air Force anticipated the demise of Dyna-Soar, it sought to transfer at least part of its role to the "Blue Gemini" program.

> If the anticipated cancellation or cutback of Dyna-Soar takes place, the battleground for the military space program shifts to Titan 3 and Gemini. USAF thought it made a strong case for heavy participation in Gemini and considered Gemini an optimum testbed for manned satellite interceptor components, such as sensors, ferreting devices, cameras and "negation" devices.
>
> The Inspector program, formerly called Saint, has been reactivated with USAF Gemini participation after Saint had reverted to a simple demonstration of rendez-vous. Saint program was cancelled as soon as it became apparent that Gemini would fly and demonstrate rendez-vous before Saint could perform these missions. AFSC's Space Systems Division continues to seek industry advice, however, should Gemini not become the basis of the Inspector satellite. (9)

In the long run, this did not help, but McNamara indicated his preference:

> I don't wish to prejudge the studies that the Air Force and NASA are making but my own quess is that — yes, I guess that we will find that GEMINI has a greater military potential for us, even though a rather ill-defined military potential, than does DYNA-SOAR, and, moreover, that it will be available much sooner than DYNA-SOAR...
>
> I think the DYNA-SOAR project can work out satisfactorily.
>
> The real question is, what do we have when we finish it. It will cost to complete, in total, including funds spent to date, something on the order of $800 million to a billion dollars. The question is, do we meet a rather ill-defined military requirement better by proceeding down that track, or do we meet it better by modifying GEMINI in some joint project with NASA.
>
> At some point we ought to give up covering two bases and decide which one we want to cover, before we have spent a total of, roughly, $800 million for DYNA-SOAR — rather, over $800 million for GEMINI — and a total of $1.6 billion. I think we can cut back very substantially while better meeting both of our requirements, and this is our objective...
>
> I said that we have asked for (deleted) to be appropriated for the DYNA-SOAR program for fiscal 1964. I believe that is the amount. The future of the program is in doubt, in my mind, because events appear to have overtaken it... I seriously question whether our Nation requires that both programs be completed. We have no clear military requirement for either.
>
> I am very anxious, although we don't see clearly a military requirement for men in space, to develop a capability to put a man in space for military purposes, should a requirement develop in the next few years. Therefore, I am very anxious that we proceed with one or the other. (10).

The costs were large, and apparently too much for both programs. Nevertheless in the FY 1964 Hearings, the appropriations for both were still requested and therefore it had to be argued that the two programs were not competitive or duplicative. The testimony was contradictory and tortuous and was presumably recognized as such at least by some in Congress, at the same time as it provided a field day for the media supporters of the military manned space mission. (11)

The end came in December 1963 with the cancellation of the Dyna-Soar program. Four hundred million dollars had already been spent on the program, and at the time of cancellation it was anticipated that the program would cost as much as another $800 million, or $1.2 billion in all. This does not take into account the development costs for Titan III, or the earlier launchers which were planned as X-20 launchers. Costs on those projects were not directly attributed to the Dyna-Soar project. Blue Gemini (as well as the X-20) was itself replaced by the MOL, a much larger vehicle, and some of the rationale for that expansion provided the same arguments that served to kill the Dyna-Soar. Dyna-Soar was competing against the budget, against other technological developments, debates over missions, and its own technical problems. For example, it had not yet solved the problem of coatings to prevent oxidation of its refractory metals. But it must first be pointed out that the cancellation of Dyna-Soar was concomitant with three other decisions. It was by no means a decision to cancel that project alone:

1. The decision to initiate the MOL project. Although a project of a substantially different nature, this still held out some promise for the Air Force of a manned military space mission.
2. By December 1963, when Dyna-Soar was cancelled, the decision to go ahead and produce Projects 505 and 437, the ground based direct ascent anti-satellite Nike-Zeus and Thor missiles in the Pacific had already been made. This took the edge off the anti-satellite mission and Asst Sec. of Defense Harold Brown explicitly argued that this was technically the better way to perform the mission. At the same time it also removed the emphasis on the inspection requirement.
3. The START L/D program was expanded and accelerated. This kept alive the development of manned orbital maneuverable reentry vehicles with wide cross-range landing capabilities. Thus
   - Projects 505 and 437, the direct ascent missiles, took over the ASAT mission,
   - MOL absorbed the manned space goals,
   - START took over the L> D reentry vehicle design
   - and the new Space Object Identification — SOI — systems, as part of Spadats, replaced the needs for inspection.

As far as immediate funding levels were concerned, the net effect of all these changes balanced out, and left both the service and the Department levels where they were. It is ambiguous whether these programs were seen by the OSD as competing against other Defense priorities. Minuteman and Polaris missile procurement was at its height during this period, yet there is substantial evidence that the Department of Defense was anticipating a drop in US military expenditure roughly in the 1963-65 period. (12) In testimony in the FY 1965 Appropriation Hearings, both McNamara and Brown, the latter even more sharply, defended their decisions in cancelling the X-20 and in initiating MOL in very terse terms. Dyna-Soar had been putting the cart before the horse. The problem was to decide what man could do in space that unmanned systems could not, or how much better he could do such things. If it turned out that man was of substantial or novel benefit, then one could think about how to bring him back. Dyna-Soar was focused on the wrong questions. It was designed to answer questions about the reentry and maneuvering phase. MOL would be designed so that it included precise experiments to measure what the man in the vehicle could do. It was also easy to point out that Dyna-Soar was the wrong vehicle to use for testing if man could do anything novel in space. Its useful payload was very low, some 2,500 pounds, as was the time duration in which it could stay in space, some three days. The pilot had no mobility. MOL and its crew would be able to work in a shirtsleeve environment and if necessary could leave the vehicle. Its payload was 20,000 pounds (which would later even be criticized by proponents of the system as being too low). There was both room and payload for experiments. The arguments concerning useful payload, duration, and space in which to work all held for MOL as against Blue Gemini as well. The Air Force wanted a "man in space" — to perform the ASAT mission as well as anything and everything else that could be thought of — more than they wanted an ASAT, which is probably why they kept losing their proposals in the form that they were in. In addition, they were always big projects (as SAINT had been), extremely demanding of complex systems, and pushing the state of the art, or well past it. Projects 505 and 437 were ASATs. They were also quite small, simple and compounded of off-the-shelf existing components. The "basic element" underlying any ASAT system, SPADATS, was already there. The Air Force (and probably the Joint Chiefs of Staff) were no longer unanimous in their approval of Dyna-Soar. How far this extended to the military manned space mission, for the ASAT roll as well as for other things, is not clear. When the Soviet ASAT decision came, it was much more similar to the Project 437 one, in the sense that it was much more of an evolutionary system although it was a space-based, rather than a land-based system (and though it was not — as far as is known — quickly deployed).

REFERENCES

1. Space Handbook; Astronautics and Its Applications. Staff Report, Select Committee on Astronautics and Space Exploration, 85th Congress, 1959, p. 144.
2. "Dyna-Soar's History Full of Reexaminations." Aviation Week & Space Technology 79:4 (July 22, 1963): 233.
3. R. Rotelli, "X-20 Design and Development", in Civilian and Military Uses of Aerospace, Annals N.Y. Academy of Sciences 134:1 (November 22, 1965): 80-92.
4. C. Witze, "Let's Get Operational in Space: Walter Dornberger, Space Pioneer and Visionary", Air Force Magazine 48:10 (October 1965): 81-88.
5. Rotelli, op. cit.
6. J.S. Butz, Jr., "Building Blocks...But No Building", Air Force/ Space Digest 46:4 (April 1963): 56-66.
7. "USAF Starts Manned Saint Studies", Aviation Week & Space Technology 76:23 ( ): 34.
8. "Way to Speed Dyna-Soar", Missiles & Rockets 7:15 (November 10, 1960).
9. E.H. Kolcum, "USAF Sees X-20 Cancellation or Cutback", Aviation Week & Space Technology 78:8 (February 25, 1963): 26-27.
10. US House of Representatives, Committee on Armed Services, Hearings: Military Reserve Posture (Washington, D.C.: US Govt. Printing Office, 1963), pp. 465-467, 477 and 589.

12. Milton Leitenberg, "Efforts at Reducing Defense Expenditure in the United States, 1960-1978", Public Policy 29:4 (Fall 1981): 437-471.

OTHER LIFTING BODY REENTRY VEHICLES

These programs had been started long before the cancellation of the Dyna-Soar program in December 1963, but R & D on them was accelerated as a consequence of that cancellation decision. The $40 million ASSET (Aerothermodynamic/Elastic Structural Systems Environmental Test) L>D vehicle program existed in parallel with the Dyna-Soar. These vehicles are often referred to as L>D or L/D spacecraft, indicating their design intended to produce "lift-greater-than-drag." The data obtained from them was to have been "applicable to vehicles such as Dyna-Soar and an entire family of spacecraft envisioned for global surveillance", that is, for manned orbital and maneuverable reentry vehicles. (1) The preliminary design of the ASSET vehicle had been completed by March 1961, and seven reentry tests, launched from USAF Blue Scout launchers, were to begin in July 1962. (Six tests were flown.) Some years later, NASA also began tests with two L/D vehicles of its own, the M2-F2 and the HL-10. In October 1964, under the direction of Dr. E. Fubini of DOD, the concept of "the technology program" was formalized, and ASSET was established as only the first of four planned phases of the USAF START (Spacecraft Technology and Advanced Reentry Tests) program. Under DOD pressure subsequent to the entry of the Kennedy Administration, Dyna-Soar was also defined as "a research program". START was to be a low-budget program, and it was made evident that the development pace for a manned L>D reentry body would subsequently be dictated by separate programming of technological steps, with the result of each step dictating budgeting and content of the next. As subsequently developed, it was not the results alone that were crucial, but the results in competition and compared with other technologies, with unmanned vehicles, and with programs and missions. The fourth phase never arrived. If the L>D program can be put in a chain of development, it should perhaps be described as the progenitor of the Space-Shuttle. The START program was more or less explicitly a technology program to take the place of Dyna-Soar, but the Air Force's wish for a manned space mission was not to be permitted as its guiding rationale.

The first phase, the unmanned ASSET, was already approved. The second phase, the unmanned PRIME (Precision Recovery Including Maneuvering Reentry) SV-5D vehicles had also been approved. Four vehicles were to be launched by Atlas launchers and their flight schedule included high Mach speed (10-12) reentry from space. The third phase, the manned PILOT — a manned low-speed (Mach 2) vehicle — was still unapproved, as was the fourth phase, studies for a manned reentry vehicle and flight above Mach 5; in effect a full blown "Dyna-Soar" program all over again since it assumed orbital testing of the manned vehicle. The fourth phase was rarely discussed. By 1966, PILOT had been approved. Only one vehicle was to be built, the SV-5P, later called the X-24 and X-24A, and its design had been developed by Martin over a period of seven years in various Air Force studies of manned reentry vehicles going back to 1959 (3-5). Under the constraints imposed by the Office of the Secretary of Defense (OSD) all these vehicles and programs were pursued as technology development programs, while the Air Force was still looking for its man in space — in a manned maneuvering orbital vehicle. Apparently, it was sometimes also thought that these vehicles would in some way be joined to the MOL program. It is interesting that Congressional testimony regarding these vehicles was often deleted, particularly in the earlier years before the aerospace trade journals contained substantial information on them. Military reluctance was very likely due to the not unreasonable suspicion that the START program would be seen as the revival of the cancelled Dyna-Soar program under a different name. In some ways, it was and in others it was not — or at least not yet. Some of the START program vehicles were more advanced than the Dyna-Soar in certain aspects, but the <u>manned</u> orbital and <u>manned</u> high Mach speed reentry portions of the Dyna-Soar program — the more technologically demanding and hence expensive portions of the program — still were not there. It was hence a far less expensive program. Funding through FY 1967 was $47,000,000. (7)

However, it should come as no surprise that someone in the Air Force was thinking about missions and where the program might go to become an operational vehicle, even though OSD could testify that these were solely technological programs. The fourth phase, the manned reentry and orbital vehicles were out of the question unless a specific competitive advantage could be shown for one or more of the dozen or so missions hypothesized for L>D spacecraft as filling some specific "need". Under the PILOT program, the Air Force Space Systems Division (SSD) contracted for the study of the "imperative and the competitive parameters for possible military missions for L>D craft." (7) In February 1967, it was stated that

> "... only one of (these possible spacecraft missions) appears definite for operational development. This is the unmanned maneuverable strike vehicle."

This would have been in direct competition with the much simpler and much less expensive MIRV program. (It would also have served as a superb justification and impetus for Soviet ASAT development.) A second and related study, the Medusa/Phalanx system called for

> "multiple launch from air breathing manned hypersonic platforms of unmanned maneuvering L>D warheads to orbital velocities. The concept would mean faster reaction than, say, manned bombers to the second wave strategic attack problem of hitting significant targets overlooked or simply missed by a first-wave ICBM attack." (8)

In addition to the unmanned L>D strike vehicles, the concept called for other hypersonic launch vehicles to lift L>D manned command/ reconnaissance vehicles. The costs of such a system were realized as being very large. In examining the other possible L>D missions and their technical problem areas and judging their "Imperativeness, Effectiveness, and Mission Merit", the manned satellite inspector came out well ahead of all other proposed missions. (9) Perhaps in desperation, the writer, attempting to second guess the contents of the AFSSD commissioned Martin and Douglas Corporation studies and at the same time to protect them from criticism,suggested that the manned satellit inspector mission could be carried out under United Nations auspices.

REFERENCES.

1. Stone, I. "Asset Reentry Vehicle Test Series Will Begin in July" Aviation Week & Space Technology 76:6 (February 5, 1962): 50-52.

2. Stone, I, "USAF Wants Larger Lifting Body Than M2/F2 for Manned START". Aviation Week & Space Technology 83:7 (August 16, 1965). 34-35.

3. "Lack of Funding Worries Air Force." Missiles & Rockets 18:22 (May 30, 1966): 72-76.

4. Normyle, W.J. "Manned Flight Tests to Seek Lifting Body Technology." Aviation Week & Space Technology 84:20 (May 16, 1966): 64-72.

5. "Martin Wins Reentry Vehicle Contest." Missiles & Rockets 18:5 (April 1966): 14.

6. Dighton, R. "Greatest Innovation Since the Missiles." (AP) St. Louis Post Dispatch, March 19, 1967.

7. Alelyunas, P. "L>D Spacecraft". Space/Aeronautics 47:2 (February 1967): 52:65

8. Ibid.

9. Ibid.

Space Shuttle

The U.S. Space Shuttle vehicle (the Orbiter) is discussed in the context of this paper only because of its potential for satellite retrieval and satellite inspection. Whether it would have that specific military role remains ambiguous, but is probably extremely unlikely. The question arises essentially because of one operational capability that the Air Force is known to have insisted be built into the vehicle

Plans for the shuttle originated in the 1960's as an outgrowth of early studies of a permanent manned orbiting space station. Following the three-man Skylab project, due to fly in 1973, a 12 man space station was projected for the 1980's. In the mid-1960's there had already also been NASA studies of 25- and 50-man space stations. Ferrying men and supplies to such stations via conventional expendable rockets was prohibitively expensive, and therefore a reusable shuttle was conceived in conjunction with these manned stations. NASA first proposed the Space Shuttle in 1969 in conjunction with proposals for manned space stations, as two parts of a single system. The combination however ran into strong opposition in the U.S. Congress, in both the Senate and the House, and nearly suffered defeat in votes in both houses. In 1971 NASA rejustified the shuttle as an economic launch system to replace all national expendable national launchers for unmanned space systems. (1)

At the end of 1969 the Air Force also commissioned a series of studies much to the same purpose. (2) The studies were being conducted by the same private corporations that were preparing the NASA designs and studies, and a Joint NASA-DOD report was to be prepared. The USAF-funded studies essentially revived thinking of the early 1960s about an "aerospace plane" that was to have flown after the X-20 Dyna-Soar. The difference in this case was in the configuration of the vehicle. The earlier USAF concepts had not been for satellite transporters. Because the Shuttle's orbit altitude is on the order of 100 miles and synchronous orbits require altitudes around 20,000 miles a third-stage vehicle, the Space Tug, was also required. As the Tug was not expected to be available before 1984, the Air Force was developing an Interim Upper Stage.

The study with which NASA justified the cost-effectiveness of the Space Shuttle system as against expendible launchers, as well as all the early descriptions of the system, included satellite retrieval as one of the Orbiter's essential roles. (3) There have been subsequent doubts as to whether retrieval would be as economical as originally estimated, but in any case the mechanical devices for satellite retrieval are an essential component of the Orbiter's design. (4)

Aside from the function of launching Air Force and other military satellites (the Department of Defense would deliver its own satellites into orbit, which will comprise about half the Shuttle's flights in a projected ten year period), the DOD would also conduct its own classified manned missions in space for as long as 30 days. But it was a second Air Force requirement that was even more unique. The Air Force insisted that the shuttles Orbiter vehicle had to be capable of circling the earth once in any direction, and then landing at its take-off point. Why the Air Force wanted this "one-orbit capability" was classified, and remains so to this day. The mission requirement produces critical performance and structural requirements which had not been required by NASA. A requirements conflict between NASA and the Air Force lasted for about a year and a half, and was resolved when NASA acceeded to the Air Force demand in January 1971. The consequences of the requirement are as follows. The earth rotates about 1100 miles during the time taken for the orbiter vehicle to make its one revolution. That means that the orbiter must be able to glide at least that far to either side of its orbital path during reentry. The Air Force was asking for 1,500 to 2,000 miles of this sideways maneuverability, which is called cross-range capability. Such reentry cross range capability requires particular wing shape, to obtain the greater lift. In addition reentry is slower, hence heating is more severe, and the Orbiter vehicle would require an extra 15,000 lbs of insulation. (5) This meant greater cost, and an extended development program time table. NASA felt that a 200-nautical mile cross range capability "probably could satisfy the bulk of military mission requirements." (6) Descriptions of the military requirements stressed a need for unrestricted launch azimuth capability and to be able to leave orbit very quickly and return to earth, (— perhaps due to the danger of being itself vulnerable to intercept and destruction if it stayed in orbit?). All of this sounds very reminiscent of the major operational requirement of the earlier USAF Dyna-Soar X-20 vehicle. What then were the small fraction of military mission requirements which needed the single orbit capability and the large cross range landing footprint? The question is whether this capability is best understood in terms of satellite inspection, and perhaps interception, or in terms of reconnaissance. The Air Force cross range requirement is sufficient to have the Orbiter pass over the

USSR on its single pass. (6) On the other hand "surveillance of satellites" and "satellite inspection" were included in the mission profiles for the Orbiter that the Air Force was interested in. (7) Early USAF studies had even projected a small orbit-to-orbit craft for DOD missions, to be carried into orbit in the cargo bay of the main Shuttle Orbiter vehicle and which would be designed primarily for satellite inspection. USAF studies had also studied the need for nuclear hardening of the Orbiter and its systems. (8) A device which will be tested by the Orbiter is reported as a maneuverable television camera which could travel short distances from the Orbiter for satellite inspection. (9) Satellite retrieval is certainly expected to be tested.

1. Gillette, R., "Space Shuttle: Compromise Version Still Faces Opposition," Science 175 (4020), January 28, 1972, pp. 392-396.

2. "Air Force Pushing Studies of Reusable Space Shuttle," Aviation Week and Space Technology, 91 (6), August 11, 1969, p. 25.

3. Space Shuttle-Skylab, Manned Space Flight in the 1970's, Status Report for the Subcommittee on NASA Oversight, Committee on Science and Astronautics, US House of Representatives, 92nd Congress, 2nd Session, January 1972, pp. 123, 135, 155, 261, 582; Stelling, H.B., B. Gen., "Department of Defense and the Shuttle," in Space Shuttle Missions of the '80's, Vol. 32, Part I, Advances in the Astronautical Science, 1977, pp. 21-32; Taylor, L.B., Jr., "The Space Shuttle," Ordnance 62 (315), November-December 1972, pp. 217-219; "McDonnell's Shuttle Team," Flight International, 97 (3180), February 19, 1970, pp. 283-283.

4. Cepollina, F.J., "In-Orbit Servicing," Astronautics and Aeronautics, 13 (2), February 1975, pp. 48-51; Cruddance, R.G., et al., "SPEAR, Small Payload Ejection and Recovery for the Space Shuttle," Astronautics and Aeronautics, 15 (1), January 1977, pp. 42-43; Mitchell, D.H., "Retrieval of the HEAO-C Spacecraft With The Space Shuttle," in Fink, D.E., "On Orbit Satellite Servicing Explored," Aviation Week and Space Technology, 102 (15), April 14, 1975, pp. 35-39.

5. Gillette, R., "Space Shuttle: A Giant Step for NASA and The Military," Science, 171 (3975), March 12, 1971, pp. 991-993; "Reusable Space Shuttle Effort Gains Momentum," Aviation Week and Space Technology, 91 (17), October 27, 1969, pp. 22-24; Taylor, L.B., Jr., "The Space Shuttle," Ordnance 62 (315), November-December 1972, pp. 217-219.

6. Stone, I., "USAF and the Shuttle," Air Force Magazine, 53 (8), August 1970, pp. 80-83; Butz, J.S., Jr., "The Coming Age of the Economy Flight Into Space," Air Force/Space Digest, 52 (12), December 1969, pp. 37-44; O'Leary, B., "Do We Really Want a Space Shuttle," New York Times, February 16, 1972, and Congressional Record, Senate, June 29, 1971, pp. S-10282-S-10283.

7. Thomas B.K., "Reusable Space Ferry Considered," Aviation Week and Space Technology, 90 (24), June 16, 1969, pp. 57-61; "Reusable Space Shuttle Effort Gains Momentum," Aviation Week and Space Technology, 91 (17), October 27, 1969, pp. 22-24.

8. "USAF Studies Shuttle Missions," Aviation Week and Space Technology, 95 (19), November 8, 1971.

9. "The Space Shuttle System," World Armaments and Disarmament, SIPRI Yearbook, 1978, Taylor & Francis, London, 1978, pp.

Space Shuttle Mission of the 80's, Vol. 32, Part I, Advances in the Astronautical Sciences, 1977, pp. 1133-1134;

"Space Denial": 1958-1963.

The other appendixes prepared to accompany the study of the development of antisatellite weapons all concern technical systems. This brief note deals only with political-military concepts, and is only meant to indicate, in slightly greater detail, a portion of the intellectual climate in which ASAT concepts arose.

In speaking to the UN General Assembly on September 19, 1963, Soviet Foreign Minister Gromyko announced that the USSR was interested in arrangements to prohibit the placing of nuclear weapons in orbit. The USSR position had previously been that bans on weapons of mass destruction in space could only be implemented under agreements for GCD. Both the US and the USSR had proposed such prohibitions in their GCD proposals. Now, after the signing of the Limited Test Ban Treaty, the USSR indicated that it was willing to separate out this aspect as well for separate negotiation. US-USSR-UK talks began and agreement was very rapidly reached on a verbal ban. As the US had already done, the USSR expressed its intention not to station weapons of mass destruction in orbit. UN Resolution No. 1721 incorporating these declarations was unanimously endorsed by the General Assembly on October 17, 1963. The resolution made no provision for any inspection necessary to confirm the adherence to the commitment. Neither was there any verification provision when the substance of the resolution became part of the Outer Space Treaty, several years later. (The treaty was signed in 1967, and became operative in 1968.) In the absence of means for verifying compliance with this declaratory policy, President Kennedy indicated that the United States would be forced to take its own precautions. The decisions to construct the Thor and Nike-X ground launched ASAT systems had by then already been taken.

The contrast between these events and at least a portion of the theorizing that preceeded it is remarkable. In the years 1957-1958 it was common for individuals such as Werner von Braun, former Gen. Dornberger, and Gen. Thomas A. White, US Air Forces Chief of Staff, to speak of "space control" and "control of space". (1) It was only a short step from these very vague and general notions for others to suggest "space denial" and "satellite denial", which Simon Ramo paraphrased as believing that "... it is of interest to a competitive nation to seek out and destroy any space vehicle of its potential enemy". (2) Another early expression of this notion was the euphemistically labeled "Panama Hypotheses," which didn't, however, explicitly include discussion of destruction of Soviet space vehicles.

"The Panama Hypotheses can be summarized in this statement: There are strategic areas in space — vital to future scientific, military, and commercial space programs — which must be occupied by the United States, lest their use be forever denied us through prior occupation by unfriendly powers." (3)

Klass gratuitously suggests that there must have been at least some Soviet officials who argued that the USSR should develop a capability to destroy US space reconnaissance satellites once they had heard the general capabilities of these discussed in 1958 at bilateral US-USSR discussions on the avoidance of accidental nuclear war. (4) He does this on the basis of Soviet antipathy to the U-2 flights, and their interception of a U-2 aircraft. Certainly it was a period during which the USSR maintained that the passage of reconnaissance satellites over their territory contravened international law. (5)

However, the U.S. discussion of "space denial" was in terms of interception of Soviet vehicles carrying nuclear weapons in orbit: (6)

"If spacecraft threaten national survival of a member of the United Nations, must that nation stand by and await an actual physical attack, or may it take necessary preventive measures before receiving a crippling blow? Concretely, when and where may a nation in self-defense attack a suspected spacecraft...If (a satellite) is equipped with a nuclear device which can be released and propelled downward by radio command, the satellite is an imminent threat to every State in its path."

The series of papers by Frye which introduced the phrase "Space Denial" stopped asking rhetorical questions. (8) Frye suggested that the US develop a satellite interceptor system. He stated that there was no way to be certain that orbiting Soviet satellites were not platforms containing nuclear weapons that might subsequently be launched at the US. This should be considered an intolerable risk to US national security. He then suggested that unless the USSR made prior announcement of all space launchings, permitted international inspection of all payloads, and allowed international observers to attend all space shots, the United States was

"compelled to destroy every vehicle which the Soviets fire into orbit or in a trajectory toward our territory. In short, if the Soviets refuse to provide reasonable guarantees of their good faith in the exploitation of outer space, then we should do our utmost to deny them any access at all to the area."

Frye thought these problems more urgent than the ICBM programs. Since every earth satellite launched by the USSR must at some time pass over the United States, Frye suggested that the United States could claim the legal justification of infringement of sovereignty, exactly the argument the US was afraid that the USSR would invoke when the United States began its satellite reconnaissance program. Frye suggested that the USSR would also develop a satellite intercept system, and that this might lead to a stalemate in the use of space; however "There would be no comparable need for Russia to intercept American satellites, since the United States remains ready to permit prior inspection of its vehicles and payloads..." Perhaps one can only consider this amusing. Frye's thesis was criticized by strategic analysts not very much removed from Frye's essential persuasion on the USSR, but Frye kept to his position. (9) These papers were followed by a more thorough and detailed analysis of the costs and consequences of a space denial program, including weapon system costs, which destroyed the concept. (10) Perhaps the episode should be considered a temporary aberration, since in the following year Frye wrote a reasonably balanced study for RAND on "Space Arms Control," which did not even mention his proposals of the previous year. (11)

REFERENCES

1. Gen Thomas O.White, "Space Control and National Security", Air Force Magazine, 41 (4), April 1958, pp. 80-83. See also V. van Dyke, Pride and Power, The Rationale of the Space Program, Urbana, Univ. of Illinois Press, 1964, pp. 42, 50-59.

2. Dr. Simon Ramo, "A Realistic Approach to Space Conquest," " Air Force Magazine, 41 (4) April 1958, pg 92-96

3. Cole, D., "Response to the 'Panama Hypothesis'", Astronautics, 6 (6), June 1968, pp. 36-39, 76-80.

4. Klass, P.J., Secret Sentries in Space, (Random House, N.Y.), 1971, p. 216.

5. Gerald Steinberg , Satellite Reconnaissance. The Role of Informal Bargaining, New York: Praeger, 1983.

6. Among the better papers on orbital nuclear weapons and their arms control implications are the following:
   - Hibbs, A.R., "Space Technology: The Threat and the Promise, "Disarmament and Arms Control, 3 (1), Spring 1965, pp. 63-74.
   - Clemens, W.C., Jr., "Arms Control for Outer Space," Disarmament, No.12, December 1966, pp. 5-11.
   - Abt, C.C., "The Problems and Possibilities of Space Arms Control," Journal of Arms Control, 1 (1), January 1963, pp

7. Cooper, J.C., "Self-Defense in Outer Space... and the United Nations." Air Force /Space Digest, 45 (2), February 1962, pp. 51-56.

8. Frye, A., "Breaking the Cold War Stalemate: A Proposal, "Air Force/ Space Digest, 45 (7), July 1962, pp. 53-55.

9. "Space Denial, An Amplification," Air Force/Space Digest, 45 (10) October 1962, pp. 54-56.

10. Abt, C.C., "Space Denial: Costs and Consequences," Air Force/Space Digest, 46 (3), March 1963, pp. 45-55.

11. Frye, A., Space Arms Control: Trends, Concepts, Prospects, RAND p-2873, February 1964, 22 pages.