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Space Handbook

A War Fighter's Guide to Space

Volume One

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To the Reader

As with any published work, the material immediately dates itself, thus at times becoming less relevant. These two volumes have been written with the expressed intent of remaining valid for as many years as possible--with the hope of imparting an educational framework to build upon rather than current and specific facts that often change quickly. We hope the reader will learn principles and be stimulated in thought, rather than struggle with errata induced by rapid change.

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"The space support for Desert Storm [and] Desert Shield will probably be the minimum support expected in any future crisis."

Vice Adm W. A. Dougherty, USN
Deputy Commander, US Space Command
15-21 April 1991
Space News

"The Gulf War 'was the first space war . . . it was the first war of the space age.' "

Gen Merrill A. McPeak
Air Force Chief of Staff

8 April 1991
Aviation Week & Space Technology

"Our technology superiority, particularly in space, was essential to our ability to prosecute the war quickly, safely and successfully."

Donald Atwood
Department of Defense Deputy Secretary
22 April 1991
Military Space

"This was the first war in which space played a central part, and DSP was a very important part of it."

Henry Cooper
Director of US Strategic Defense Initiative Organization
1-7 April 1991
Space News

"Space systems have become an integral part of all battle resources."

Lt Gen James S. Cassity, Jr., USAF
Director of Command, Control, and Communications for the Joint Chiefs of Staff
1-7 April 1991
Space News

"Imaging and SIGINT satellites played a very major role in the success of the air war and as a result, the success of the ground war, just in terms of providing a comprehensive target list, target base, for planning the air war, [and] allowing the assessment of damage."

Jeffrey T. Richelson
National Security Archive
Washington D.C.
4 March 1991
Aerospace Daily

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Foreword

For over 30 years, space has been integral to the security of the United States and its allies. Secretary of the Air Force Donald B. Rice said, "Space forces are a central element of our global reach, the principal attribute of the Air Force' s aerospace operations of the future."

Recent conflicts have underscored the role space now plays in our combat capability. Our navigation satellites provide instant pinpoint positioning and targeting information to aircraft, ground forces, ships, and command centers. Communications satellites provide global connectivity between all levels of our national security infrastructure. Weather satellites report meteorological data in near real time directly to forces in the theater. Early warning satellites, which detect and report ballistic missile launches, serve strategic objectives as well as tactical purposes. These and other space systems will continue to be essential to the success of future military operations. Whenever and wherever American men and women fight, space will forevermore be critical to their success.

Air Force policy states, "Spacepower will assume as decisive a role in future combat operations as airpower has today." As we move toward this goal, educating our future leadership becomes even more critical. Air Force Space Command has collaborated with Air University to produce this new edition of the Space Handbook. It is an excellent two volume instructional and reference manual. Volume 1 discusses space system organizations, roles and missions, policy, and space applications. Volume 2 provides an introduction to the physical laws and principles of space.

This handbook will provide new students of space a sound basis from which to grow and will stimulate experienced professionals. It is your guide to space and your invitation to all the excitement and opportunity therein.

[Signature]

JAY W. KELLEY
Lieutenant General, USAF
Commander, Air University

Preface

One of the primary efforts of all space advocates is to integrate, fully and effectively, the tremendous force enhancement capabilities of space-related assets into our national war-fighting capabilities. Lt Gen Thomas S. Moorman, Jr., states that Air Force Space Command's focus should relate to learning what the war-fighting commands need in the way of space systems. Part and parcel of this job is to demystify space and develop new applications for our space products.

Recent military operations have shown that the immense tactical application possibilities of current space systems are underused. The reason is that the war fighters are not familiar with space assets or capabilities and therefore do not have the tools or training to use them. The primary focus of this volume is to educate and begin to convince war fighters that space systems can do so much more for them than simply let them watch the fight. If the vast potential of space systems is fully understood and effectively applied, space can have a tremendous impact on mission planning and execution, saving friendly lives and increasing weapon effectiveness.

Need

Support from space assets has been successful in several recent operations. For example: Desert One (Iran), Urgent Fury (Grenada), El Dorado Canyon (Libya), and Just Cause (Panama). Prior to the massive effort to integrate space into the Desert Storm theater, most efforts using space had limited success and focused mostly on communications and intelligence. Primarily, this focus was due to a lack of knowledge and understanding of space systems capabilities within the war-fighting community. Most requests were ad hoc reactions and piecemeal efforts, not fully coordinated between users and providers of space systems.

Classified Annex A to this handbook covers in-depth space support to Operation Desert Storm. Even though Desert Storm was tremendously successful, it showed the need for better space understanding and applications. Gen Norman Schwarzkopf echoed this idea when he briefed Congress on problems with battle damage assessment and intelligence dissemination. Better space applications can greatly improve these areas as well as other missions.

Potential

We have not fully exploited the expansive potential of space systems. We have extremely sophisticated and capable space systems that have the advantages of high volume collection and relay of global data in real time or near real time. These advantages allow our forces to see, measure, and proactively respond to a threat. However, among other problems, the users have prototype equipment operated by untrained personnel which results in a trickle of noncurrent information to the unit and aircrew level. Also, there is the continuing problem of overclassifying the output and products of some space systems. Space asset owners and operators must capitalize on the enormous amount of money already spent on space systems and maximize their capabilities in supporting combat execution.

Desert Storm featured a great improvement in space system utility, giving us a new baseline from which to grow. According to Lt Gen Thomas S. Moorman, Jr., "We proved our worth in the Persian Gulf, and in the future we will prove our worth as we continue to enhance combat effectiveness with space systems." Space provided critical support to all the services in navigation, communications, weather, and intelligence. In an encouraging article from *Air Force Magazine,* James Canan writes, "In military circles, space is losing its high-flown, R&D aura and is taking on a down-to-earth, operational look. Warfighting commanders are fast becoming sold on space systems." The information that space systems provide to tactical forces is extremely well received and changes the way we plan a lot of missions. We are making a difference! This difference is an example of what needs to happen, but we must also improve our education process.

Increasing the War Fighter's Comfort Index for Space Systems

According to Lt Gen Thomas S. Moorman, "Our goal [as space advocates] is to create a climate where the flying commands are comfortable with space, and think of space solutions to their operational problems." The space community needs to sell the utility and value of space to the war fighters and thereby increase their comfort index on space. Lt Col Randy Peixotto, Air Force Special Operations Command (AFSOC) states, "AFSOC forces use space capabilities on a daily basis and on every operational mission, but like most organizations, we do not normally recognize the extent to which we are dependent on satellites" War-fighting commands have to become familiar with what is available and practice using it. We need to ensure they have continuous hands-on access to hardware even during peacetime. The phrase "train as we fight" applies here and lies at the heart of the *Space Handbook.* This text is a training tool or a stepping stone for the uninitiated and is for use by neophytes who need to be aware of the capabilities and potential of space. We must educate our leaders and war fighters on space, and the *Handbook* is a means to help.

The bottom line is that Air Force Space Command and the *Space Handbook* focus on space as a force enhancer to war-fighting operations. The objective is to provide better understanding which will capitalize on the billions of dollars invested in space systems to allow us to execute combat operations more effectively.

Acknowledgments

As with most work, many people are responsible for this project's success. There are many to thank--some for considerable help and a few for their superlative efforts--without whom I could not have completed this project! There are so many to acknowledge that I can list only their names. I hope they will forgive this brevity. They know what they have accomplished, how helpful they have been, and that I am truly grateful !

The following individuals made most meaningful contributions in many areas, including helping to: organize, provide information, consult, support, coordinate, edit, advise, approve, assist, empathize, suggest, and more.

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Maj Jerry Rand
Maj Laurie Reh
Col Rod Payne
Capt Robert Freeman
Mr John Jordan
Maj Ron Del Gizzi
Maj Dwight Rauhala
Maj Jeff Walters

Maj Robin Squatrito **Maj Daryl Tomczyk**

There were three standouts in terms of support on this effort. These three individuals kept pushing me onward and upward towards what I hope and believe is a useful document. These individuals helped in such areas as typing, coordinating, editing, correcting, cheerleading, admonishing, encouraging, consulting, listening, and advocating. My deepest and sincerest thanks go to my wife Shirley Hand and to my friends and coworkers Andrea Pollitt and Bonnie Houchen! I am forever indebted to you.

To any whom I may have omitted, my apologies, but thank you nonetheless.

Chapter 1

Space History

The Evolution of Space Power

The seeds of American rocket science sprouted haphazardly in a climate of apathy and ridicule. Due to a lack of interest in research and development before World War II, America's early rocket pioneers found few, if any, financial sponsors. Thus, European rocketeers took a substantial lead in rocket science.

Robert Goddard, the earliest and arguably the greatest American scientist in rocketry, was born in 1882. Inspired by the writings of H. G. Wells, Goddard began experimenting with solid-propellant rockets during World War I and, with the help of the Smithsonian Institution,[1] published his first thesis on rocket propulsion, "A Method of Obtaining Extreme Altitudes" in 1919.[2] He began experimenting with liquid rocket engines in 1923.

Goddard conducted more than 100 static tests, 48 live flight tests, and developed the first functional gyroscopic attitude control system for rockets. Other firsts included the first liquid propellant rocket in 1926 and pressure and pump feed systems. These were tremendous accomplishments by amateur standards, which is the way he should be rated when compared to the highly organized German efforts of the same period. His one-man-show methods were totally outdated by 1940, and his secrecy left his later and most important writings unpublished.[3]

Goddard was not the only American interested in rockets. The American Interplanetary Society (AIS), founded in 1930, sponsored liquid propellant rocket experiments on a farm in New Jersey. AIS changed its name to the American Rocket Society (ARS) in 1934.[4] Of greater significance than ARS's rocket experiments was the founding of Reaction Motors, Incorporated (the first American private firm devoted to rocketry) by four ARS members.[5]

During World War II, the Allies became increasingly aware of the tremendous technological edge the Germans had in rocket development.[6] The Allies began laying plans as early as 1942 to plunder German technology after the war, and a new type of military unit, the scientific intelligence unit, appeared in British and US services.[7] The Soviets also demonstrated an interest in German technologies, and all these units worked to uncover as many Nazi secrets as possible because their respective governments were anxious to create their own rocket programs.[8] In the United States too, there was high-level government interest in German rockets. The National Defense Research Committee became the Office of Scientific Research and Development, a very powerful organization with direct access to the president. Headed by Vannevar Bush, chairman of the National Advisory Committee on Aeronautics (NACA),[9] this organization worked loosely with similar British organizations gathering scientific intelligence.[10] Towards this end, the British and Americans on one hand and the Soviets on the other tried to keep as much of this information from each other as possible.[11]

Late in the war, the Germans used their rockets as vengeance weapons against the Allies. The German's greatest achievement, the A-4 or V-2--the first medium-range ballistic missile--had a length of 46.1 feet and a 56,000-pound-thrust engine powered by alcohol and liquid oxygen. Driven by its liquid propellant engine, the V-2 had a range of approximately 200 miles. Its warhead consisted of 2,000 pounds of amatol. For the most part, the V-2 and the earlier V-1 Buzzbomb had little immediate effect, but Hitler's weapons did exact a vengeance of sorts after the war by touching off a major international competition to secure the spoils of the Peenemunde rocket center.[12]

On 11 April 1945, US Army intelligence units reached the Mittelwerke, the secret underground V-2 factory in the Harz Mountains.[13] (The Germans had moved production of the V-2 there after Allied bombing heavily damaged Peenemunde.[14]) As part of Operation Hermes (an American plan to secure rocket expertise), US personnel searched for German scientists to help with US rocket development and to get them out of the area before the Soviets arrived.[15] (Both Peenemunde and the Mittelwerke were in the Soviet zone of occupation.) The Army immediately shipped enough parts to the US to assemble 100 V-2s for testing at White Sands Proving Grounds (now White Sands Missile Range [WSMR]) in New Mexico.[16] Then on 2 May 1945, the Peenemunde rocket group (including Maj Gen Walter Dornberger, military chief of the rocket program, and Wernher von Braun, the chief scientist) surrendered to the US Seventh Army. By 30 September 1947, the US had recruited and contracted 457 German scientists and technicians who helped put the US in space faster than might otherwise have been possible.[17]

Truman Years: 1945-1952

As World War II ground to a close, President Harry S Truman was faced with a decision that was to have far graver consequences for the postwar world than German V-2 development. This was the decision to use the atomic bomb in an effort to end the war against Japan quickly and at a lower cost in American lives than an invasion would require. The atomic bomb was to have a significant effect on the cold war between the Western Allies and the Soviet Union after World War II. The cold war manifested itself as a series of political, military, and propaganda confrontations characterized by limited wars, wars by proxy, the nuclear arms race, and the threat of nuclear war. In the end, the cold war encouraged competition, both friendly and unfriendly, and helped accelerate the pace of the coming space race.

In 1946, the US government began Project MX-774 to research and develop a 5,000-mile-range intercontinental ballistic missile (ICBM). Convair, the prime contractor, flew three experimental vehicles in 1948, largely at its own expense. These vehicles tested such advanced concepts as gimbal-mounted engines, separable nose cones, and stainless steel skin rolled so thin that it had to be inflated to keep its unsupported structure from collapsing (the balloon tank concept).[18]

Also in 1946, another US program, Project Bumper, began. This program gave the US much needed experience in the handling and design of large rockets and involved launching captured German V-2 rockets. Sixty-four V-2 rockets flew from White Sands, some as modified two-stage upper-atmospheric test vehicles employing the WAC -Corporal second stage. Two V-2s were launched from the Long Range Proving Ground (now the USAF Eastern Test Range on Cape Canaveral, Florida). The US Navy even launched a V-2 from an aircraft carrier, the USS *Midway*.[19]

The Hermes Project, the first major US ballistic missile program, was based at Fort Bliss, Texas. German scientists led by von Braun tested many rocket components and concepts. The Hermes Project laid the groundwork for what was to come. After Hermes ended in 1950, von Braun and his team moved to the Redstone Arsenal near Huntsville, Alabama, and worked for the Army Ballistic Missile Agency.[20]

Meanwhile, many top US military and scientific leaders, including Gen Henry H. ("Hap") Arnold, Vannevar Bush, Theodore von Karman, Hugh L. Dryden, and the Army Air Force Scientific Advisory Group, were skeptical of mating nuclear weapons with long-range missiles. In December 1945, Dr Bush told a congressional committee: "In my opinion, such a thing is impossible, I don't think anybody in the world knows how to do such a thing [put nuclear weapons on long-range missiles] and I feel confident it will not be done for a very long time to come."[21]

As a result of such expert testimony, US ICBM research stopped in 1947. The argument was strong. No existing rocket could carry the atomic bomb of the day which weighed 10,000 pounds. Also at that time there was no way to guide such a weapon to a target halfway around the world.[22] Experts said it would take at least 10 years to develop the systems necessary to make such a missile practical.[23] The Air Force opted to design and test a number of cruise missile weapons that could carry the "bomb" better and farther with existing technology.[24] Of these, only the Snark cruise missile reached the deployment stage in the late 1950s, and the Air Force deactivated it in 1961 after the Atlas ICBM came on line.[25] In the meantime, development continued on shorter-ranged weapons, while the Atomic Energy Commission (AEC) tried to make nuclear weapons smaller.

In 1946, the RAND Corporation first proposed a military satellite system. A 2 May 1946 RAND study stated that a "satellite offers an observation aircraft which cannot be brought down by an enemy who has not mastered similar techniques," but mastering the techniques to build such a vehicle proved to be difficult.[26] Electronics of the day were the roadblock as they were based on vacuum tubes. Electronic components were large, heavy, and needed lots of power. In 1948, a major breakthrough occurred when Bell Telephone Labs invented the transistor. The transistor was smaller and lighter than tubes and made lighter electronics possible for the first time. Likewise, an extremely important breakthrough in the 1950s would be development of long-range boosters. These boosters coupled with upper stages would be able to launch heavy satellites.[27]

From the RAND recommendations, the Air Force initiated Operation Feedback in April 1951. This program researched the possibility of using satellites for military observation and other purposes. Operation Feedback was the first US military satellite program. By 1954 it was the plan for weapon system (WS)-117L, a full-scale research and development (R&D) effort for space observation.[28]

Eisenhower Years: 1953-1960

At the time of the 1952 presidential election, technology was changing rapidly. The testing of the first US hydrogen bomb on 1 November 1952 and the first Soviet H-bomb detonation the next August changed the outlook for ICBM development. The new H-bomb, smaller and more powerful than the A-bomb, could be carried by a smaller, less accurate rocket.[29] Due to this breakthrough, the US restarted its ICBM programs in 1954.

As these programs started again, concern about a thermonuclear-armed and potentially hostile Soviet Union became more intense. Because of the closed nature of the Soviet state, little concrete information was available on its state of readiness, military capabilities, or intentions. US military planners could not even draw up a reasonable war plan because they did not know the location of Soviet military targets. Lack of solid information on Soviet intentions meant that a misunderstanding might trigger a nuclear war, while the same lack of knowledge left the US vulnerable in a surprise attack.

Because of a fervent desire to avoid "a nuclear Pearl Harbor," President Dwight D. Eisenhower proposed Open Skies to the world in July 1955.[30] Written by Nelson Rockefeller with inspiration from Henry Kissinger, Open Skies proposed that the US and USSR exchange information on their military establishments and allow uninhibited overflights of their territory for verification. This proposal would lessen the fear of a surprise attack. Although highly regarded by the European community, Open Skies was rejected by the Soviets.[31]

International Geophysical Year

The scientific scene changed along with the world military picture in the early 1950s. The big event of the decade was the International Geophysical Year (IGY), a worldwide scientific extravaganza lasting from 15 July 1957 through 31 December 1958. During the IGY, scientists coordinated high altitude scientific research activities on a worldwide scale. The United Nations Special Committee for the IGY invited world governments to launch satellites in the interests of global science.[32]

However, in launching a satellite, there was more at stake for the US than just science. There were such goals of high national importance as establishing the legality of overflight in accordance with Eisenhower's Open Skies or Freedom of Space doctrine and being first in space.[33]

On 28 July 1955, the US announced its intention to launch a satellite during the IGY. The US program would follow National Security Council (NSC) recommendations (laid out in NSC Directive 5520, dated 26 May 1955) and was not to interfere with existing military missile development programs. The NSC recommendations created a de facto separation of the US space effort into military and civilian sectors.[34] The Soviets also announced the intention to launch a satellite and claimed that they would better any attempt made by the US. No one took them seriously at the time.[35]

The Stewart Committee (formed by the assistant secretary of defense to review proposals and pick a US satellite program for launch related to IGY) reviewed Project Vanguard, a Naval Research Laboratory (NRL) proposal based on the Viking upper atmospheric research rocket. The scientific (nonmilitary) nature of the rocket pleased the committee as did the NRL's scheme for tracking the satellite, a radio network called Minitrack. In August 1955, the Stewart Committee chose Vanguard for the IGY based almost completely on its separation from the military. Thus, the committee seemed to ignore the national goal of being first in space. Von Braun's promise to launch his group's satellite, *Orbiter,* in 90 days did not sway the committee.[36] The government sanctioned the IGY program in the hope of legalizing satellite overflight with a civilian scientific satellite with no military or political implications.[37]

By late 1955, the changing political and military situation relegated Vanguard to the back burner. To match newly revealed Soviet missile programs, Eisenhower made the US ICBM programs a top priority, and to gain intelligence on the Soviet R&D effort, did the same with the US spy satellite program.

Meanwhile, the Glenn L. Martin Company (now Martin Marietta), the Viking builder, logically became the Vanguard contractor.[38] It also got the contract for the Titan I ICBM shortly after the Vanguard program started. Martin moved its best people to the military project leaving the Vanguard program with little support.[39] Vanguard became a bureaucratic orphan because the armed services had little interest in a nonmilitary project.

Martin finished the Vanguard vehicle design in February 1956 and began construction shortly thereafter. Martin and NRL conducted a number of successful flight tests from December 1956 through October 1957 and scheduled launch of a small test satellite for December 1957.[40]

At this time, the Soviets were making considerable headway with a missile development program drawing heavily on German expertise obtained after World War II. Years ahead of US expectations, the Soviets created the world's first ICBM, the SS-6 Sapwood. Development of this missile began in 1955 as an attempt to redress the perceived arms imbalance brought on by US preponderance in manned bombers.[41] Designed before the technology breakthroughs, the primitive, first-generation nuclear bomb the SS-6 was to carry dictated its immense size.[42] News of the Soviet missile tests leaked to the West and caused the first twinges of what became the missile gap scare.

[Image 16K]

Echo Balloon

After a successful test flight on 3 August 1957, the Soviets announced that they alone possessed an ICBM.[43] However, the missile did not reach initial operational capability (IOC) until 1959, by which time US ICBMs had rendered it obsolete.[44] Although some Western reaction to these events was understandably grim, most experts did not take the threat seriously. This view changed radically on 4 October 1957 when the Soviets stunned the world with the launch of Sputnik I, the world's first artificial satellite. Since the Soviets had no aversion for interlacing the military with space, they used their new SS-6 ICBM as the booster allowing faster development than with the US's "from scratch" approach. Shock swept across the US, even though the Soviets had made numerous claims that they were very nearly ready to launch their satellite. Now many scientists, engineers, and military officials were convinced the rocket that put the 184-pound Sputnik into orbit had serious military potential. The launch seemed to validate Soviet claims of a massive military launch capability including ICBMs. If nothing else, Sputnik aided Eisenhower' s attempts to legalize satellite overflight since no nation protested the overflight of its territory by the Soviet satellite.

The launching of Sputnik pushed Vanguard to the forefront of US public attention while it was still an underfunded and highly experimental system. Without the launch of Sputnik, the subsequent failure of Vanguard would probably have left little impression on the nation. Unfortunately, because of the Soviet success, the country expected Vanguard to work immediately.

On top of these expectations, the media whipped the public into a frenzy over the Sputnik launch.[45] Then a 9 October White House press release, misinterpreted by the press, seemed to indicate that the December Vanguard test flight was an operational launch when the statement said it was just another test.[46] Finally on 3 November, the Soviets launched Sputnik II, the first bio-satellite, with the dog Laika aboard. The 1,200-pound Sputnik II was "proof" that the Soviets possessed a fully capable launch system. Thus expectations for Vanguard ran even higher.

On 6 December 1957, with the whole world watching, Vanguard exploded on the launch pad.[47] This disaster became the symbol of failure for the US space program. The Soviets took advantage of the propaganda opportunity by offering to assist the US through the UN program for technological assistance to primitive nations.[48]

After the Vanguard failure, the US government seemed to scramble for a quick solution to this embarrassment and chose to go with a modified version of von Braun's Project Orbiter. In fact, this decision had been made in November, well before the failure. The Juno launch vehicle, topped by a small scientific satellite called Explorer I lifted off on 31 January 1958, and the US had a satellite. Explorer I discovered the presence of radiation belts around the Earth, undoubtedly the most important discovery of the IGY.[49]

The Sputnik launch and the Vanguard fiasco were tremendous blows to US prestige as predicted by von Braun in his 1954 "A Minimum Satellite Vehicle." These events alarmed the US public who pressured the government for action. Eisenhower, bowing in part to congressional and public pressure, recognized the need for a centralized space program and policy. Moreover, the IGY events were major contributors to the growing missile gap scare because of concern among US military and political leaders that they had drastically underestimated Soviet potential. The more tangible reactions were accelerated--US ICBM programs, expanded U-2 overflights, and the beefed-up spy satellite R&D programs.

National Aeronautics and Space Administration

To avoid the difficulties experienced with Vanguard, which many blamed on faulty management and lack of unified direction, the government created a new agency to solidify national space policy. The National Aeronautics and Space Act created the National Aeronautics and Space Administration (NASA) in July 1958.[50] The act essentially codified the NSC directive of May 1955 by officially dividing the civilian and military sectors. NASA would solidify policy on peaceful uses of space.[51] It absorbed the resources and facilities of NACA and other space-related agencies (such as the Army Ballistic Missile Agency and the Advanced Research Projects Agency [ARPA]).[52] NASA was the brainchild of James R. Killian, presidential scientific advisor, and opened its doors on 1 October 1958.[53]

As Killian and Eisenhower had devised it, NASA would be a strictly civilian enterprise, thereby limiting the military's role in the national space program. Within its original charter, there was only a vaguely defined relationship with the military. Congress, on the other hand, envisioned a strong military role in space and wished to modify NASA's relationship with the military. To this end, Congress created the Civilian-Military Liaison Committee (to coordinate NASA and Department of Defense [DOD] activities) and the National Aeronautics and Space Council (chaired by the president as commander in chief of the US military to create national space policy).[54]

NASA's first major project, the Mercury Program, began as a result of the 1958 Space Task Group recommendations[55] Mercury, a stepping stone to the Moon mission later known as Apollo, was to send a man into low-Earth orbit and return him safely. Additionally, Mercury was to discover some of man's capabilities and limitations in space.[56] In mid-1959, after the most extensive physiological and psychological testing ever performed on humans, NASA selected seven astronauts to take part in Mercury.[57]

[Image 28K]

Mercury Capsule (Artist's Conception)

[Image 16K]

Mercury Capsule Dimensions

Long-term planning for Apollo, the US Moon program, began simultaneously with Mercury. By late 1960, Eisenhower became disenchanted with the tremendous estimated cost of putting someone on the Moon. T. Keith Glennan, NASA chief, told the president, "If we fail to place a man on the moon before twenty years from now, there is nothing lost." Glennan planned to go public with this view when Eisenhower saved him the trouble by stopping the funding for Apollo.[58]

Missile Gap

In the 1950s the overriding theme in US strategic thinking was that the Soviets had the "bomb," and no one knew what they might do with it. Sputnik increased apprehension about the subject. The US government needed facts to quell the rising anxiety. As the Soviets were rejecting Open Skies, US intelligence services were trying desperately to peer over the iron curtain into the Soviet Union. As an early and partial solution to the information need, the US, like many other Western nations, employed agents to collect information. These agents were only marginally successful due to the closed nature of the Soviet state. Although the US gained useful information, American intelligence agencies could not see all that was going on in the Soviet Union.[59]

Another method of intelligence gathering employed during this period used large, high-altitude balloons (similar to the Skyhook scientific research balloon) to carry a camera across the USSR. The camera payload was designated WS-119L and code-named Moby Dick. The US released balloons from West Germany, Turkey, and Norway to ride the prevailing winds across the USSR. The Soviets captured many of the balloons, displayed them to the world, and vehemently protested the illegal overflights. The US stopped the flights in March 1956, not because of the protests, but because of poor results. Since the balloons flew at the mercy of the winds, the US could not control or anticipate their speed and direction which made specific targeting impossible.[60]

Surveillance aircraft also flew into Soviet airspace, but before the mid-1950s these aircraft could not penetrate deep enough into the USSR to see facilities far from the border and generally could not fly high enough or fast enough to avoid detection and interception by Soviet fighters.[61] Thus, the Air Force began a new R&D program for a specially designed, high-altitude strategic reconnaissance aircraft, the U-2. Built by Lockheed, it first flew on 4 August 1955. The U-2 could fly above 80,000 feet, well above the service ceiling of all contemporary fighters.[62] However, even before the U-2' s first flight, the Air Force had begun serious work on reconnaissance satellites under Project Feedback.

On 16 March 1955, Air Research and Development Command (ARDC), later Air Force Systems Command, requested studies for a strategic satellite system, designated WS-117L, code-named Pied Piper.[63] The satellite was to carry a camera designed to develop its pictures on board the satellite, scan them with a TV camera, and send images back to Earth. ARDC selected three contractors--Martin, Lockheed, and RCA--for these studies.[64]

Meanwhile the Missile Gap controversy received an added boost from the 1957 report of the Gaither Committee, who had been tasked to evaluate the feasibility of civil defense during a nuclear attack but had broadened its scope to include survivability of US nuclear forces. The committee' s final report pointed out the extreme vulnerability of US forces to nuclear attack due to lack of a fast-reaction bomber force and the means to detect missile attack before the missiles impacted. These obvious problems greatly concerned Congress. The controversy centered on Soviet missile production rates and when these missiles would be operational.[65]

This missile controversy pitted USAF Intelligence against the Central Intelligence Agency in a debate over Soviet capabilities. These organizations made differing estimates of Soviet missile production and the number of operational missiles. Moreover, none of the US intelligence services knew where the Soviet factories were, much less their capacity for manufacturing the necessary electronics and other "high-tech" materials required for large-scale missile production.66Because of the lack of concrete information, US intelligence agencies turned to their best performer, the U-2.

The U-2s searched for Soviet ICBMs. By summer 1957, U-2s flying out of Pakistan returned with the first pictures of the Tyuratam SS-6 test site. However, analysis of the photos seemed to show that, other than at this one site, there were no ICBMs deployed at all.67 This finding should have alleviated fears about a missile gap, but the secrecy surrounding the program prevented the public and even some political leaders from seeing this evidence, so the outcry continued.68

By March 1958, with reconnaissance satellites now well along in their development, Eisenhower wanted to keep U-2 flights to a minimum to avoid provoking the Soviets. But by this time, U-2s provided 90 percent of US intelligence on the USSR, and the information was literally priceless.69 Therefore, the US reluctantly continued the U-2 flights at ever-increasing risk of being shot down. On 1 May 1960, a Soviet air force surface-to-air missile shot down a U-2 flying from Turkey. The pilot, Francis Gary Powers, failed to activate the destruct mechanism, and the Soviets recovered both the pilot and the aircraft.[70] The president immediately suspended overflights and the US lost all information that U-2s had been providing. But, in less than three months, the US again had photos of Soviet missile installations, this time the photos came from space.[71]

Military Space Systems

Because it now wished to use reconnaissance satellites, the US had to modify its policy on the peaceful use of space. What had started out as "nonmilitary" became "nonaggressive" use of space. Military observation from space was likened to military observation from the high seas. The right of free passage through space and the denouncement of rights to sovereignty over space became the major cornerstones of US space policy, in part to protect military satellite overflights.[72]

While the U-2s were hunting ICBMs, the fledgling US space reconnaissance program struggled along, underfunded and ignored. Then the Soviets launched Sputnik, and attitudes changed overnight. By late November 1957, Pied Piper funding quadrupled. In January 1958, Eisenhower approved reorientation of the program towards a simpler reentry capsule approach that seemed more promising in the short term. The government depicted this new program, code-named Corona and later known as Discoverer in public news releases, as a scientific research program.[73]

Discoverer used the Thor intermediate range ballistic missile (IRBM) as the booster and the Lockheed Agena upper stage. Launching into polar orbit allowed photographs of the whole Soviet landmass. Discoverer carried a reentry/recovery capsule designed to detach, deorbit, and be recovered at sea or by an airborne capture method.[74]

The new Discoverer satellite first flew on 28 February 1959 from Vandenberg Air Force Base (AFB) using the Thor-Agena A in the first test of the WS-117L program. The flight failed when the stabilization system malfunctioned.[75]

The Discoverer program's first success came with Discoverer 13 which was launched 10 August 1960 with no instrumentation aboard. It made 17 orbits and reentered smoothly. US Navy frogmen retrieved it near Hawaii after the recovery aircraft missed the parachute. Discoverer 13 was the first man-made object recovered from space. Discoverer 14 was the first satellite to carry cameras and bring back pictures. Launched 18 August 1960, Discoverer 14 restored much of the intelligence capability lost by the cancellation of U-2 flights.[76]

Communication and Navigation. The importance of space support for communications was recognized earlier in the space era. As a military follow-on to NASA's Score satellite (early repeater communication satellite), the Army built the first military communication satellite, Courier lB. Launched on 4 October 1960, Courier weighed 500 pounds and was powered by 20,000 solar cells. Like Score, Courier was a delayed repeater satellite, capable of storing and retransmitting up to 68,000 words a minute. The satellite operated only 17 days due to a power failure.[77] Another use for satellites is navigation. For centuries mankind had navigated using the stars as guides. Celestial navigation has certain limitations since stars could not be seen in daylight or inclement weather. A method of overcoming this problem is the use of artificial stars emitting radio waves rather than light so that they can be detected in all conditions. Navigation satellites also provide increased positional accuracy and are less affected by weather, interference, or distance from the station.[78]

The Navy was the first service to become interested in navigation satellites. The first launch of the experimental Transit lA satellite in September 1959 initiated the world's first military navigational satellite system. Use of Transit to fix locations enabled Polaris submarines to improve the accuracy of their missiles to about one mile.

Antiballistic Missiles. When the ICBM became a reality, military planners began to look for a method to counter the new threat. In the mid-1950s, both the Army and the Air Force began to work in earnest on antiballistic missile (ABM) systems. The first US ABM program, the Army's Nike Zeus, began in 1955. In 1958, the government selected this program for development. The system's nuclear warhead had less than a one megaton yield and was guided to the target by two radars.[79] These radars fed data to the target intercept computer which calculated the steering commands for the missile.[80] The first Nike Zeus launch took place on 16 December 1959. In 1960, the Army ran tests at Ascension Island against Atlas reentry vehicles. Later, the Army conducted successful tests and built an entire Nike Zeus launch complex at Kwajalein Missile Range (KMR). Although the tests continued, DOD canceled the Nike Zeus ABM program in May 1959 because the mechanical tracking radars were too slow and the computer's target processing was unsatisfactory due to inadequate memory. The system also needed a high acceleration missile interceptor for last-ditch defense within the atmosphere (terminal phase interception).[81]

Antisatellites. Virtually as soon as the Soviets vanquished the dreaded U-2 from their skies, they were faced with a new reconnaissance platform, Discoverer. As with the U-2, they threatened to shoot down US satellites and worked hard to develop an antisatellite (ASAT) weapon. The Soviets developed several systems in the 1960s and tested them many times with varied, though promising, results.[82]

Meanwhile, half-veiled Soviet threats to orbit nuclear weapons made US development of an ASAT system imperative. Such a system would be a countermeasure to space weapons and, as such, could enforce any agreement banning orbital weapons. ASATs would also provide a means to destroy such a weapon before it could reach its target. Since no one knew how far along the Soviets were in their development program, little time was available for development in the US program. Therefore the US decided to adapt existing hardware.[83]

The Air Force's satellite interceptor (SAINT) was the first US antisatellite program. SAINT developed from ARDC studies on defense against hostile satellites in 1956. ARPA took over the project in 1957 under ARDC oversight. On ll June 1959, the Air Force let a contract to RCA for research into ASAT techniques, and the Air Force Ballistic Missile Division began development on 20 August when DOD gave final approval for full-scale development of SAINT.

SAINT was to employ the orbital rendezvous technique of interception. The Air Force also envisioned the system as an active defense against Soviet ASATs . It was to defend US satellites, search for orbital nuclear weapons, and rendezvous with and inspect suspect satellites via a TV camera. Not only would the satellite look for nuclear weapons but it also was to differentiate between weather satellites and reconnaissance satellites. Satellites found to be benign would be left alone. Those found to he hostile would be earmarked for destruction.[84]

SAINT used much off-the-shelf equipment to keep costs and development time down. In phase I, SAINT was strictly a satellite inspector using the Atlas-Agena B combination.[85] Air Force planned phase II to include a "kill" capability, perhaps using small, spin-stabilized rockets. However, in July 1960, DOD directed the Air Force to stop referring to a kill capability for SAINT. Once operational, SAINT was to transmit its data to the North American Air Defense Command (NORAD).[86]

X-20. Although unmanned space systems were the dominant theme in the 1950s, the dream of manned space flight was ever present. In the late 1950s, Walter Dornberger, working with Bell Aircraft, suggested to the Air Force the construction of a manned space vehicle called BoMi (bomber missile). This craft would be capable of bombing and reconnaissance from low-Earth orbit. In 1955 Bell received approval to begin research for this program, conceived as a follow-on to the X- 15 program. The program' s emphasis changed to strictly reconnaissance, and in October 1957, the Air Force combined all efforts to create the X-20. NACA joined the program in May 1958, and the government let contracts to Martin and Boeing for weapon system definition studies.[87]

A version of the Titan rocket launched the X-20. Achieving speeds up to 25,000 feet per second, the X-20 would orbit the Earth at a mission altitude of 60 miles. When its mission was complete, it would reenter the atmosphere and land as a glider.[88] In April 1960, DOD gave approval for the first step (suborbital) of a three-step development program for the X-20 with 1966 as the probable date for full operation. However, DOD expressed the opinion that there was no clear-cut need for the X-20, and it remained a contingency program while the Air Force tried to develop a real military mission for it. The lack of a clear mission, along with competition for funds, led to the X-20's eventual demise.[89]

Missile Warning and Space Surveillance. The launch of Sputnik I triggered more than just apprehension and a response in kind (i.e., the launch of US satellites). It also created an entirely new field of endeavor, tracking of objects in space using the Space Tracking System.[90] The first US system, Minitrack, was already in existence at the time of the Sputnik launch, but the US quickly discovered that Minitrack could not reliably detect and track satellites. The US Navy designed Minitrack to track the Vanguard satellite, and so long as satellites followed the international agreement on satellite transmitting frequencies, Minitrack could track any satellite.[91] However, the Soviets chose not to use the international satellite frequencies. Thus, a major limitation of this system became visible. Minitrack could not detect or track an uncooperative or passive satellite.[92]

Concurrent with Minitrack was the use of the Baker-Nunn satellite tracking cameras. These systems used modified Schmidt telescopes of great resolution to photograph and identify objects in space.[93] The cameras first became operational in 1956 and eventually operated at sites worldwide. The Air Force ran five sites, the Royal Canadian Air Force ran two, and the Smithsonian Institution's Astrophysics Observatory operated a further eight sites.[94] The Baker-Nunn system, like Minitrack, provided little real-time data and was limited to night, clear weather operations.[95]

Beyond the problems in acquiring data on satellites, it became obvious that the US tracking network would soon be overwhelmed by the tremendous number of satellites that followed Sputnik and Vanguard. The huge amounts of satellite tracking data accumulated required creation or expansion of organizations and equipment just to sift through and catalog the objects. The need for real-time detection and tracking information to deal with Soviet satellite launches led on 19 December 1958 to ARPA's implementation of Executive Order 50-59 to establish a spacetrack network. This spacetrack network, Project Shepherd, began with the Space Track Filter Center at Bedford, Massachusetts, and an operational space defense network (i.e., a missile warning network). ARDC took up the spacetrack mission in late 1959 and in April 1960 set up the Interim National Space Surveillance Control Center at Hanscom Field, Massachusetts, to coordinate observations and maintain satellite data.[96] At the same time, DOD designated the Aerospace Defense Command (ADCOM), formerly Air Defense Command, as the prime user of spacetrack data. ADCOM formulated the first US plans for space surveillance.[97]

Program 496L. In time, radar largely replaced other tracking methods and provided precise and timely tracking and identification information. A number of new radar sites were built under the direction of the 496L System Program Office. ARPA created this office in late 1959 to develop techniques and equipment for military surveillance of satellites with the "immediate objective of detecting and identifying all man-made satellites."[98]

Authorized under 496L, the Naval Space Surveillance (NAVSPASUR) system has three transmitter sites and six receiver sites dispersed at equal intervals along the 33d parallel in the southern United States. NAVSPASUR projects a detection fence of radio frequency energy far out into space to detect and track all objects passing over the United States. This continuous wave detection radar provides precise satellite position data.[99] With its processing center at Dahlgren, Virginia, NAVSPASUR forms an integral part of the space detection and tracking network.

North American Aerospace Defense Command and the Missile Warning Network. New technology created new challenges for military planners. In the early 1950s, the primary air defense problem was the manned bomber. By the late 1950s, fear of ICBM attack prompted studies (e.g., the Gaither Committee) to determine how the US could react to such attack. Military planners soon realized that there was, at that time, no way to detect an ICBM attack until the weapons hit the ground, which would be too late. To detect and report an attack in time to mount a retaliatory strike, the US constructed a series of interconnected radar sites, each reporting to NORAD.[100]

NORAD became operational 12 September 1957 with the mission of air defense of the North American continent. Headquartered at Ent AFB, Colorado Springs, Colorado, NORAD was and still is a combined US and Canadian command, the first two-nation, joint-service military organization on this continent. In October 1960, NORAD assumed the space defense mission with the formation of the space detection and tracking system. ADCOM became the US Air Force component of NORAD. NORAD's missions were (1) warning of ballistic missile attack, (2) defense against manned bomber attack, and (3) space surveillance.[101]

The first radar systems to come on-line to fulfill the missile warning role were part of the Ballistic Missile Early Warning System (BMEWS) built under the direction of the 496L office. BMEWS provided early warning of an over-the-pole ICBM attack and provided timely and accurate space surveillance data to the NORAD Space Surveillance Center. BMEWS gave 15 minutes warning of an ICBM attack.[102] The first BMEWS operational site was the 12th Missile Warning Squadron at Thule AFB, Greenland, which began operating in January 1960.[103]

Kennedy and Johnson Years: 1961-1968

President John F. Kennedy's administration began its term of office with the traditional policy review. DOD discovered confusion in the military space R&D sector because each service had its own space programs. In March 1961, Secretary of Defense Robert McNamara sought to correct this duplication of effort with DOD Directive 5160.32, *Development of Space Systems*. This directive allowed all of the services to conduct preliminary R&D on space technology. Then, on 28 March, McNamara made the Air Force the lead agency for R&D and operations of DOD satellites and their ground support. Although McNamara's decision made the Air Force the primary DOD space agency, it did not satisfy the Air Force completely by making it the sole military agency in space.[104]

Within months after the national election, the Kennedy administration began to withhold information on military space systems. In November 1961, the administration issued an order that there would be no press coverage of military launches, no published orbital characteristics, and no government officials would even admit that many of the programs existed. The reasons were obvious--to prevent the Soviets from learning anything that might help them counter the satellites, to keep from embarrassing the Soviets by publicizing US space achievements (thereby causing the Soviets to attempt to shoot down US military systems), and to avoid compromise of these important satellites. After November 1961, the government did not announce launches or vehicle and program names.[105] In time, the US canceled the early programs and deorbited and replaced the satellites associated with them with more sophisticated and capable, though more clandestine, systems. The military programs sank into obscurity, known only to a select few, while NASA's up and coming manned programs seized and held the spotlight for the next decade.

During 1963 space systems played a tremendous supporting role in the Cuban missile crisis. Although they did not locate missiles in Cuba, US satellites told Kennedy that the capabilities of Soviet nuclear forces were quite limited. Knowing the threat enabled Kennedy to call Khrushchev's bluff. Soviet counterpart systems told Khrushchev that the US was positioning forces to attack Cuba and that the US Navy was moving into position to stop Soviet ships. The message was clear: The US meant business. The Soviets backed down, and the crisis was averted.

Military Space Systems

Despite the large sums of money the Air Force allocated for its manned X-20 R&D program, many civilians involved with the program (including McNamara) refused to see X-20 as a weapon system. At the same time, the success of the NASA manned systems, Mercury and Gemini, led some military planners to look seriously at military applications for man in space. Placing a human being in a space station to carry out military tasks seemed to have a number of advantages over unmanned spacecraft. People possess intelligence, reasoning ability, the ability to improvise, and the ability to recognize an unexpected pattern. With a person in a spacecraft, a system would no longer be limited to following a program blindly.[106]

The first studies for manned military space missions began in the early 1960s. These studies stressed orbital rendezvous, the use of winged spacecraft for reentry, and the justification of a manned versus an automated system. The NASA study program of the same time period developed into Gemini, an advanced version of Mercury. In June 1962, Air Force Space Systems Division developed the concept of using a modified Gemini as a military system. The first step in the program, called the Manned Orbital Development System, would demonstrate man ' s capabilities in space with a space station and four crew members. The program would use either the Gemini or Apollo capsules as the reentry vehicle, but was not planned to be an operational system.[107] In August 1962, the program expanded to include six Gemini missions with Air Force astronauts under the code name Blue Gemini, but it engendered serious political problems.[108]

When McNamara's defense analysts showed that Gemini would be able to do the X-20 military missions cheaper, DOD cut X-20 funding and postponed the first flight to 1966. Subsequently, McNamara insisted on an equal or dominant role for the Air Force in the Gemini program. NASA claimed that this level of Air Force involvement would jeopardize its ability to meet the lunar landing schedule and would signal the militarization of the US civilian space program. Later NASA agreed to carry some

DOD experiments piggyback on Gemini.[109] In July 1963, NASA suggested to DOD a space station program to look for a possible military mission for man in space. This program became the Air Force Manned Orbital Laboratory (MOL). The X-20 lost out in the funding battle with MOL, and in October 1963, McNamara bypassed the X-20 altogether and obtained funding for MOL. In December 1963, the Air Force made a last bid to save the X-20, suggesting that it be a supply ship for MOL. McNamara answered by canceling the X-20 outright and announcing MOL to the press.[110]

The MOL would be a modified Gemini capsule called Gemini B and a large cylindrical orbital module housing a lab 41 feet long. A Titan IIIC would be the MOL launch vehicle.[111] MOL would determine man's usefulness in space in a cost-effective manner using off-the-shelf equipment and eliminating the need to rendezvous and dock. In a polar orbit, the station would be operational for 30 days. It would test military missions for man in space with 25 experiments including Earth observation via a large orbital optics package, determination of man's ability to survive on orbit for extended periods, and large-structure assembly (such as a radar array) in space.[112]

In January 1965, McNamara reviewed a NASA space station proposal, called Apollo X, because both the Air Force and DOD saw it as direct competition for MOL with all the added expense and duplication that would entail. NASA insisted that since MOL was a short-term program intended to fly in the late 1960s and Apollo X would not be funded until the early 1970s, the two programs were not mutually exclusive. On 25 August 1965, the government gave the formal go-ahead for development of MOL. The five planned flights would begin in 1968.[113]

As the Vietnam War heated up in 1965, DOD reallocated funds to cover the war' s costs. Concurrently, development problems delayed the MOL schedule, and the first launch was rescheduled for late 1970.[114] On 3 November 1966, NASA flight-tested a modified Gemini 2 capsule fitted with a Gemini B hatch in the heat shield. In this unmanned test, the hatch survived without problems. In fact, recovery crews found it welded shut. This test turned out to be the only flight of the MOL program.[115]

Military Satellites. As technology advanced in the late 1960s, the first viable military communication satellites were built. The Defense Satellite Communications System (DSCS) involved three spacecraft phases to provide a reliable network of secure strategic communication satellites with global coverage. Managed by the Air Force, the DSCS satellites were developed by Thompson-Ramo-Wooldridge, Inc. (TRW). The first phase, called the Initial Defense Satellite Communications System (IDSCS) or DSCS I, flew in June 1966. The IDSCS satellite weighed 99 pounds and was 33.5 inches in diameter. This phase involved launching 26 spacecraft into subsynchronous orbits.[116] Launched eight at a time on a Titan IIIC, the satellites stayed in view of a ground station for about four days.[117] Subsequent phases have increased capabilities and survivability.[118]

The military became involved with weather satellite systems when it became apparent that the civilian systems could not meet many of unique DOD requirements. Thus, in 1965 the USAF began the Defense Meteorological Satellite Program (DMSP).[119] DMSP provides timely global visual and infrared cloud imagery and other meteorological data along with space environment information to the Air Force Global Weather Central, the Fleet Numerical Oceanography Center, and the Air Force Space Forecast Center to support strategic missions.[120]

Vela. The Vela Program monitored the Limited Test Ban Treaty of 1963 by detecting nuclear explosions.[121] Vela studies began in 1959 in an AEC and ARPA program. This program also provided information on natural phenomena such as solar flares. On 16 October 1963, the first Vela launch using an Atlas-Agena booster put up two Vela R&D satellites With their 68,000 mile orbits, the TRW-built Velas were the highest orbiting satellites of their time. The high orbit allowed one satellite to view an entire hemisphere of the Earth at once. Therefore, two satellites could cover the whole Earth at once. On 8 April 1970, the last two Velas launched. The Air Force Satellite Control Facility shut down the last Vela satellite on 27 September 1984 as all functions had been taken over by other systems.[122]

Antisatellites. On 9 August 1961, Premier Nikita Khrushchev openly threatened the West with a new and terrifying weapon, the orbital H-bomb. "You do not have 50- or 100-megaton bombs, we have bombs more powerful than 100 megatons. We placed Gagarin and Titov in space, and we can replace them with other loads that can be directed to any place on Earth."[123] Although the US had hypothesized orbital bombs and had developed countermissions for systems like SAINT, this was the first public indication that the Soviets were actively pursuing this course of action. Within a few months, however, analysis of the threat diminished its proportions. In the light of this analysis, the US cut back the SAINT program in December 1962 and then canceled it outright. Off-the-shelf hardware proved inadequate, and the resultant system reliability was questionable. DOD also doubted SAINT's usefulness against disguised weapons and decoys.124

In March 1961, the Navy presented to Congress an extremely advanced ASAT system, Early Spring. This ASAT , based on the Polaris missile, did not use a nuclear weapon as its kill mechanism.[125] R&D work continued into 1964 with researchers investigating several system configurations.[126]

Theoretically, a missile submarine parked itself under the path of the target satellite. The crew launched a missile that had a booster with just enough power to attain the desired altitude. Attached to a restartable upper stage, the payload would hover at the target altitude for up to 90 seconds waiting for the satellite to arrive. An optical scanning system, sensitive enough to see an object that the unaided eye would strain to see, first located the target with a wide field of view and then, once it had identified the target, tracked it with a narrow field for precise guidance. The missile relayed data to the submarine for real-time control. Once it had identified the target, the vehicle maneuvered onto a collision course, and a proximity fuse detonated the warhead releasing thousands of steel pellets. The impact of even one pellet would destroy the satellite. A submarine could launch several missiles at one target.[127] A major advantage of Early Spring was that the Polaris submarines could go almost anywhere to get at a satellite. Although the Navy successfully tested the optical tracker in the late 1960s, it canceled Early Spring because of funding difficulties and problems of real-time command and control at sea.[128]

Another, less versatile system was Program 505, the US Army ASAT program based on the Nike Zeus ABM, code-named Mudflap. McNamara approved the Army's request to restructure the Nike Zeus ABM program into an ASAT in May 1962. Program 505 was the world's first operational ASAT . Modifications gave the missile increased range to do the ASAT mission. The Army based 505 at Kwajalein Missile Range at the facility built for the Nike Zeus ABM tests. In December 1962, the first Nike Zeus ASAT , launched from White Sands Missile Test Range against an imaginary target, succeeded. Many other tests over the next year had fairly good results. After a 27 June 1963 ASAT policy meeting, McNamara directed the Army to complete the Nike Zeus facility at KMR (including its nuclear warheads).[129]

At the same time, the Air Force's second ASAT , Program 437, began on 9 February 1962 as Advanced Development Objective 40 (ADO-40). It was intended as a "demonstration of the technical feasibility of developing a nonorbital collision-course satellite interceptor system capable of destroying satellites in an early time period."[130] The program stressed system effectiveness, simplicity, short reaction time, economy of support and maintenance, and use of both nuclear and nonnuclear warheads. The war- fighting capability of the system was a major consideration.[131] On 8 May 1963, President Kennedy directed the DOD to develop an ASAT capability as soon as possible.132

The Air Force based the system at Johnston Island, a small island 715 miles south of Honolulu, Hawaii. The launch complex had all the necessary support facilities for full operations. The remoteness of the island assured safety and security. Program 437 employed the Thor IRBM with an intercept range of 700 miles. The Thor ASAT employed a nuclear warhead as the kill mechanism and produced a five-mile kill radius. System reaction time started out at two weeks, although the Air Force had desired a two-to-three-day reaction time to achieve a kill.[133]

In March 1963, DOD made the Thor ASAT a high priority and directed Air Force to support it fully. Air Force Systems Command and Aerospace Defense Command jointly controlled the program for some time. Air Force Space Command's (AFSC) 6595th Test Squadron conducted the system tests. On 15 February 1964, the squadron launched the first Program 437 rocket. The test succeeded with a simulated warhead passing within easy kill distance of the target, a Transit 2A rocket body. By 10 June 1964, the missiles were fully operational and on 24-hour alert. From 1966 through 1970, the Air Force conducted many successful test launches.[134]

McNamara believed that Program 505 competed directly with the Air Force ASAT , and that DOD could maintain only one program. Program 437 had higher altitude capability while Program 505 had faster reaction time (solid versus liquid propellants) . Program 437 received top priority, but the Army still kept the 505 missiles ready at KMR as a fast-reaction ASAT missile for low-altitude satellites. In May 1966, McNamara declared Program 505 redundant and directed its phaseout.[135]

Antiballistic Missiles. By 1960 the threat posed by the growing numbers of ICBMs and decoys rendered the Nike Zeus system obsolete even before it started. In January 1963, the government authorized a new program called Nike X. The Army developed this system to counter the threat posed by depressed trajectory submarine-launched ballistic missiles (SLBM) (for which reaction time was far more critical) as well as ICBMs. A low-altitude nuclear burst would be the kill mechanism for the system. Unfortunately, the burst to destroy the reentry vehicle could be as harmful to friendly soft targets as the explosion of the enemy device.[136]

By October 1965, the Army finalized the Nike X design, which consisted of 12 sites with the mission of protecting civilian and military targets against an all-out Chinese or Soviet ICBM/SLBM attack. The program included two missiles, the exoatmospheric Spartan and the endoatmospheric Sprint. The long-range Spartan's first flight was in March 1968. The hypersonic Sprint carried a nuclear warhead of low-kiloton yield and zipped from zero to Mach 10 in less than five seconds. Sprint's first flight was in November 1965.[137]

To complement these missiles, the Army developed new radars. The perimeter acquisition radar (PAR), a phased array radar located at Concrete, North Dakota, detected incoming missiles and provided targeting data. The multifunction array radar, tested at WSMR in July 1964, proved inadequate and the Army replaced it with the improved missile site radar (MSR). The new radar first operated at KMR in September 1968. Located at the missile site, the MSR could discriminate targets at 700 miles and provided terminal phase guidance and targeting information for Spartan and Sprint. An ABM complex consisted of a long-range PAR , a short-range MSR, and Spartan and Sprint missiles with four remote Sprint launch sites about 25 miles from the MSR. Total cost was about $6 million.[138]

McNamara, long against ABM systems, believed that the offense could always overwhelm such a defense at a lower cost. Thus there was really no hope of protecting the general population. Therefore, on 15 September 1967, McNamara announced that there would be no nationwide ABM system (that is Nike X) because an ABM system only prompted the opponent to build more missiles to overwhelm it. In its place would be a "thin" ABM system called Sentinel, covering only major US cities. It would be designed primarily as a precaution against a limited Soviet or Chinese attack. However, the change of administrations would bring yet another change in thinking.[139]

Fractional Orbit Bombardment System. In the early 1960s, the Soviets needed a way to overcome the West's geographic advantages (forward bases in Turkey, Europe, and Asia from which shorter range missiles and bombers could attack the USSR) . The Soviet attempt to place missiles in Cuba would have been a partial remedy. When the Cuban venture did not go as planned, they moved to other technological possibilities The Soviets demonstrated the technology necessary to orbit a space vehicle and then land it in a specific place with the Vostok launches. It was thus logical to assume they could place nuclear weapons in orbit and return them to Earth at any time and place.[140] Khrushchev made this suggestion in 1961, but on 15 March 1962, as part of the rhetoric proceeding the Cuban crisis, he made yet another, more ominous suggestion.

> We can launch missiles not only over the North Pole, but in the opposite direction, too.... Global rockets can fly from the oceans or other directions where warning facilities cannot be installed. Given global missiles, the warning system in general has lost its importance. Global missiles cannot be spotted in time to prepare any measures against them.[141]

This statement was the first hint of a new concept called the fractional orbit bombardment system (FOBS). This weapon, a modified upper stage launched by the SS-9 Mod 3, Scarp, carried a one- to three-megaton warhead and went into low-Earth orbit, giving the ICBM unlimited range and allowing it to approach the US from any direction, avoiding US northern-looking detection radars and, therefore, giving little or no warning. The reentry vehicle came down in less than one revolution, hence the "fractional" orbit.[142]

After the failure of their first two tests in 1966, the Soviets tested their FOBS with nine launches between 25 January and 28 October 1967. All missions followed the same distinct flight profile--launching in the late afternoon into an elliptical, near-polar low-Earth orbit and deorbiting over the Soviet landmass before one complete orbit. This profile allowed the Soviets to monitor the deorbit, reentry, and impact. US planners viewed FOBS as a pathfinder system intended to precede a conventional ICBM attack. FOBS could destroy ABM radars, disrupt US retaliatory capability, destroy command posts, the White House, and the command and control network. But, due to its limited accuracy and payload, FOBS was ineffective against hardened targets.[143]

Missile Warning and Space Surveillance Network

As new strategic threats appeared, the missile warning and spacetrack network expanded to meet these challenges. BMEWS grew to include three sites: Clear AFS, Alaska; Royal Air Force Fylingdales Moor, England; and Thule, Greenland. These BMEWS sites provided an unavoidable detection fence across the entire northern approach to the North American continent.[144] For spacetrack, the Air Force built a totally new type of system, the AN/FPS-85, a prototype phased array radar at Eglin AFB, Florida. The radar reached initial operational capability (IOC) in 1968 with the 20th Surveillance Squadron (SURS) specifically assigned to do the space surveillance mission.[145] Looking to the south, the AN/FPS-85 can see up to 80 percent of all the objects in space each day. This system greatly enhanced NORAD' s space surveillance capability.

From the late 1960s and throughout the 1970s, the Soviet missile threat increasingly came from the oceans as the Soviets developed and deployed SLBM-carrying submarines. To counter this new threat, the USAF planned the SLBM detection and warning system with new radar sites along the coasts and improvements to existing systems to provide warning of missile attack from the sea.[146]

National Aeronautics and Space Administration

While NASA geared up for its first manned space launch, the Soviets again beat the US into space. On 12 April 1961, the Soviets launched Vostok 1 with cosmonaut Yuri Gagarin aboard. He made one orbit and landed safely. Here was a blow to US prestige on a par with Sputnik. The situation seemed to galvanize the American public. On 31 January 1961, a chimpanzee named Ham survived launch and reentry aboard the Mercury Redstone 2 (MR-2) rocket. Had a man been aboard this capsule, the US would have beaten the Soviets by two and one-half months. On 5 May 1961, US Navy Commander Alan B. Shepard became the first American to go into space with a suborbital flight aboard MR-3. Twenty days later, President Kennedy took advantage of the ground swell of emotion after Shepard's flight to call for putting a man on the moon by the end of the decade.[147] The loss to the Soviets and the immediate US response made the American people willing to support a program of Apollo's magnitude.

[Image 22K]

MR-3 Lift-off

There were five more Mercury flights, the last four using an Atlas rocket as booster. With this Mercury-Atlas (MA) combination, Marine Lt Col John Glenn became the first American in orbit (three revolutions) aboard MA-6. The last Mercury flight by USAF Maj Gordon Cooper aboard MA-9 was the longest, 22 revolutions (34 hours, 20 minutes).[148]

[Image 16K]

Mercury-Atlas 9

NASA was virtually dependent on the Air Force for trained launch personnel, launch vehicles, and facilities All NASA manned launches were carried out by Air Force personnel with Air Force vehicles and facilities until completion of the Apollo Pad 39 launch complex in 1966. However, as NASA's requirements and Air Force involvement grew to meet the challenge of the Moon launch, the Air Force's influence over NASA actually decreased. Many Air Force manned projects were in direct competition with NASA projects. The Moon project, and the stepping stones that led to it, developed a momentum of their own which the Air Force could neither redirect nor reduce.[149]

[Image 20K]

Gemini IX Lift-off

NASA's Mercury follow-on, Project Gemini, developed procedures and practiced orbital maneuvers, rendezvous and docking, and extra-vehicular activity (EVA), and allowed US astronauts to gain experience needed for longer missions. Too massive for an Atlas rocket launch, Gemini flew atop a man-rated version of the Titan II ICBM. Gemini achieved many successes. In March 1965, Gemini Titan 3 (GT-3), the first manned flight, performed the first orbital plane change. In June 1965, Edward White performed the first US EVA aboard GT-4. GT-6 and GT-7 conducted the first US dual flight in December 1965. GT-7 set the space endurance record (to that date) of 330 hours 35 minutes. In July 1966, GT- 10 performed the first hard docking of two spacecraft when it docked with the Agena docking target vehicle (ADTV). In September 1966, GT-11 accomplished the first one-orbit rendezvous with ADTV only 94 minutes into the flight.[150]

[Image 23K]

GT-3 Lift-off

By 1966 NASA's Moon project was well under way. The system designed to take men to the Moon and back was huge and massively complex. Its three-stage Saturn V rocket was the largest launch vehicle to date. The first stage, with five Rocketdyne F-1 engines, developed more than 7.5 million pounds of thrust at lift-off. The first flight of the Saturn V took place on 9 November 1967. The smaller Saturn lB rocket launched early test missions into near-Earth orbit.[151]

[Image 32K]

Saturn S-IVB Engine

On 27 January 1967, the Apollo flight test program started in tragedy as three astronauts died in a capsule fire during a launch pad rehearsal. The cause of the fire is still unknown, but the pure oxygen environment of the capsule was a major contributing factor. Astronauts Virgil ("Gus") Grissom, Ed White, and Roger Chaffee died in the fire. The accident set the first Apollo launch back to 11 October 1968 due to the need for extensive capsule redesign.[152]

[Image 32K]

Apollo 15 Rollout

Nixon and Ford Years: 1969-1976

On 13 February 1969, President Richard M. Nixon formed a space task group (STG) to examine future US space activities. Its September 1969 report recommended several changes for the national space program, including comprehensive cost reduction. The STG stressed the need for practical applications and international cooperation in space.[153] The group recommended a reusable space system to provide low cost-per-pound to orbit. This system, with its envisioned 100-flight lifetime, developed into the National Space Transportation System (STS).[154] Regarding military programs, the group recommended that new programs be considered within the context of the threat, economic constraints, and national priorities. Such programs would only be authorized when shown to be more cost effective than other methods.[155]

In 1969 the Nixon administration approached the Soviets with the idea of mutual limitations on strategic nuclear arms. These Strategic Arms Limitation Talks (SALT) would last for eight years, produce three arms limitation treaties, and lay much of the groundwork for later arms negotiations. The Treaty on the Limitation of Anti-Ballistic Missile Systems limited systems to those meant to counter strategic ballistic missiles. This treaty was a product of the SALT I talks but was negotiated separately from the Interim Agreement (IA) on Strategic Nuclear Arms. Signed on 26 May 1972, the ABM Treaty entered into force for the US on 3 October 1972. Its provisions included limits on ABM systems to curb the strategic arms race and decrease the risk of nuclear war. Under the provisions of the treaty:

1. Each nation could have no more than 15 ABM launchers at test ranges for R&D purposes (Article IV).

2. Both parties agreed not to develop, test, or deploy ABM systems or components that are sea-based, space-based, or mobile land-based (Article V).

3. Neither nation could have rapid reload capability (Article V).

4. Both parties agreed not to give missiles, launchers, or radars--other than ABM missiles, ABM launchers, or ABM radars--the capability to counter strategic ballistic missiles and not to test them in an ABM mode (Article VI).

5. In the future there would be no deployment of early warning radars for strategic missile attack except for those along the periphery of the national territory and oriented outward (Article VI).

6. Both countries may use national technical means of verification to assure compliance as in the IA (Article XII).

7. The treaty, of unlimited duration, is subject to review every 5 years (Article XIV).

Under the 1974 Protocol, each nation could build and operate only one ABM system to protect the national capitol or one of its ICBM fields. This single ABM system could contain no more the 100 launchers and no more than 100 ABM interceptors.

Soviet Threat

By 1968 the Soviets' FOBS program settled into a two-flight-per-year pattern which indicated an operational status, although they only deployed FOBS in 18 silos.[156] Also that year, the Soviets began testing what appeared to be a co-orbital ASAT . Little attention was paid to these events because they occurred during the national election and at a time when Vietnam had all the headlines. Almost two years passed between the second and third ASAT tests. There was little public recognition of the hiatus or the resumption of testing.[157]

However in 1970, NSC requested DOD to take a look at the mysterious Soviet satellite program and its potential impacts. Consensus was that this program. was a form of antisatellite system although no one was quite sure why the Soviets were building such a system, why they had chosen a co-orbital system (unlike the US Nike Zeus or Thor ASATs), or indeed, what the ASAT 's target might be. DOD recommended US space systems and procedures be modified to reduce their vulnerability to the Soviet "killer satellite." As for whether the US should develop a similar capability as a response or deterrent, DOD felt that a US counter would not deter Soviet use of an ASAT because of greater US dependency on its space assets. In such a contest, the US would be hurt by an ASAT more than the Soviets would be.[158]

Antiballistic Missiles

The new administration thoroughly reviewed the ABM system the previous administration had reluctantly initiated. The size and disposition of the system was not a major point of concern, but the philosophy of its employment was. On 14 March 1969, Nixon announced that the US would replace Sentinel with the new Safeguard program. With the same strength and sites as Sentinel, Safeguard would cover the Strategic Air Command' s ICBM fields to protect the US nuclear deterrent instead of major cities. Nixon said that the only true way to protect the US population was to prevent a nuclear war by keeping a viable deterrent. The first two of the six sites would be at Grand Forks, North Dakota, and Malmstrom AFB, Montana.[159]

After the signing of the ABM Treaty, work proceeded on only the ABM site at Grand Forks AFB. The Grand Forks site reached completion in fall 1975. On 1 October 1975, the site became operational, but on 2 October, Congress ordered it closed. The reasons for closure are numerous. The cost of the one system was staggering.[160] The cost of the entire system (six sites) would have been almost $40 billion. The SALT I treaties had limited defensive systems, and the Soviet introduction of multiple independently targetable reentry vehicle warheads on their missiles could simply confuse and overwhelm any US ABM system just as McNamara said it would.[161] Therefore, the US limited all ABM activities to research until the Strategic Defense Initiative began in 1983.[162]

Military Space Systems

Even before the publishing of the Strategic Task Group report, new DOD leadership began implementing cost-cutting measures in line with the STG recommendations. On 10 June 1969, DOD cut the MOL program that had been carried over from the Kennedy and Johnson years.[163]

DOD stated that due to budget restrictions, it had the choice of drastically cutting several smaller projects or deleting one large R&D project.[164] MOL, like so many other programs, was a victim of the tight DOD budget and other problems.[165]

Antisatellites. While the Soviets were getting their ASAT system going, the US ASAT, Program 437, was falling on hard times. Back in 1962, the Starfish High Altitude Nuclear Test released sizable amounts of radiation into space. This radiation, trapped by the Earth's magnetic field, created artificial radiation belts 100 to 1,000 times stronger than background levels and damaged a number of satellites. The conclusion reached from this experience was that if Program 437 were ever used in anger, it would destroy friend and foe alike. Compounding this problem, the Soviets put up so many military satellites that there were too many potential ASAT targets. Also, there were major funding cuts in the program due to the Vietnam War. To make matters worse, the Air Force was simply running out of Thors. Therefore, in October 1970, DOD moved Program 437 to standby status as an economy measure. Thirty days were now needed to prepare for an interception, which totally destroyed the system's credibility as a weapon.[166]

On 19 August 1972, Hurricane Celeste delivered another major setback for Program 437 by destroying most facilities on Johnston Island. The facilities were repaired and back in service by September 1972, but because of undetected damage, the system went down again on 8 December and, after more repairs, returned to service on 29 March 1973. The satellite intercept mission for the Johnston Island facility ended with a program management directive for Program 437 (10 August 1974). NORAD notified the JCS of program termination on 6 March 1975.[167] On 1 April 1975, DOD terminated the program altogether.[168]

In August 1974, President Gerald R. Ford reassessed the Soviet ASAT threat and US capability to respond to it. The Soviets were pursuing an "adventurist policy" by deploying an ASAT that could disrupt US communications and other systems. The 1975 Slichter Report pointed out tremendous vulnerabilities in US space systems while US dependence on these systems was growing. The apparent Soviet "blinding" of two US satellites in October and November 1975 and resumption of ASAT testing in February 1976 created considerable concern in the White House. In response, the president issued National Security Decision Memorandum (NSDM) 333 in the fall of 1976. It directed DOD and others to take steps to redress satellite vulnerability. Air Force Systems Command's Space Division set up a system program office to conduct studies in this area.[169]

In December 1976, another report, by the Buchsbaum Panel, echoed the concern over the growing US dependency on satellites for communications, intelligence, and warning functions and the glaring vulnerability of satellites and ground stations. The report insisted that immediate measures be taken to correct this situation. The Buchsbaum group and DOD agreed that a US ASAT could not function as a deterrent to Soviet use. However, they stated that a US ASAT could be used against Soviet intelligence systems and as a bargaining chip to induce the Soviets to enter ASAT arms control negotiations. Verification of a limit on ASAT weapons would be a difficult task since a very small number would have a significant impact. Also it would be very easy to hide a residual capability. Eventually, such an agreement would have to stop R&D as well as deployment and possibly seek to dismantle all ASAT-capable systems.[170]

President Ford was not impressed with the low priority DOD gave to the ASAT matter. DOD stated that the US should use restraint with regard to space weapons in the hope that the Soviets would reciprocate. President Ford did not agree and in light of the turn of events (the Buchsbaum Report and the Soviets' 27 December 1976 ASAT test) decided to redress this situation. On 18 January 1977, just two days before he left office, Ford signed NSDM 345 directing DOD to develop an operational ASAT capability while studying options for ASAT arms control. He left it up to his successor to carry out this directive.[171]

Missile Warning and Space Surveillance Network. Reacting to impending limits set by SALT on their land-based ICBMs, the Soviets expanded their nuclear missile submarine fleet dramatically. In response, DOD upgraded and enhanced the SLBM warning network. The Air Force installed eight mechanical, pulsed conical scan tracker radars, designated AN/FSS-7, at strategic points along the US coast. These radars were on-line by April 1972. Also in 1972, the Air Force' s AN/FPS-85 space surveillance radar at Eglin AFB, Florida, received computer software changes to convert the system to the SLBM detection mission in addition to its spacetrack mission.

The Grand Forks AFB, North Dakota, Safeguard ABM site closed in February l976. However, in January 1977, the Air Force took over the perimeter acquisition radar located at Concrete, North Dakota, for use in the Missile Warning and Spacetrack Network and renamed the AN/FPQ-16 (phased array radar) the Perimeter Acquisition Radar Characterization System (PARCS)

. With modifications, the system operated again as an SLBM/ICBM detection site watching the polar regions and Hudson Bay. Operated by the 10th Missile Warning Squadron, PARCS provided space surveillance data as a tertiary mission.[172]

National Aeronautics and Space Administration

While DOD canceled many military space programs and scrutinized space policy, NASA's manned space program rode high as the decade neared its close. In December 1968, Apollo 8 performed the first manned flight to the vicinity of the Moon, and Apollos 9 and 10 conducted tests in Earth and lunar orbit in early 1969. Then Apollo ll provided the first manned landing on the Moon on 19 July 1969. Astronaut Neil Armstrong became the first man to set foot on the Moon. The Moon crew deployed a large number of scientific experiments and collected several pounds of rocks.[173]

Although the enthusiasm for the space program was high and NASA would land on the Moon five more times in the next two years, the first Moon landing was the high water. There would soon be drastic NASA budget reductions.

Apollo X. The MOL cancellation early in the Nixon presidency left only NASA's Apollo X program to carry on space station development. By late 1972, NASA was completing this station, now called Skylab. Skylab used the first and second stages of a Saturn V rocket to get into orbit. The station had 11,700 cubic feet of space for the crew, a length, with Apollo spacecraft attached, of 118.5 feet, and a weight of 168,100 pounds or 84 tons (Skylab only).[174] Skylab tested long-term weightlessness and the ability of humans to adapt to it, and conducted experiments in solar physics, astronomical observation (unencumbered by the Earth's atmosphere), and space manufacturing. Crews also conducted experiments and observations related to Earth resources studies, and they conducted space medicine research.[175]

[Image 29K]

Skylab

NASA launched Skylab 1, unmanned, on 14 May 1973. It suffered serious damage during launch when the meteoroid shield tore away, one solar panel ripped off, and the other jammed shut. This damage resulted in the loss of electrical power and caused severe overheating because of the loss of the reflective shielding. NASA launched three manned Skylab missions to dock with Skylab on 25 May, 28 July, and 16 November 1973. Skylab' s orbit decayed and it reentered in 1979.[176]

Apollo/Soyuz Test Program. Limited US and USSR cooperation in space occurred during the 1960s. The cooperation consisted of information exchange between the space agencies. With improved relations in the 1970s, the possibility for greater cooperation grew. Talks on the subject of astronaut/cosmonaut safety and use of common docking technology began as early as 1969, but specific joint working groups were not formed until October 1970. At the Moscow Summit in May 1972, the US and Soviet Union signed the five year Agreement on Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes, the SALT IA, and the ABM treaties. The agreement scheduled a joint US/USSR space flight in 1975. This agreement was the beginning of the Apollo/Soyuz Test Program (ASTP), which developed rescue systems for saving astronauts and cosmonauts in emergencies in space (like Apollo 13 and Soyuz 11). Joint task groups designed and built a compatible docking module with the Soviet-style docking apparatus on one end and American type on the other. Both nations launched vehicles on 15 July 1975. On 18 July, Apollo 18 docked with the Soviet Soyuz 19 spacecraft. The two spacecraft remained docked until 21 July and carried out joint scientific and medical experiments. Although the joint flight was a success and added measurably to the US and Soviet relationship, it remains the only joint US/USSR spaceflight venture to date.[177] ASTP was the last US space flight for almost six years.

[Image 17K]

Apollo/Soyuz Test Project Spacecraft

Carter Years: 1977-1980

ASAT arms control keenly interested the Carter administration. President Jimmy Carter approached the Soviets on the subject in March 1977. While negotiating, the US continued to work on its own ASAT. DOD intended to develop the US ASAT in an orderly fashion and did not plan a crash program to get the system on-line. The Carter administration believed that even the threat of an operational US ASAT could be used as a bargaining chip to provide the Soviets incentive to negotiate. This method of arms negotiation and simultaneous ASAT R&D came to be called the Two-track Policy.[178]

On 11 May 1978, Carter signed the Presidential Decision on National Space Policy 37 which laid out the founding principles of US space policy. Carter's space policy principles included US sovereign rights over its space objects and the right of passage into and through space. A new principle was added, fueled by Soviet testing of their ASAT system--the right of self defense in space. This principle would bring about a major change in US space policy because it recognized space as a possible war-fighting medium. The presidential memorandum directed DOD to formulate plans to use civil, military, and commercial space assets in wartime or other emergencies as determined by the president. DOD was also to take actions to make US space systems survivable in the event of a conflict and to develop an operational ASAT. DOD was to create an integrated attack warning, notification, verification, and contingency reaction capability for space defense. The US would continue to exercise restraint in the use of space weapons and recognized that negotiations on the subject of space arms control were desirable. As a result of this rethinking of the traditional roles of space systems and the reevaluation of the medium, the influence of the R&D world of Air Force Systems Command in space matters began a slow but steady decline. At the same time, the space operations world increased its power and influence as war-fighting capability (survivability, reliability, responsiveness, etc.) became the new order of business for space systems.

[Image 21K]

Voyager Spacecraft

Military Space Systems

In October 1977, Secretary of Defense Harold Brown announced that the Soviets had an operational ASAT system. This fact was the prime consideration in the Carter administration's change in US space policy and the redirection of the US military space program. DOD initiated the Space Defense Program in 1977 to perform research into ASAT technology, satellite survivability, and improved space surveillance.[179]

Antisatellite Weapons. Ford's administration had rekindled large-scale ASAT weapon research although considerable work had been done from the early 1970s under the Missile and Space Defense Program. Research centered on the miniature homing vehicle (MHV) with nonnuclear kill capability. In September 1977, Vought contracted to build the MHV. The MHV's intercept sequence began with launch aboard a ground-launched booster or from a high-altitude aircraft. The MHV maneuvered to the calculated vicinity of the target, where its sensors locked on and tracked the target. The MHV then homed in on the target and destroyed it via collision.[180]

The Air Force dropped the ground-launched option which used a modified Minuteman III ICBM in favor of air-launch from an F-15 fighter. The air-launched booster was a Boeing short-range attack missile first stage and a Vought Altair III second stage. Air-launch provided the advantages of flexibility, mobility, and "more attacks per day." MHV's biggest advantage over the old Program 437 and 505 systems was that it did not have to wait for the target to come to it.

In May 1978, the Joint Chiefs of Staff (JCS) published a report containing a prioritized listing of potential Soviet target satellites for the MHV. At the same time, JCS directed DOD to work on another ASAT system, termed the conventional ASAT, as a low-risk alternative system using off-the-shelf technology. This system, employing pellets as its kill mechanism, was intended as a backup in case the MHV proved too difficult.[181]

Satellite Survivability. The Space Defense Program also conducted satellite survivability research. Studies showed that satellites were extremely vulnerable to countermeasures. The US ASAT system might, in time, provide some measure of defense for some satellites in a contingency situation, though that was not its intended purpose. The satellites and their command and control network needed serious attention to allow them to function in a hostile environment. Efforts to improve the battle worthiness of these systems were directed at three areas--the orbital segment, the link segment, and the ground segment.[182]

The command and control facilities were in particular need of attention. The Air Force Satellite Control Facility at Sunnyvale, California, was, and still is, an unhardened, above-ground facility located on the San Andreas Fault. (It is in serious danger in case of an earthquake.) The Air Force began construction of a modern, survivable facility east of Colorado Springs, Colorado. This facility, the Consolidated Space Operations Center, is designed to control most DOD space assets. Also, the Air Force envisioned ground-mobile satellite command and control units to ensure survivability through mobility and proliferation[183]

Although measures to improve the survivability of US space assets made sense, the US implemented them in a piecemeal fashion. Budgetary constraints were much to blame. Payload limitations also restricted the amount of satellite redundancy and hardness. Probably the leading reason for the haphazard treatment of survivability was the low priority placed on space systems despite their unquestioned value. The low priority was the result of the lack of a single constituency advocating change.[184]There was no single unified view of space and its place in the military structure. During the Reagan administration this problem would be given major consideration.

Directed Energy Weapons. Since the late 1960s, the services and ARPA , now called the Defense Advanced Research Projects Agency (DARPA), did considerable work on directed energy weapons (DEW), which are lasers and particle beams. However, only towards the end of Ford's tenure did such exotic technologies begin to show promise as weapons. The laser blinding incidents in 1975 (previously mentioned) showed that the Soviets were moving in this direction and had the potential for building a usable system. This increased US interest in this type of system, but considerable controversy existed over the direction of any project involving DEW and the level of funding to be given to these programs.[185]

The Carter administration was skeptical of DEW programs and felt that these were not mature technologies. It viewed conventional methods for ASAT , ABM, and ground target destruction (e.g., ICBMs) as more cost effective, and all DEW efforts remained exploratory in nature.[186]

Missile Warning and the Space Surveillance Network. The Air Force constructed an advanced radar site on the remote Aleutian island of Shemya in the northern Pacific. Construction of the system, the AN/FPS-108, Cobra Dane phased array radar, started in 1973, and it became operational in August 1977. The 16th Surveillance Squadron operates the radar, conducts surveillance of foreign missile launches, provides missile warning of ICBM and SLBM attack, and supports the Air Force Space Surveillance Network.[187]

In 1978, the Air Force initiated the Spacetrack Improvement Program which led to the construction of new systems and integration of existing systems into a larger and more effective surveillance network. The Air Force created the Pacific Radar Barrier including sites at Kwajalein, Guam, and the Philippines.[188] The 17th Surveillance Squadron which was located on Luzon Island at the San Miguel Naval Communications Station, Republic of the Philippines, was a typical example of these systems. Activated in 1980, its mission was the detection and tracking of foreign missile launches and the identification of selected payloads and space debris. The 17th's AN/GPS-10 radar reached IOC in April 1983. In June 1990, the 17 SURS ceased operations and was supplanted by a new surveillance facility, Detachment 5, 18 SURS at Saipan.[189]

Another improvement was the conversion and integration of DARPA 's space object identification facility on the Hawaiian island of Maui with the Air Force's planned ground-based electro-optical deep space surveillance (GEODSS) sites.[190] The GEODSS system was the successor to the Baker-Nunn camera system.[191] MIT Lincoln Lab developed and tested GEODSS at Experimental Test Site 1 at Socorro, New Mexico, near WSMR.[192] GEODSS used powerful telescopes, electro-optic cameras, and high-speed computers to gather tracking and identification data on deep space satellites

A major improvement made to space operations command and control took into account the wartime role of space systems envisioned by Carter' s space policy. Originally conceived as the NORAD Combat Operations Center, the Space Defense Operations Center (SPADOC) was to be the hub of Air Force wartime space activities. The SPADOC would consolidate all US ASAT , space surveillance, and satellite survivability operations in a single operations center. The SPADOC became operational on 1 October 1979 for limited development operations at the NORAD Cheyenne Mountain Complex.[193]

During the spacetrack network upgrades, the missile warning net received new systems as well with the introduction of PAVE PAWS , the AN/FPS-115, advanced phased array radars built by Raytheon Corporation and designed for the SLBM warning mission. PAVE PAWS provides improved radar coverage and detection capability as well as additional warning against ICBM attack as a secondary mission and space surveillance as a tertiary mission.[194]

National Aeronautics and Space Administration

The Space Shuttle Program continued to be NASA's chief area of interest when the Carter administration took office in January 1977. NASA tentatively scheduled the first orbital test flight for March 1978. In February 1977, NASA began the first of the STS approach and landing test program flight tests with the shuttle *Enterprise* at the Dryden Flight Research Center at Edwards AFB, California. A modified Boeing 747 airliner carried the shuttle piggyback. The first free-flight occurred on 12 August 1977 with astronauts Fred Haise and Gordon Fullerton aboard. The last such flight was on 26 October 1977.[195] *Enterprise* never went into space.

After many hours of structural testing with *Enterprise*, NASA declared the orbiter design structurally flightworthy in April 1979.[196] Meanwhile *Columbia,* the first shuttle intended to fly into space, arrived at the Kennedy Space Center in March 1979, already a year behind schedule, and sat for more than two years. The delay was caused by problems with the 30,922 tiles of the thermal protection system and the space shuttle main engines which were also two years behind schedule. NASA rescheduled the first flight for 10 April 1981.[197]

Reagan Years: 1981-1988

The new president tasked NSC to review US launch vehicle needs; the adequacy of the current administration policy to meet continued US civil, commercial, and military needs; NASA/DOD space shuttle organizational responsibilities and capabilities; and potential legislation on space policy. The NSC space policy review began in August 1981. DOD performed an internal space policy study at the same time.[198]

On 4 July 1982, President Ronald W. Reagan spoke at Edwards AFB at the fourth space shuttle landing. In this, his first speech on space policy, the president called for "a more permanent presence in space" for the US and said that steps must be taken to provide "assured access to space."[199] On the same day as his speech, the White House issued National Security Decision Directive (NSDD)-42, which reiterated the principles of Carter's PD/NSC-37. However, there were significant differences. NSDD-42 emphasized the US ASAT as a deterrent to Soviet use of their system with eventual deployment as a goal of the program. The ASAT would deny the enemy the use of space and space assets in time of war or crisis. The directive went on to say that the administration would study and consider treaties on weapons in space compatible with US national security interests. This statement was somewhat less positive than Carter's assertion that such agreements were desirable. Like PD/NSC-37, NSDD-42 also extended the principle of sovereign rights over a nation's space assets to include the right to defend those assets in space.[200]

The DOD space policy review contained "no new directions in space weaponry."[201] However, deterrence was now the primary role of the US ASAT program despite the fact that many experts said that this role was unworkable in light of the disparity in dependence and launch capacity between the US and USSR. DOD would explore technological avenues for prompt space support and projection of force in and from space and to assure free access while denying the same to the enemy.[202] As such, NSDD-42 laid the groundwork for use of space as an arena for military operations by asserting the right of self-defense, and it opened the way for development of assets to fighting in and from space.

On 23 March 1983, President Reagan made his now famous Star Wars Speech announcing the Strategic Defense Initiative (SDI). The president called for increased military spending to meet US military requirements and commitments Then, to the surprise of most everyone (including members of his staff), Reagan called for defensive measures to render Soviet missiles obsolete. This call was a direct move away from the old policy of mutual assured destruction towards a policy of strategic defense as a means of deterrence. Secretary of Defense Caspar Weinberger stated, "The defense systems the President is talking about are not designed to be partial. What we want to try to get is a system which will develop a defense that is thoroughly reliable and total." This "system" grew into a series of systems forming a layered ballistic missile defense.[203]

Two days after the speech, the Reagan White House released NSDD-85, "Eliminating the Threat from Ballistic Missiles." The NSDD directed "an intensive effort to define a long term research and development program aimed at an ultimate goal of eliminating the threat posed by nuclear ballistic missiles." The directive was a total commitment to a long-range R&D program for ballistic missile defense. The White House set up committees to study technological, political, and strategic considerations of such a system.[204]

Arms Negotiations

In August 1981, the US rejected a Soviet offer to discuss a draft space weapons control treaty (Draft Treaty on the Prohibition of the Stationing of Weapons of Any Kind in Outer Space), which the Soviets had presented to the UN General Assembly as a supplement to the Outer Space Treaty of 1967.[205] The US offered no counterproposal and gave no indication that it was interested in talks on the subject.[206] The Soviets introduced another draft of the treaty which even went so far as to offer to dismantle the existing Soviet ASAT system. Although the draft covered many US concerns about space weapons, the US rejected it because it also prohibited the use of the space shuttle as a military system, while verification (always a sticking point) was still questionable. The US was also concerned over ground-based laser attacks (which were hard to trace to a source) and residual Soviet ASAT capability in their existing ABM systems.[207]

Considerable criticism focused on the administration's refusal to negotiate an ASAT treaty. Congress threatened to withhold funds for US ASAT development unless some legitimate justification could be provided. The administration briefed Congress on its problems with this or any such treaty: It was virtually impossible to verify; there were diverse sources of threats to US systems; and there was the threat posed by Soviet surveillance systems that could not be negated without an ASAT .[208] In the end, despite considerable lobbying, the administration did not succeed in keeping funds for ASAT testing intact.[209]

Strategic Defense Initiative and the Antiballistic Missile Treaty

From 1983 to 1987, US position on the Strategic Defense Initiative and the ABM Treaty was that Article V of the treaty limited all SDI work to research, that is, lab work and tests of subcomponents. This interpretation limited the primary debate to what constituted testing of components (which was prohibited) and what constituted testing of subcomponents (which was not). All other debates centered on what constituted research and development and employment of dual-use technologies (such as an antitactical missile or antiaircraft missile used as an ABM).

In 1988 the DOD took a different slant and employed a lawyer to look at the legal side of the question. Thereafter DOD proposed a new interpretation. First of all, Article V applied only to systems and components that were current at the time of the treaty negotiations. Agreed Statement D, which prohibited deployment but did not address testing and development, governed new technologies. The complication in all this was that the US had tried to ban futuristic technology during the original ABM negotiations, but the Soviets were unwilling to agree to such restrictions. The Reagan administration now proposed that since the Soviets had not agreed to these restrictions, the US was not bound by these restraints either. This reasoning left the US free to deploy anything it wanted in a full-scale test. Politics became the only constraint on US actions. The US did not take advantage of this new interpretation due to European and congressional protests.

Military Space Systems

The Strategic Modernization Program, revealed on 5 October 1981 by Caspar Weinberger, had many provisions for improving the US strategic posture including deployment of the B-1 bomber, MX ICBM, and Trident SLBM. Weinberger also stated that the US would "continue to pursue an operational antisatellite system."[210] Under the Reagan administration, military space programs received increased attention across the board. There was a perceived need for effective and survivable systems for early warning, communications, and attack assessment to allow the US to fight and "prevail" in modern conflicts to include nuclear war.[211]

Antisatellites. The US ASAT , by now called the prototype miniature air launched system (PMALS), was in an advanced development stage by October 1981 when Reagan announced US commitment of $418 million in contracts to Vought and

Boeing. Ground testing of the missile and the MHV began in 1981 although the program was behind schedule.[212] The Air Force moved the initial operational capability date back from 1985 to 1987 due to developmental problems. The Air Force conducted the first captive flight tests with the F- 15 launch aircraft in December 1982. Despite obvious progress, in January 1983 the General Accounting Office (GAO) criticized the system's complexity and price of tens of billions of dollars and called for a new assessment of other alternatives, particularly ground-based options and air- and space-based laser systems.[213] GAO also criticized the system for its apparent lack of growth potential and its inability to attack up to 70 percent of its intended targets or the Soviets' ASAT system. Other sources also attacked PMALS for its dependence on existing space surveillance networks, which had limited capabilities relative to this task and which were not very survivable. DOD countered that the target list was a wish list with no monetary constraints attached and that the system would not cost as much as GAO alleged. It would cost only $3.6 billion.[214]

As if to lend credence to the Reagan administration's assertions that the US needed an ASAT device to counter threatening Soviet activities, the USSR tested its ASAT system again in February 1981, the 18th such test, and again in March 1981. The Soviet ASAT flew yet again, for the last time, in June 1982. The last flight was apparently as part of a major Soviet strategic forces exercise in which they launched two ICBMs, two ABMs, one SLBM, and one SS-20 IRBM as well as a navigation and a reconnaissance satellite. In August 1983, in a surprising demonstration of restraint, Soviet President Yuri Andropov announced a unilateral moratorium on ASAT testing. This action came at a time when there was growing US concern over the possible use of such large Soviet boosters as the Proton to launch an attack on our geosynchronous satellites. The Soviets were reportedly even developing a 300,000- to 400,000-pound lift (to low-Earth orbit) booster that could lift a prototype laser ASAT device.[215]

In February 1984, Reagan announced that the US would study follow-ons (such as a high-altitude ASAT) to meet all objectives on the target list.[216] The MHV test program had conducted two successful point-in-space intercepts by the time Congress imposed budgetary restrictions on the program. When the congressional ban on ASAT testing of the MHV lapsed for a brief period in September 1985, the Air Force took advantage of the opportunity for a live-fire test of PMALS. On 13 September, a USAF F-15 piloted by Maj Wilbert Pearson launched an ASAT missile at the P78-1 solar observatory satellite, Solwind. The MHV struck the satellite, shattering it into 250-350 pieces. A stiffer congressional ban was imposed after the test. The Air Force could not test the US ASAT unless the Soviets tested theirs. In December 1985, Air Force SCOUT rockets launched two instrumented target vehicles from Wallops Flight Center. Both reentered before they could be used.

Missile Warning and Spacetrack Network. On 21 June 1982, Air Force Chief of Staff Gen Lew Allen, Jr., announced the impending formation of Air Force Space Command, a single Air Force command that would consolidate and coordinate all Air Force space assets and activities. There had been considerable lobbying for a change in the military space organization and creation of an operational space command within the Air Force for some time. In September 1982, Space Command established its headquarters at Colorado Springs, near the headquarters for NORAD. The establishment of Air Force Space Command was the largest of the space organizational changes during the 1980s, all of which reflected the shift in policy recognizing space as a war-fighting medium.

In June 1983, the Navy announced that it was creating US Naval Space Command, which it activated on 1 October 1983 and headquartered at Dahlgren, Virginia. Although it consolidated naval space activities, the new Navy command also was intended to ensure the Navy a role in controlling DOD space programs in a unified command at a later date.[217] On 23 September 1985 DOD activated the US Space Command (USSPACECOM) at Colorado Springs as a unified command composed of Air Force Space Command, Naval Space Command, and the newly created Army Space Agency (which later became Army Space Command). USSPACECOM has the task of consolidating all assets affecting US space activities.

The Air Force established ground based electro-optical deep space surveillance sites. MIT Lincoln Lab's Experimental Test Site 1 at Socorro, New Mexico, became Air Force property in April 1981 and reached IOC on 30 July 1982. Other GEODSS sites opened at ChoeJong San, Republic of Korea; Maui, Hawaii; and Diego Garcia, British Indian Ocean Territories; under the Spacetrack Improvement Program.[218]

The Air Force also expanded the SLBM network. It completed two AN/FPS-121, modified PAVE PAWS systems, located in the southeastern and southwestern US. The first site is at Robins AFB, near Warner Robins, Georgia, and attained IOC in

November 1986. The 9th Missile Warning Squadron (MWS) operates it.[219] The second, operated by the 8 MWS, is at Eldorado AFS, near San Angelo, Texas, and became operational on 8 May 1987.[220] These radars provide improved radar coverage and detection capability for southern approaches to the US. After activation of the new PAVE PAWS southeast radar, the Air Force deactivated the last of the old AN/FSS-7 radars operated by Detachment 1, 20 MWS, at MacDill AFB, Florida.[221] Later, the Air Force reclassified the AN/FPS-85 radar at Eglin AFB, Florida, as a space surveillance radar no longer responsible for the missile warning role.

National Aeronautics and Space Administration Shuttle Program

Two years behind schedule, the space shuttle approached its launch date of 10 April 1981. However when the day arrived, NASA canceled the flight due to a computer malfunction. The first flight finally got under way on 12 April 1981 as *Columbia* lifted off from launch pad 39A at the Kennedy Space Center, 20 years to the day after Gagarin's first manned flight. Astronauts John Young and Robert Crippen made the historic first flight and landed successfully on the runway at Edwards AFB on 14 April.[222]

Over a year later, Reagan's NSDD-42 designated the space shuttle as the primary launch system for the US national security space program. It directed DOD and NASA to develop the shuttle into a fully operational, cost-effective system. All government payloads were to be compatible with the shuttle, and DOD was given priority on shuttle launches. DOD and other government agencies were to continue to develop and use expendable launch vehicles (ELV) only until the shuttle could meet all their launch needs. This directive essentially placed all of DOD's launch eggs in one basket--the shuttle.

By making the shuttle the primary launch vehicle for all government payloads, NSDD-42 guaranteed NASA all the launch business it could handle. NASA's goal was to achieve a two-flight-per-month routine that would make satellite launches cheaper and make the shuttle a self-sustaining venture. To achieve this goal, NASA needed more shuttles. In the next four years, NASA acquired three more shuttles, *Challenger* which first flew on 4 April 1983, *Discovery* which first flew on 30 August 1984, and *Atlantis* which first flew on 3 October 1985. Even with all four shuttles going at once, NASA was unable to meet its schedule because of technical problems and other delays. Far from the goal of 24 flights a year, the best NASA ever managed was nine flights in 1985.

By January 1986, NASA had flown only 24 shuttle missions in 57 months. The backlog of payloads on the manifest was growing steadily. There were few, if any, ELVs available for launch because they were being phased out, and production lines had closed. The pressure on NASA to get the shuttle up when scheduled was tremendous. Then disaster struck on 28 January 1986. The shuttle *Challenger* exploded some 70 seconds into the 25th flight because of a solid rocket booster (SRB) failure that ruptured the main propellant tank. All seven astronauts aboard were lost as was the $100 million NASA tracking and data relay system satellite. The effect on the US civilian and military space programs was devastating. Virtually all US launch capability was crippled. Two Titan 34D failures and a Delta 3920 failure within the same period only compounded the problem. Instead of having assured access, the US had virtually no access to space. The shuttle was down for over two years for an in-depth accident investigation and redesign of the faulty SRBs. During this time, there were virtually no ELVs available.

This dire situation continued until the return of the space shuttle in September 1988, the first flight of the Delta II medium launch vehicle in February 1989, and the successful first flight of the new Titan IV booster (originally designed to complement the shuttle) in June 1989. (More information on these and other launch systems is in chapter 4.) DOD instituted full-scale or expanded development of these ELV systems immediately after the *Challenger* accident and redirected almost all of its payloads to ELVs. The result has been that now there are virtually no DOD payloads scheduled for flights on the shuttle, and NASA now faces tremendous competition for US civilian and foreign payloads.

Bush Years: 1989-1992

The focus on and the transition of space policy from Reagan to Bush began when President Reagan signed the NASA Authorization Bill for 1989, which wrote the requirement for a space council into law. The National Space Council (NSpC) came into being when President George H. Bush signed Executive Order No. 12675 on 20 April 1989. In signing the order, the president said that "space is of vital importance to the nation's future and to the quality of life on Earth."[223] He charged the council to keep America first in space.

The council is chaired by the vice president, who serves as the president's principal advisor on national space policy and strategy. Other members of the council include: the secretaries of state, treasury, defense, commerce, transportation, and energy; the director of the Office of Management and Budget; the chief of staff to the president; the assistant to the president for national security affairs; the assistant to the president for science and technology; the director of central intelligence; and the administrator of the National Aeronautics and Space Administration.

The vice president invites the participation of the chairman of the Joint Chiefs of Staff, the heads of other departments, and other senior officials in the Executive Office of the President when the topics under consideration by the council so warrant. The council's charter is to advise and assist the president on national space policy and strategy, much as the National Security Council does in its area of responsibility. The council carries out activities to integrate and coordinate civil, commercial, and national security space activities. One of the first tasks for the council was to develop a national space policy planning process for development and monitoring of the implementation of the national space policy and strategy.

The planning process the council adopted consists of four phases:

- define broad goals and objectives for the US space program,
- determine strategies to implement those goals and objectives,
- monitor the implementation of these strategies, and
- resolve specific issues that arise during the implementation process.[224]

This planning process will guide future space activities and will ensure an integrated national space program by strengthening and streamlining policy for civil and commercial space activities as well as for DOD.

The council has also identified five key elements that will form the basis of the US national space strategy. Those elements are: transport, exploration, solutions, opportunity, and freedom.[225] These elements highlight the space program objectives of preserving the nation's security; creating economic opportunity; developing new and better technologies; attracting students to engineering, math, and science; and exploring space for the benefit of mankind.[226]

Development of the nation's space launch capability and related infrastructure as a national resource is one area under review by the council. Launch capability and infrastructure must accommodate the current and future needs of the space program. A second element the council is investigating is opening the frontier of space by manned and unmanned programs. The commitment is to ensure a balanced scientific program that will emphasize human activities as well as scientific excellence and research.[227] A third area is intensification of the use of space to solve problems on Earth such as environmental concerns, treaty verifications, and satellite communications to link people around the globe. Opportunity is the fourth element in the council' s plan for space. Space exploration is crucial to the nation's technological and scientific development and economic competitiveness[228] Capitalizing on the unique environment of space to produce and investigate new materials, medicine, and energy could result in private investment and new jobs. The last element is ensuring that the space program contributes to the nation's security. Ensuring freedom to use space for exploration, development, and security for the United States and all nations is an inherent right of self-defense and of US defense commitments to its allies.

The space program needs open-mindedness, practicality, and the willingness of the space establishment to get behind a feasible plan. The National Space Council is an important vehicle for the administration's national space policy.

Despite ongoing funding limitations, the space community continues to progress. Space organizations and missions are continuing to evolve and have had modest growth. Recent experience with Operation Desert Storm has highlighted the invaluable contributions of space systems. In fact, Desert Storm was a watershed event for the advancement of space information to the war-fighting personnel. Such systems as the Global Positioning System, Defense Satellite Communication System, Defense Support Program, and Defense Meteorological Satellite Program provided unprecedented levels of data support to the theater. Desert Storm proved that growing reliance on space systems for warning, intelligence, navigation, targeting, communications, and weather was merited. In subsequent chapters and annexes, this volume discusses the effect of space systems support in wars and the role the NSpC will play in shaping our current and future space policy and doctrine.

Notes

1. Walter A. McDougall, *The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books Inc., 1985), 76.

2. Ibid., 26.

3. Ibid., 77.

4. Ibid., 26, 78.

5. Ibid., 78.

6. Tom Bower, *The Paperclip Conspiracy: The Hunt for the Nazi Scientists* (Boston: Little, Brown, and Co., 1987), 27-45.

7. Ibid., 86.

8. Ibid., 108-9, 127-28.

9. McDougall, 78-79.

10. Bower, 71.

11. Ibid., 116.

12. McDougall, 141.

13. Bower, 107.

14. Ibid., 111.

15. Ibid., 123.

16. Ibid., 108-9.

17. Ibid., 169.

18. McDougall, 98.

19. Kenneth Gatland, *The Illustrated Encyclopedia of Space Technology* (New York: Harmony Books, 1981), 265.

20. McDougall, 99.

21. Curtis Peebles, *Battle for Space* (New York: Beaufort Books, Inc., 1983), 48 49.

22. Ibid., 48.

23. McDougall, 98.

24. Ibid., 48.

25. Bill Gunston, *The Illustrated Encyclopedia of the World's Rockets and Missiles* (New York : Crescent Books, 1979), 58-59.

26. Curtis Peebles, *Guardians: Strategic Reconnaissance Satellites* (Navato,Calif.: Presidio Press, 1987), 44.

27. Ibid., 44-45.

28. Paul B. Stares, *The Militarization of Space: US Policy* (Ithica, N.Y.: Cornell University Press, 1985), 29-30.

29. McDougall, 106.

30. Peebles, Guardians, 13.

31. McDougall, 127.

32. Ibid., 118.

33. Ibid., 119-20.

34. Stares, 121.

35. McDougall, 121.

36. Ibid., 122.

37. Ibid., 123. 38. Fred Reed, "The Day the Rocket Died," *Air and Space Smithsonian* 2, no. 4 (October/November 1987): 49

39. McDougall, 130.

40. Reed, 49-50.

41. Peebles, *Battle*, 52.

42. Ibid.

43. Ibid.

44. Gunston, 51.

45. Reed, 50-51.

46. Ibid., 51.

47. McDougall, 154.

48. Reed, 52.

49. Ibid.

50. McDougall, 172.

51. Stares, 42-43.

52. McDougall, 198.

53. Ibid., 176.

54. Ibid., 173.

55. Ibid., 223.

56. Gatland, 62.

57. McDougall, 223.

58. Ibid., 225.

59. Peebles, *Guardians,* 1.

60. Ibid., 8-13.

61. Ibid.,7-8.

62. Ibid., 17-20.

63. McDougall, 111.

64. Peebles, *Guardians,* 45.

65. Ibid., 33.

66. Ibid., 33-35.

67. McDougall, 219.

68. Peebles, Guardians, 36-37.

69. Ibid., 30-31.

70. Ibid., 39.

71. Ibid., 43-44.

72. Stares, 54-57.

73. Peebles, Guardians, 46.

74. Ibid.

75. McDougall, 190.

76. Peebles, *Guardians,* 49-51.

77. Gatland, 81, 86.

78. Peebles, *Battle,* 40.

79. Gunston, 172.

80. McDougall, 82.

81. Gunston, 172-73.

82. Peebles, *Battle,* 96-99.

83. Ibid., 77, 80.

84. Ibid., 99-101.

85. Ibid.

86. Stares, 115.

87. McDougall, 339-4.0.

88. Jay Miller, *The X-Planes* (Arlington, Tex.: Aerofax, 1988), 149-51.

89. Stares, 130.

90. Peebles, *Battle,* 8.

91. Reed, 48.

92. Detachment (Det) 2, 3391 School Squadron, "Space Systems Operations Textbook," Peterson AFB, Colo., November 1980, 2-4.

93. Ibid., 5-32.

94. Stares, 132.

95. Det 2, 3391 School Squadron, 2-20.

96. Stares, 131-32.

97. Det 2, 3391 School Squadron, 2-5.

98. Ibid.

99. Ibid., 2-21.

100. Ibid., 2 4.

101. Ibid., 2 6.

102. Ibid., 2-13.

103. US Air Force Fact Sheet, "12th Missile Warning Squadron," Peterson AFB, Colo., 3d Space Support Wing, Site Support Public Affairs, January 1989, 1.

104. Stares, 60 61.

105. Peebles, *Guardians,* 70.

106. Ibid., 237.

107. Ibid., 238.

108. Ibid.

109. McDougall, 340.

110. Ibid., 341.

111. Peebles, *Guardians,* 244.

112. Ibid., 251-52.

113. Ibid., 242, 244.

114. Ibid., 248.

115. Ibid., 246-48.

116. Bill Yenne, *The Encyclopedia of US Spacecraft* (New York: Exeter Books, 1985), 38.

117. Gatland, 81-82.

118. Yenne, 38.

119. US Air Force Fact Sheet, "Defense Meteorological Satellite Program," Washington, D.C., Secretary of the Air Force, Office of Public Affairs, October 1988, 1.

120. Yenne, 37-38.

121. Ibid., 157.

122. Peebles, *Guardians,* 332-36.

123. Peebles, Battle, 101.

124. Ibid.

125. Ibid., 81-82.

126. Stares, 110.

127. Peebles, *Battle,* 81-82.

128. Ibid.

129. Ibid., 82-83.

130. Stares, 120.

131. Peebles, *Battle,* 85.

132. Stares, 120.

133. Peebles, *Battle,* 87.

134. Ibid., 87-88.

135. Ibid., 85.

136. Gunston, 173.

137. Ibid.

138. Ibid.

139. Ibid.

140. Peebles, *Battle,* 58-59.

141. Ibid., 62.

142. Ibid., 64-65.

143. Ibid., 65-69.

144. Robert S. Freeman, "Space Program Overview: History," Lowry AFB, Colo., 3301 Space Training Squadron, March 1991,1.

145. US Air Force Fact Sheet, "20th Surveillance Squadron," Peterson AFB, Colo., 3d Space Support Wing, Site Support Public Affairs, January 1991,1.

146. Det 2, 3391 School Squadron, 2-8.

147. Gunston, 268-69.

148. Gatland, 64-65.

149. Stares, 61 62.

150. Gatland, 67-71.

151. Ibid., 153-59.

152. Ibid., 71.

153. Stares, 158-59.

154. Gatland, 206-7.

155. Stares, 159.

156. Peebles, *Battle,* 73-74.

157. Stares, 162.

158. Ibid., 164 65.

159. Gunston, 173.

160. Ibid.

161. Peebles, *Battle,* 14.

162. Gunston, 173.

163. Peebles, *Guardians,* 253.

164. Stares, 160.

165. Peebles, *Guardians,* 253-54.

166. Ibid., 92-94.

167. Stares, 201-3.

168. Ibid., 94.

169. Stares, 169-71.

170. Ibid., 170-71.

171. Ibid., 171.

172. US Air Force Fact Sheet, "10th Missile Warning Squadron," Peterson AFB, Colo., 3d Space Support Wing, Site Support Public Affairs, January 1989, 1.

173. Gatland, 155-63.

174. Ibid., 168-72.

175. Ibid., 168-81.

176. Ibid., 168-69.

177. Ibid., 190-97.

178. Stares, 180-83.

179. Ibid., 183.

180. Ibid., 206.

181. Ibid., 206-7.

182. Ibid., 210.

183. Ibid., 211 .

184. Ibid.

185. Ibid., 213.

186. Ibid., 213-14.

187. US Air Force Fact Sheet, "16th Surveillance Squadron," Peterson AFB, Colo., 3d Space Support Wing, Site Support Public Affairs, January 1989, 1.

188. Stares, 212.

189. US Air Force Fact Sheet, " 17th Surveillance Squadron," Peterson AFB, Colo., 3d Space Support Wing, Site Support Public Affairs, January 1989, 1.

190. Stares, 212.

191. US Air Force Fact Sheet, "Ground-Based Electro-Optical Deep Space Surveillance," Peterson AFB, Colo., 3d Space Support Wing, Site Support Public Affairs, January 1989, 1.

192. US Air Force Fact Sheet, "Detachment 1, 1st Space Wing," Peterson AFB, Colo., 3d Space Support Wing, Site Support Public Affairs, January 1989, 1.

193. Stares, 212.

194. US Air Force Fact Sheet, "PAVE PAWS Radar Systems," Peterson AFB, Colo., 3d Space Support Wing, Site Support Public Affairs, January 1989, 1-2.

195. Gatland, 210-13.

196. Ibid., 211.

197. Ibid., 213.

198. Stares, 217.

199. Ibid.

200. Ibid., 218-19.

201. Ibid., 219.

202. Ibid., 218-19.

203. Ibid., 225.

204. Ibid., 225-26.

205. Ibid., 229.

206. Ibid., 217.

207. Ibid., 231-32.

208. Ibid., 232-34.

209. Ibid., 234.

210. Ibid., 217.

211. Ibid.

212. Ibid., 220 21.

213. Ibid., 221.

214. Ibid., 221-22.

215. Ibid., 222-23.

216. Ibid., 222.

217. Ibid., 220.

218. US Air Force Fact Sheet, "Ground-Based," 1.

219. US Air Force Fact Sheet, "9th Missile Warning Squadron," Peterson AFB, Colo., 3d Space Support Wing, Site Support Public Affairs, January 1989, 1.

220. US Air Force Fact Sheet, "8th Missile Warning Squadron," Peterson AFB, Colo., 3d Space Support Wing, Site Support Public Affairs, January 1989, 1.

221. US Air Force Fact Sheet, "12th Missile Warning Squadron," 3.

222. Gatland, 213.

223. Brochure, The National Space Council, Washington D.C., undated, 1.

224. Ibid., 2.

225. Ibid.

226. Ibid., 5.

227. Dan Quayle, vice president, remarks to the American Astronomical Society, Arlington, Va., 10 January 1990.

228. Ibid.

Chapter 2

Space Law, Policy, and Doctrine

Space policy and doctrine define the overarching goals and principles of the US space program. International and domestic laws and regulations, national interests, and security objectives shape the US space program. Furthermore, fiscal considerations both shape and constrain space policy. Space policy formulation is a critical element of the US national planning process because it provides the framework for future system requirements.[1]

This chapter examines the international and domestic legal parameters within which the US must conduct its space programs and outlines the basic tenets of US policy and doctrine. The chapter details Department of Defense (DOD) and Air Force space policies, which are derived from national space policy, and concludes with an analysis of the doctrinal principles that guide the conduct of military space activities.[2]

The term *space law* refers to a body of law drawn from a variety of sources and consisting of two basic types of law: international and domestic. The former refers to rights and obligations the US has agreed to through multilateral or bilateral international treaties and agreements. The latter refers to domestic legislation by Congress and regulations promulgated by executive agencies of the US government.[3]

International Space Law

Table 1 summarizes key international treaties and agreements that affect the scope and character of US military space activities. Listed below are some of the more important basic principles and rules.

- International law applies to outer space. Such law includes the United Nations (UN) Charter, which requires all UN members to settle disputes by peaceful means, prohibits the threat to use or actual use of force against the territorial integrity or political independence of another state, and recognizes a state' s inherent right to act in individual or collective self-defense.
- Outer space, the Moon, and other celestial bodies are not subject to appropriation by claim of sovereignty, use or occupation, or any other means. In 1976 eight equatorial countries claimed sovereignty over the geostationary orbital arc above their territory. Most other countries, including all major space powers, rejected the claim.

- Outer space is free for use by all countries. This principle is related to the nonappropriation principle and is analogous to the right of innocent passage on the high seas.

- Outer space will be used for peaceful purposes only. Most Western nations, including the US, equate peaceful purposes with nonaggressive ones. Consequently, all nonaggressive military use of space is permitted, except for certain activities, noted elsewhere in this section, that are specifically prohibited.

- Objects launched into space must be registered with the UN.

- A country retains jurisdiction and control over its registered space objects. This rule applies regardless of the condition of the objects.

- A country is responsible for regulating, and is ultimately liable for, the outer space activities of its citizens.

- Nuclear weapons tests and other nuclear explosions in outer space are prohibited. In 1958, before this prohibition, the US exploded three small nuclear devices in outer space over the course of two weeks in Project Argus. Such an experiment would be prohibited today.

- Nuclear weapons and other weapons of mass destruction (such as chemical and biological weapons) may not be placed into orbit, installed on celestial bodies, or stationed in space in any other manner.

- A country may not test any kind of weapon; establish military bases, installations, or fortifications, or conduct military maneuvers on celestial bodies. The use of military personnel for scientific research or other peaceful purposes is permitted.

- The development, testing, or deployment of space-based anti-ballistic missile (ABM) systems or components is prohibited. This prohibition does not apply to research and development of space-based ABMs preceding field testing. This provision of the ABM Treaty and, in fact, the entire treaty (see table 1) have received much public attention in recent years because of progress in the Strategic Defense Initiative. It is quite possible that signatories could renegotiate or even eliminate the treaty before the end of the decade.

- Interfering with national technical means of verification is prohibited, provided such systems are operating in accordance with generally recognized principles of international law and are in fact being used to verify provisions of specific treaties.[4]

Table 1

International Agreements that Limit Military Activities in Space

Agreement	Principle/Constraint
United Nations Charter (1947)	Made applicable to space by the Outer Space Treaty of 1967. Prohibits states from threatening to use, or actually using, force against the territorial integrity or political independence of another state (Article 2(4)). Recognizes a state's inherent right to act in individual or collective self- defense when attacked. Customary international law recognizes a broader right to self-defense, one that does not require a state to wait until it is actually attacked before responding. This right to act preemptively is known as the right of anticipatory self-defense (Article 51).

Limited Test Ban Treaty (1963)	Bans nuclear weapons tests in the atmosphere, in outer space, and underwater. States may not conduct nuclear weapon tests or other nuclear explosions (i.e., peaceful nuclear explosions) in outer space or assist or encourage others to conduct such tests or explosions (Article 1).
Outer Space Treaty (1967)	Outer space, including the Moon and other celestial bodies, is free for use by all states (Article I). Outer space and celestial bodies are not subject to national appropriation by claim of sovereignty, use, occupation, or other means (Article II). Space activities shall be conducted in accordance with international law, including the UN Charter (Article III). The Moon and other celestial bodies are to be used exclusively for peaceful purposes (Article IV). Nuclear weapons and other weapons of mass destruction (such as chemical and biological weapons) may not be placed in orbit, installed on celestial bodies, or stationed in space in any other manner (Article IV). A state may not conduct military maneuvers; establish military bases, fortifications, or installations; or test any type of weapon on celestial bodies. Use of military personnel for scientific research or other peaceful purpose is permitted (Article IV). States are responsible for governmental and private space activities, and must supervise and regulate private activities (Article IV). States are internationally liable for damage to another state (and its citizens) caused by its space objects (including privately owned ones) (Article VII). States retain jurisdiction and control over space objects while they are in space or on celestial bodies (Article VII). States must conduct international consultations before proceeding with activities that would cause potentially harmful interference with activities of other parties (Article IX). States must carry out their use and exploration of space in such a way as to avoid harmful contamination of outer space, the Moon, and other celestial bodies, as well as to avoid the introduction of extraterrestrial matter that could adversely affect the environment of the Earth (Article IX). Stations, installations, equipment, and space vehicles on the Moon and other celestial bodies are open to inspection by other countries on a basis of reciprocity (Article XII).
Antiballistic Missile (ABM)	Between the US and USSR. Treaty (1972) -- Prohibits development, testing, or deployment of space-based ABM systems or components (Article V). Prohibits deployment of ABM systems or components except as authorized in the treaty (Article I). Prohibits interference with the national technical means a party uses to verify compliance with the treaty (Article XII).
Liability Convention	A launching site is absolutely liable for damage by its space object to people or property on the Earth or in its atmosphere (Article II).

	Liability for damage caused by a space object, to persons or property on board such a space object, is determined by fault (Article III).
Convention on Registration (1974)	Requires a party to maintain a registry of objects it launches into Earth orbit or beyond (Article II). Information of each registered object must be furnished to the UN as soon as practical, including basic orbital parameters and general function of the object (Article IV).
Environmental Modification Convention (1980)	Prohibits military or other hostile use of environmental modification techniques as a means of destruction, damage, or injury to any other state if such use has widespread, long-lasting, or severe effects (Article 1).

Source: Adapted from Air Command and Staff College , *Space Handbook* (Maxwell AFB, Ala.: Air University Press, January 1985), 15-2 through 15-3.

The US adheres to the premise in international law that any act not specifically prohibited is permitted. Thus, even though the list (see table 1) of prohibited acts is sizable, overall there are few legal restrictions on the use of space for nonaggressive military purposes. As a result, international law implicitly permits the performance of such traditional military functions as surveillance, reconnaissance, navigation, meteorology, and communications. It permits the deployment of military space stations; the testing and deployment in Earth orbit of nonnuclear, non-ABM weapon systems, including antisatellite weapons and space-to-ground conventional weapons; and the use of space for individual and collective self-defense as well as virtually any conceivable activity not specifically prohibited or otherwise constrained.

Another widely accepted premise is that treaties usually regulate activities between signatories only during peacetime. This rule holds true unless a treaty expressly states that its provisions apply or become operative during hostilities, or the signatories can deduce this from the nature of the treaty itself. In other words, countries presume that armed conflict will result in the suspension or termination of a treaty' s provisions. Good examples are treaties whose purpose is to disarm or limit quantities of arms maintained by the signatories. Therefore, during hostilities, the scope of permissible military space activities may broaden significantly.

Finally, it is important to understand that historically the former Soviet Union has been the most important space power next to the US. Most of the space-related treaties to which the US has agreed were signed by the Soviet Union, and some are bilateral agreements exclusively with that nation. As the USSR dissolved, the US adopted a policy of continuing to observe the requirements of all treaties and to apply their provisions to the independent states that have emerged. Nevertheless, a degree of legal uncertainty is likely to exist for a period of years until precedent establishes policy more firmly or formal agreements are concluded with the new states. Although uncertainty applies on both sides, the obligations of the US under the new conditions are clear because the state of US sovereignty has not changed, and the spirit of the original agreements still exists for the most part. It is less clear that the emerging states of the former Soviet Union will feel obligated to observe past agreements, but there are indications at this writing that they will do so.

Domestic Space Law

Domestic law has always shaped military space activities through the spending authorization and budget appropriation process.[5] A perfect example occurred in the mid-1980s when Congress deleted funding for further testing of the USAF's direct ascent ASAT weapon--effectively cancelling the program. In addition, a number of laws not designed solely to address space have a space aspect. For instance, under the Communications Act of 1934, the president has the authority to gain control of private communications assets owned by US corporations during times of crisis. Since the 1960s, this authority has included both the ground and space segments of domestically owned communications satellites. Space-specific legislation (beyond the annual National Aeronautics and Space Administration [NASA] authorization) is a relatively recent activity.

The Reagan administration placed emphasis on the creation of a third sector of space activity--that of commercial space--in addition to the traditional military and civil sectors. To facilitate the development of a commercial launch industry in the US, for example, Congress passed the Commercial Space Launch Act of 1984. From a DOD perspective, the importance of this legislation lies in its authorization for commercial customers to use DOD launch facilities on a reimbursable basis. Thus, the DOD is now in the business of overseeing commercial operations from its facilities and placing commercial payloads in the launch queue. While a recent development, this trend towards intertwining the commercial space industry and the DOD space program is increasing.

National Space Policy

A nation' s space policy is extremely important, especially as it relates to space law and space doctrine. If we are to understand present US space policy and try to predict its future, we should start with a look at its evolution.[6] We must be mindful that while policy provides space goals and a national framework, it is itself shaped by national interests and national security objectives. This framework leads us towards building and meeting future US requirements and subsequent national space strategies.

Early Policy

The launch of Sputnik I on 4 October 1957 had an immediate and dramatic impact on the formulation of US space policy. Although the military had expressed an interest in space technology as early as the mid-1940s, a viable program failed to emerge for several reasons. These include intense interservice rivalry; military preoccupation with the development of ballistic missiles that prevented a sufficiently high funding priority from being assigned to proposed space systems; and, perhaps most importantly, national leadership that did not initially appreciate the strategic and international implications of emerging satellite technology, and when it did, was committed to an open and purely scientific space program.

Sputnik I changed all that. Besides clearly demonstrating that the Soviets had the missile technology to deliver payloads at global ranges, sputnik led to much wider appreciation of orbital possibilities The result was the first official US government statement that space indeed was of military significance. This statement was issued on 26 March 1958 by President Dwight D. Eisenhower's science advisory committee and said that the development of space technology and the maintenance of national prestige were important for the defense of the United States. Congress also quickly recognized that space activities were potentially vital to the national security.

The first official national space policy was the National Aeronautics and Space Act of 1958. This act declared that the policy of the United States was to devote space activities to peaceful purposes for the benefit of all mankind. It mandated separate civilian and national security space programs and created a new agency, NASA, to direct and control all US space activities except those "peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States."[7] The Department of Defense was to be responsible for these latter activities.

A legislative basis for DOD responsibilities in space was thereby provided early in the space age. The act established a mechanism for coordinating and integrating military and civilian research and development, encouraged significant international cooperation in space, and called for preserving the role of the US as a leader in space technology and its application.

The policy framework for a viable space program was thus in place. In fact, the principles enunciated by the National Aeronautics and Space Act, which included peaceful focus on the use of space, separation of civilian and military space activities, emphasis on international cooperation, and preservation of a space role, have become basic tenets of the US space program. All presidential space directives issued since 1958 have reaffirmed these basic tenets.

What was missing, however, was a space program of substance. The Eisenhower administration's approach to implementing the new space policy can be characterized as conservative, cautious, and constrained. Early DOD and NASA plans for manned space flight programs were disapproved consistently. Instead the administration preferred to concentrate on unmanned, largely scientific missions and to proceed with those missions at a measured pace. It was left to subsequent administrations to give the policy substance.[8]

Intervening Years

Two presidential announcements--one by John F. Kennedy on 25 March 1961 and the second by Richard M. Nixon on 7 March 1970--were instrumental in providing the needed focus for America' s space program. The Kennedy statement came during a period of intense national introspection. The Soviet Union launched and successfully recovered the world's first cosmonaut. Though Yuri Gagarin spent just 89 minutes in orbit, his accomplishment electrified the world and caused the US to question its scientific and engineering skills and its entire educational system. The American response--articulated by President Kennedy as a national challenge to land a man on the Moon and return him safely to Earth--defined US space goals for the remainder of the decade.

Prestige and international leadership were clearly the main objectives of the Kennedy space program. However, the generous funding that accompanied the Apollo program had important collateral benefits as well. lt permitted the buildup of US space technology and the establishment of an across-the-board space capability that included planetary exploration, scientific endeavors, commercial applications, and military support systems.[9]

As the decade of the 1960s drew to a close, a combination of factors, including domestic unrest, an unpopular foreign war, and inflationary pressures forced the nation to reassess the importance of the space program compared to other national needs. Against this backdrop, President Nixon made his long-awaited space policy announcement in March 1970. His announcement was a carefully considered and worded statement that was clearly aware of political realities and the mood of Congress and the public. It stated in part:

> Space expenditures must take their proper place within a rigorous system of national priorities... What we do in space from here on in must become a normal and regular part of our national life and must therefore be planned in conjunction with all of the other undertakings which are also important to us. [10]

Though spectacular lunar and planetary voyages continued until 1975, largely as a result of budgetary decisions made during the 1960s, it was clear that the Nixon administration considered the space program of intermediate priority and could not justify increased investment or the initiation of large new projects. It viewed space as a medium for exploiting and extending the technological and scientific gains that had already been realized. The emphasis was on practical space applications to benefit American society in a variety of ways.[11]

Within the DOD, this emphasis on practicality translated into reduced emphasis on manned spaceflight, but led to the initial operating capability for many of the space missions performed today. For example, initial versions of the systems now known as the Defense Satellite Communications System, the Defense Support Program, the Defense Meteorological Satellite Program, and the Navy's Transit navigation satellite program (later to evolve to the Global Positioning System) were all developed and fielded during this period.

One major new space initiative undertaken during the 1970s eventually had far greater impact on the nation' s space program than planners had originally envisioned--the space transportation system (STS), or space shuttle. The shuttle's goal was routine, low-cost access to orbit for both civil and military sectors. As development progressed, however, the program experienced large cost and schedule overruns. These problems caused the US space program to lose much of its early momentum as it became apparent that the high costs would adversely affect other space development efforts--both civil and military--and that schedule slippage meant a complete absence of American astronauts in space for the remainder of the decade.[12]

Carter Administration Space Policy

President Jimmy Carter's administration conducted a series of interdepartmental studies to address the malaise that had befallen the nation's space effort. The studies addressed apparent fragmentation and possible redundancy among civil and national security sectors of the US space program and sought to develop a coherent recommendation for a new national space policy. These efforts resulted in two 1978 presidential directives (PD): PD-37 on national space policy and PD-42 on civil space policy.[13]

PD-37 reaffirmed the basic policy principles contained in the National Aeronautics and Space Act of 1958, and for the first time, spelled out in coherent fashion the broad objectives of the US space program and the specific guidelines governing civil and national security space activities.[14]

PD-37 was important from a military perspective because it contained the initial, tentative indications that a shift was occurring in the national security establishment's view on space. Traditionally, the military had seen space as a force enhancer; that is, as a medium in which to deploy systems to increase the effectiveness of]and, sea, and air forces. Although the focus of the Carter policy was clearly on restricting the use of weapons in space, PD-37 reflected an appreciation of the importance of space systems to national survival, a recognition of the Soviet threat to those systems, and a willingness to push ahead with development of an antisatellite capability in the absence of verifiable and comprehensive international agreements restricting such systems. In other words, the administration was beginning to view space as a potential war-fighting medium.[15]

PD-42, directed exclusively at the civil space sector, set the direction of US efforts over the next decade. However, it was devoid of any long-term space goals, preferring instead to state that the nation would pursue a balanced evolutionary strategy of space applications, space science, and exploration activities. The absence of a more visionary policy reflected clearly the continuing developmental problems with the shuttle and the resulting commitment of larger than expected resources.[16]

Reagan Administration Space Policy

President Ronald Reagan's administration published comprehensive space policy statements in 1982 and 1988. The first, pronounced on 4 July 1982 and embodied in National Security Decision Directive 42 (NSDD-42), reaffirmed the basic tenets of previous (Carter) US space policy and placed considerable emphasis on the STS as the primary space launch system for both national security and civil government missions. In addition, it introduced the basic goal of promoting and expanding the investment and involvement of the private sector in space and space-related activities as a third element of US space operations, complementing the national security and civil sectors.[17]

The single statement of national policy from this period that could most influence military space activities and that clearly reflects transition to a potential space war-fighting framework is NSDD-85, dated 25 March 1983. In this document, President Reagan stated as a long-term objective, elimination of the threat of nuclear armed ballistic missiles through the creation of strategic defensive forces. This NSDD coincided with the establishment of the Strategic Defense Initiative Organization (SDIO) and represented a significant step in the evolution of US space policy. Since 1958, the US had for a variety of reasons refrained from crossing an imaginary line from space systems designed to operate as force enhancers to establishing a war-fighting capability in space. The antisatellite (ASAT) initiative of the Carter administration was a narrow response to a specific Soviet threat. The SDI program on the other hand, represented a significant expansion in the DOD's assigned role in the space arena.[18]

The Reagan administration's second comprehensive national space policy in early 1988 incorporated the results of a number of developments that had occurred since 1982, notably the US commitment in 1984 to build a space station and the space shuttle *Challenger* accident in 1986.

For the first time, the national space program treated commercial space as an equal of the traditional national security and civil space sectors, and addressed it in some detail. Importantly, the new policy retreated dramatically from dependence on the STS and injected new life into expendable launch vehicle programs. In the national security sector, this program was the first to address space control and force application at length, further developing the transition to war-fighting capabilities in space.

In 1988, the last year of the Reagan presidency, Congress passed a law allowing creation of a National Space Council (NSpC)--a cabinet-level organization designed to coordinate national policy among the three space sectors. The incoming George Bush's administration would officially establish and very effectively use the National Space Council.[19]

Bush Administration Space Policy

Released in November 1989 as National Security Directive 30 (NSD-30), and updated in a 5 September 1990 supplement, the Bush administration's national space policy retained the goals and emphasis of the final Reagan administration policy. The Bush policy resulted from an NSpC review to clarify, strengthen, and streamline space policy, and has been further enhanced by a series of national space policy directives (NSPD) on various topics. Areas most affected by the body of Bush policy documentation include civil and commercial remote sensing, space transportation, space debris, federal subsidies of commercial space activities, and space station Freedom.

The policy reaffirms the organization of US space activities into three complementary sectors: civil, national security, and commercial. The three sectors coordinate their activities closely to ensure maximum information exchange and minimum duplication of effort.

Space leadership is a fundamental objective guiding US space activities. The policy recognizes that leadership does not require preeminence in all areas and disciplines of space operations but does require US preeminence in those key areas critical to achieving space goals.[20] Those goals are:

- to strengthen the security of the United States;
- to obtain scientific, technological, and economic benefits for the general population and to improve the quality of life on Earth through space-related activities;
- to encourage continuing United States private sector investment in space and related activities;
- to promote international cooperative activities, taking into account United States national security, foreign policy, scientific, and economic interests;
- to cooperate with other nations in maintaining the freedom of space for all activities that enhance the security and welfare of mankind; and
- as a long-range goal, to expand human presence and activity beyond Earth orbit into the solar system.[21]

These general goals are not much changed from the goals articulated in 1978 by President Carter, and their heritage goes back as far as the 1958 National Aeronautics and Space Act. The major changes are increasing detail in policy objectives and implementation guidelines, the introduction and expansion of emphasis on commercial space activities, and, underlying it all, a maturing recognition that space, like land, sea, and air, is a potential war-fighting medium. Space can be used in many different ways to strengthen the security of the United States. To accomplish these goals, US space activities will be conducted in accordance with the following principles:

- The United States is committed to the exploration and use of outer space by all nations for peaceful purposes and for the benefit of all mankind. Peaceful purposes allow for activities in pursuit of national security goals.
- The United States will pursue activities in space in support of its inherent right of self-defense and its defense commitments to its allies.
- The United States rejects any claims to sovereignty by any nation over outer space or celestial bodies, or any portion thereof, and rejects any limitations on the fundamental right of sovereign nations to acquire data from space.
- The United States considers the space systems of any nation to be national property with the right of passage through and operations in space without interference. Purposeful interference with space systems shall be viewed as an infringement on sovereign rights.
- The United States shall encourage and not preclude the commercial use and exploration of space technologies and systems for national economic benefit. These commercial activities must be consistent with national security interests and international and domestic legal obligations.
- The United States will, as a matter of policy, pursue its commercial space objectives without the use of direct federal subsidies.
- The United States shall encourage other countries to engage in free and fair trade in commercial space goods and services.

- The United States will conduct international cooperative space-related activities that are expected to achieve sufficient scientific, political, economic, or national security benefits for the nation. The United States will seek mutually beneficial international participation in space and space-related programs.[22]

The Bush policy goes on to detail specific policy. It implements guidelines and actions for each of the three space sectors and for intersector activities[23]

The civil sector will engage in all manner of space-related scientific research, develop space-related technologies for government and commercial applications, and establish a permanent manned presence in space. NASA is the lead civil space agency.

Commercial policy centers around government activities to promote and encourage commercial space-related endeavors. These efforts seek to secure the economic and other benefits to the nation that a healthy and vigorous commercial space industry would bring. NASA and the Departments of Defense, Commerce, and Transportation work cooperatively with the commercial sector and make government facilities and hardware available on a reimbursable basis.

The US will conduct those activities in space that are necessary to national defense. Such activities contribute to security objectives by (1) deterring or, if necessary, defending against enemy attack; (2) assuring that enemy forces cannot prevent our use of space; (3) negating, if necessary, hostile space systems; and (4) enhancing operations of US and allied forces. To do these things, DOD develops, operates, and maintains a robust space force structure capable of satisfying the mission requirements of space support, force enhancement, space control, and force application.

Primarily directed at the civil and national security sectors, several policy requirements apply across sector divisions. These include such things as continuing the technology development and operational capabilities of remote-sensing systems, space transportation systems, and space-based communications systems, and the need to minimize space debris.

In summary, US national space policy has, for the most part, kept pace with the growth of its US space program and is now one of the most well-documented areas of government policy. It clearly articulates goals that are both challenging and within the realm of possibility. We can expect a continuation of the Bush administration's series of NSPDs to further clarify and implement specific areas of US national space programs.

Department of Defense Space Policy

The most recent statement of comprehensive DOD space policy occurred on 4 February 1987. Though released prior to the current national space policy, the DOD policy is consistent with and supports NSD-30. In many instances, the DOD policy served as a model for principles incorporated into later national policy statements regarding the national security sector.[24]

The significance of the DOD policy is the degree to which the department has recognized the utility of space in accomplishing national security objectives and the extent to which it has embraced the space role given to it by law and national policy. That foresight was directly responsible for the development and deployment of the space forces that were so important to US and allied success in Operation Desert Storm.

One of the most important drivers of the 1987 policy was President Reagan's announcement in December 1986 which rescinded earlier direction that the space shuttle would be the primary launch vehicle for all military and civil payloads. By that time, the Challenger accident had occurred, confirming the flaws in a policy that the DOD (and the Air Force) had long opposed. DOD embarked on a long-term launch recovery program and took care to formalize the strategy in the new space policy. "DOD will develop and maintain the capability to execute space missions regardless of failures of single elements of the space support infrastructure"[25] Other important elements of the DOD policy, besides the general purpose of supporting and amplifying US national space policy, are that it:

- explicitly recognizes space as a medium within which the conduct of military operations in support of national security can take place, just as on land, sea, and in air;

- requires that DOD maintain development, acquisition, and budget planning activities to be able to respond effectively to major space contingencies;
- affirms that DOD will actively explore roles for the military man in space, focusing on unique or cost-effective contributions to operational missions; and
- provides policy guidelines for the development of specific capabilities to fulfill the military space functions of space support, force enhancement, space control, and force application.[26]

Air Force Space Policy

The earliest recorded statement of Air Force policy regarding space occurred on 15 January 1948, when Gen Hoyt S. Vandenberg stated, "The USAF, as the service dealing primarily with air weapons--especially strategic--has logical responsibility for the satellite." As reflected in General Vandenberg's statement, Air Force leaders have traditionally viewed space as a medium in which the Air Force would have principle mission responsibilities. This view was perhaps best articulated by former Air Force Chief of Staff Gen Thomas D. White, when he coined the term *aerospace* during testimony before the House Committee on Science and Astronautics in February 1959.[27]

> Since there is no dividing line, no natural barrier separating these two areas (air and space), there can be no operational boundary between them. Thus air and space comprise a single continuous operational field in which the Air Force must continue to function. The area is aerospace.[28]

As a result of this early positioning, the Air Force assumed the predominate space role within the DOD, and the Air Force space policy evolved as that role grew. Until 1988, however, that policy was never formally documented. In late 1987 and early 1988, the Air Force convened the Blue Ribbon Panel on the future of the Air Force in space--a senior-level working group composed of both space and aviation professionals, that considered whether the service should continue to seek the leadership role for DOD space activities and, if so, how best to proceed.

The panel strongly affirmed the desirability of operating in space to accomplish Air Force missions and achieve wider national security objectives, and it developed a list of recommendations for making most effective use of the space arena in future Air Force operations. On 2 December 1988, the Air Force formally adopted the Blue Ribbon Panel's fundamental assumptions and codified them in a new space policy document. With only minor modification to accommodate organizational change within the service, this document remains the current statement of comprehensive Air Force space policy. The tenets of that policy are:

- Space power will be as decisive in future combat as air power is today. This long-term vision recognizes the inherent advantages that space operations bring to military endeavors and looks forward to a time when technology, experience, and widespread acceptance allow the US to make full use of those advantages.
- We must be prepared for the evolution of space power from combat support to the full spectrum of military capabilities. The Air Force believes that space is a military operating arena just as are land, sea, and air. Expansion of the space control and force application mission areas is necessary and desirable to take full advantage of the opportunities space offers for effective accomplishment of national security objectives.
- The Air Force will make a solid corporate commitment to integrate space throughout the Air Force. To use space effectively, the Air Force must fully institutionalize space operations. There can be no separation of a "space Air Force" and an "aviation Air Force"--combat power is greatest and most effective when operations in the two mediums are closely integrated. To accomplish this integration, the Air Force undertakes to incorporate space into its doctrine, to normalize space responsibilities within the Air Staff, to institute personnel cross-flow measures to expand space expertise throughout the service, to encourage space-related mission solutions and expertise at all major commands and air component commands, and to consolidate space system requirements, advocacy, and operations (exclusive of developmental systems) in Air Force Space Command.

The US, DOD, and Air Force all have a policy for the military space mission areas of space control, force application, force enhancement, and space support and have implementation guidelines for each area. Allowing for slight differences in their dates of issue, each policy is consistent with the other two. This section describes the policy for these mission areas since Air Force space policy offers the most direct and concise guidance available and is the policy that Air Force agencies are directly responsible for implementing.

For aerospace control, the Air Force will acquire and operate antisatellite capabilities. The Air Force will provide battle management/command, control, and communications (C^3) for US space control operations and will perform the integration of ASAT and surveillance capabilities developed for space control operations. When technology permits cost-effective deployment, the Air Force will acquire and operate space-based antisatellite capabilities.

For force application, if the US should make a ballistic missile defense (BMD) deployment decision, the Air Force will acquire and operate space-based ballistic missile defense assets, will provide battle management/C^3 for BMD, and will integrate BMD forces. The Air Force will acquire and operate space-based weapons when they become a feasible and necessary element of the US force structure.

For force enhancement, the Air Force will continue to acquire and operate space-based systems for navigation, meteorology, tactical warning and attack assessment, nuclear detonation detection, and multiuser communications. The Air Force will continue to support the multiservice approach to conducting space surveillance and for providing mission-unique, space-based communications. The Air Force will acquire and operate a space-based wide-area surveillance, tracking, and targeting capability and will provide space-based means for space surveillance.

For space support, the Air Force will continue its long-standing role to provide DOD launch support. Additionally, the Air Force will continue to provide common-user, on-orbit satellite systems support.

Finally, the policy states that the Air Force will continue to be the major provider of space forces for the nation's defense. Together, national, DOD, and Air Force space policy provides a solid and long-standing basis for military space activities. As the US space program has matured, and as the global security environment has changed, there has been a clearly identifiable trend towards expanding the Air Force's role in space beyond its early focus on force enhancement and space support into the mission areas associated directly with combat operations--space control and force application.

Like earlier military expansions into the undersea environment and into the air, America' s decades-long expansion into space has not increased our predisposition to wage war. Rather, it has enhanced our ability to maintain the peace by increasing the options available to US civilian leadership. US military space policy promotes nonaggressive use of space across the spectrum of conflict in support of America's national security goals and objectives, and in compliance with domestic and international law.

Space Doctrine

Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms,* defines doctrine as "fundamental principles by which the military forces or elements thereof guide their actions in support of national objectives. It is authoritative but requires judgment in application." A shorter and perhaps more workable definition espoused by Professor I. B. Holley, Jr., of Duke University is: "Military doctrine is what is officially believed and taught about the best way to conduct military affairs."[29]

Accordingly, military space doctrine articulates what is officially believed and taught about the best way to conduct military space affairs. This section examines joint space doctrine and Air Force space doctrine.

Joint Space Doctrine

At this writing, there is no documented DOD-level space doctrine, although DOD is working on such a project. Good doctrine is founded on military experience, tempered where experience is lacking by military theory, and appreciates how advancements in technology, strategy, and operational tactics will change the nature of warfare. Actual conflict experience with space forces is still extremely limited and, prior to Operation Desert Storm, was practically nonexistent. Along with the rapid evolution of space forces and operations, this has resulted in a situation where the lessons of military experience are only now becoming clear. The previous heavy reliance on theory was insufficient to gain interservice agreement on the best way to conduct military space affairs.

Prior attempts to gain such agreement and to articulate a joint space doctrine have been unsuccessful for a variety of reasons. In the aftermath of Desert Storm, and as a result of the Air Force pressing ahead with the development of service doctrine for space, there is wider recognition within DOD of the need for published space doctrine and wider acceptance of those fundamental principles of space operations which proved to be effective in time of war.

Although doctrine specifically for space operations has lagged, the incorporation of space capabilities--particularly force enhancement capabilities--into the wider body of joint air, sea, and land doctrine is proceeding well. This is one method by which the Air Force accomplishes its policy goal of institutionalizing space throughout DOD.

Air Force Space Doctrine

The Air Force did not have a space doctrine until October 1982 when it published Air Force Manual (AFM) 1-6, *Military Space Doctrine*. AFM 1-6 clearly reflected the changing emphasis on the military use of space. It recognized the inherent benefits to be gained by any nation that chooses to exploit the military advantages of space and chartered the Air Force "to provide forces for controlling space operations and gaining and maintaining space superiority."[30]

The manual also sought to establish the Air Force as the premier service with regard to space. It stated that

> the Air Force was responsible for developing space forces, operational concepts, and employment tactics for the unified and specified commands [this was three years before the establishment of a separate unified command for space, US Space Command], for the management of space operations including launch, command and control, and on-orbit sustainment of military space assets for the DOD, NASA, and other government agencies and branches, and for promoting advanced technologies in order to develop the space force structure of the future.[31]

AFM 1-6 never gained the wide acceptance necessary to institutionalize space doctrine, primarily because it failed to incorporate the historical experience gained in other military environments which might be relevant to space. What resulted was a doctrine that was highly constrained by the policy of the time, rather than a clear articulation of "the best way to conduct military affairs" in space.[32] The manual was rescinded in September 1990, in conjunction with a complete update of the hierarchy and content of all Air Force doctrine. During the eight years of its existence, however, it was successful in increasing the awareness of space operations and the potential of space throughout the Air Force.[33]

Current Air Force practice is to fully incorporate space into a single basic doctrinal manual for both air and space, AFM 1-1, *Basic Aerospace Doctrine of the United States Air Force,* and to promote detailed space doctrine through AFM 2-25, *Space Operations*. The purpose is to recognize space forces as an immature but ultimately equal partner with air forces in the efficient employment of aerospace power. Together, these two manuals articulate space doctrine at the strategic and operational levels of war. The Air Force published AFM 1-1 in March 1992. At this writing, AFM 2-25 is in draft.

Air Force space doctrine rests on four fundamental premises:

- The focus of armed conflict will remain on the earth's surface for the foreseeable future. Although the capabilities of space forces to influence the terrestrial battlefield are growing and actual conflict will probably occur in space someday, the terrestrial-based governments or other entities that command these forces are the ultimate focus of the conflict. Military force is used (in space or elsewhere) to cause these governments or entities to alter their policies and actions.
- Space doctrine must be minimally constrained by current policy. Instead, it articulates what we believe to be long-lasting principles about the best way to conduct military affairs. We use doctrine and policy together to derive the military strategies and rules of engagement with which we fight.
- Space doctrine must anticipate the future. This is true of all military doctrine but is particularly necessary for space for at least three reasons. First, our military experience in space is very limited, and we have little choice but to anticipate future operations. Second, the rate of space technology development is extremely rapid, and publishing doctrine strictly for

today' s systems and operational concepts would quickly leave us with obsolete doctrine. Third, one of the fundamental purposes of doctrine is to guide the development of future forces. If we fail to anticipate the future, we risk fielding the same unimproved space systems indefinitely.

- The principles of war: mass, objective, surprise, maneuver, the offensive, simplicity, unity of command, economy of force, and security apply fully and completely to space operations. As we have moved into space, we have not found reason to question these principles, nor have we discovered new ones.[34]

Air Force space doctrine builds on these premises, along with the characteristics of space forces and the space environment, and the general mission areas space forces fulfill--space control, force application, force enhancement, and space support--to develop operational-level employment principles for those forces. Air Force doctrine recognizes and articulates both the similarities and the differences between air and space forces. As the Air Force moves towards the concept of integrated aerospace power, a clear grasp of the differences between the two becomes more important. Some of the employment principles for space forces are similar to those for air forces, but others are quite different. Among the employment principles for space forces are:

- Gain and maintain control of space. With control of space, friendly space forces, acting either as a force enhancer or force applier, can help put enemy forces on the defensive, disrupt operations, and even cause enemy forces to suffer significant losses. Control of space enhances and, in the future, may even secure freedom of action for friendly forces in all geographical environments and preserve for them the advantage of tactical surprise.

- Centralize control, decentralize execution. Space forces must be organized to achieve the concentration, direction, and focus required to achieve decisive results. This is best accomplished through a single commander for space forces with responsibility and authority to prosecute the space campaign. Opportunities for decentralized mission execution are somewhat limited today but, in the future, will more fully allow subordinate commanders to draw on their own ingenuity and initiative to accomplish campaign objectives.

- Attack the enemy' s centers of gravity. A military center of gravity is a characteristic, capability, or locality from which a force derives its freedom of action, physical strength, or will to fight. For the present, space forces assist terrestrial forces who attack traditional centers of gravity--in the future, space forces will have more direct space control and force application combat roles.

- Seize the initiative. Initiative allows commanders to dictate the timing and tempo of operations and exploit the capabilities of space forces to the maximum extent possible. By controlling timing and tempo, the space forces commander can dominate the action, remain unpredictable, create uncertainty in the enemy commander's mind, and operate beyond the enemy's ability to react effectively.

- Maintain sufficient reserves. Space forces commanders, in particular, should consider carefully what level of reserve capability is appropriate. They must consider ongoing and continuous space operations, as well as unanticipated future requirements. Moreover, forces held in reserve can have a dramatic effect when committed at times and places such that they produce significant changes in the space or terrestrial battle.[35]

Space doctrine is concerned with the preparation as well as the employment of space forces, and proper training and equipping of forces is a subject of both AFMs 1-1 and 2-25. AFM 2-25 provides space doctrine down to the level of the space campaign, giving guidance for each of the space mission areas, in turn, from the perspective of the operational space forces commander. The overall effect of the two manuals together is to describe in some detail how the Air Force can use space systems and the space environment effectively to perform or support all of its missions and tasks.[36]

The responsibilities of the Air Force in space include a large and growing number of functions that contribute to the defense of the United States. Space operations are important elements of a credible deterrent to armed conflict--they have proven their value in helping to resolve conflicts on terms acceptable to the United States by providing various kinds of information and support to military forces and national decision makers. In the future, space systems will provide the decisive edge in countering threats to US national interests.

The Air Force regards military operations in space as being among its prime national security responsibilities and conducts these operations according to the letter and spirit of existing treaties and international law. In response to national direction, the Air Force ensures freedom of access to space for peaceful pursuits and uses space systems to perform unique, economical, and effective functions to enhance the nation's land, sea, and air forces. As the Air Force space program has matured over a period of nearly four decades, Air Force policy and doctrine have reflected ever-increasing roles and responsibilities and have particularly expanded their emphasis on space as a war-fighting medium wherein the full spectrum of military conflict may, and eventually will, take place.

Notes

1. Air Command and Staff College, *Space Handbook* (Maxwell AFB, Ala.: Air University Press, January 1985), 15-1.

2. Ibid.

3. Maj Kevin Spradling, "Space Law, International Law and Domestic Space Law" (Unpublished paper, Air Force Space Command, 1991), 1-5.

4. Ibid., 3.

5. Ibid., 5.

6. Air Command and Staff College, 15-4.

7. Ibid., 15-5.

8. Ibid.

9. Ibid., 15-6.

10. Ibid.

11. Ibid.

12. Ibid.

13. Ibid.

14. Ibid., 15-7.

15. Ibid.

16. Ibid.

17. Ibid., 15-8.

18. Ibid.

19. Ibid., 15-10 through 15-11.

20. White House Fact Sheet, "US National Space Policy," Washington, D.C., Office of the White House Press Secretary, 16 November 1989, 1.

21. Ibid.

22. Ibid., 1-2.

23. Ibid., 2-14.

24. Department of Defense, *Department of Defense Space Policy* (Washington, D.C.: Government Printing Office, 10 March 1987, l-2.

25. Ibid.

26. Ibid.

27. Air Command and Staff College, 15-9.

28. Ibid.

29. Quoted in Lt Col David E. Lupton, *On Space Warfare: A Space Power Doctrine* (Maxwell AFB, Ala.: Air University Press, June 1988), 3.

30. White House Fact Sheet, "Commercial Space Launch Policy," Washington, D.C., Office of the White House Press Secretary, 5 September 1990, 1.

31. AFM 1-6, *Military Space Doctrine,* 15 October 1982, 7-8.

32. Lupton, 3.

33. Capt James R. Wolf, "Toward Operational-Level Doctrine for Space: A Progress Report," *Airpower Journal* 5, no. 2 (Summer 1991): 29.

34. Ibid., 33-34.

35. Ibid., 39.

36. Ibid., 39-40.

Chapter 3

Space Support to the War Fighters

Space Missions and Military Space Systems

The Air Force views space as a medium, like the air or sea, in which to carry out different types of missions. Air Force doctrine specifically integrates space missions into the four basic roles performed by aerospace forces: force support, force enhancement, aerospace control, and force application.

This chapter defines space missions associated with each of the four roles. Next is a brief description of the military space systems involved in the execution of space missions.[1]

Force Support--Air Force Satellite Control Network

Force support, the ability to sustain forces, includes the space mission of on-orbit support for satellites.[2] During the entire life of any satellite or military space system, from prelaunch checkout to on-orbit operations, there is a requirement for constant control, support, and direction of the satellite and its assigned mission. The Air Force maintains this critical operations capability through the Air Force Satellite Control Network (AFSCN).

The AFSCN is a global system to provide command, control, and communications for space vehicles (SV). The AFSCN consists of dedicated and common-user equipment and facilities which, collectively, provide operational telemetry, tracking, and commanding (TT&C) support for virtually all Department of Defense (DOD) SVs plus selected National Aeronautics and Space Administration (NASA) and foreign allied nations' space programs. DOD space programs support requirements of the national command authorities (NCA), the Joint Chiefs of Staff, and the unified and specified war-fighting commanders under peacetime and wartime conditions. In addition to providing TT&C support, the AFSCN processes and distributes satellite mission data to the appropriate users and provides research and development (R&D) support for space test activities.[3]

Satellite command and control is the essential mission of the AFSCN. To accomplish this complex task, various control centers are organized to integrate incoming and outgoing satellite control data for decision making. The complexity of the AFSCN mission increases with the number of active satellite missions.[4] Supporting resources of the AFSCN consist of leased and allocated communications, and host-base-provided facilities and utilities.[5]

Dedicated and Common-User Elements

Elements of the AFSCN generally fall into two groups: (1) dedicated elements that support a single space program or military space system and (2) common-user elements that support a number of different space programs or military space systems. Most of these elements are at fixed locations throughout the world, but the AFSCN can deploy a number of transportable assets whenever and wherever military forces need them.[6]

Dedicated elements specific to one satellite system support dedicated programs. A dedicated program is a closed system with separate control centers and remote tracking hardware. Two examples of dedicated satellite programs supported by dedicated elements are the Defense Meteorological Satellite Program (DMSP) and the Global Positioning System (GPS) satellite program. The dedicated control centers for DMSP are located at Fairchild Air Force Base (AFB), Washington, and the Multi-Purpose Satellite Operations Center (MPSOC) at Offutt AFB, Nebraska. The dedicated control center for the GPS program, known as the Master Control Station (MCS). is located at Falcon AFB. Colorado.[7]

Common-user elements of the AFSCN include a wide variety of assets strategically located around the world. These elements consist of command posts, mission control centers, resource control centers, and remote tracking stations, as well as various communication links, computer facilities, and training and testing facilities. These elements support multiple programs. The principle common-user mission control centers and command posts are located at Falcon AFB, Colorado, and Onizuka AFB, California.[8]

Types of Satellite Support

The AFSCN has the ability and flexibility to support continuously a wide variety of space vehicles in various orbits and altitudes. Operations support for satellite missions and limited ballistic/suborbital vehicle flights generally fit into five categories.[9]

Low-altitude satellites are characterized by near-polar orbits, with altitudes ranging from 100 to 200 nautical miles. Their operational lifetimes are short, and the satellites have a short pass duration (2.5 to 10 minutes per tracking station). They are the most dynamic of all vehicles supported, requiring frequent command message transmission.

Medium-altitude satellites generally have an orbital inclination of near 90 degrees, with altitudes ranging from 200 to 10,000 nautical miles. These satellites average one tracking station contact every other revolution, with a pass duration ranging from 10 to 20 minutes. Planned support is for one year or longer.

High-altitude satellites usually have low-inclination (equatorial) orbits, with altitudes exceeding 10,000 nautical miles (NM). Their operational lifetimes are measured in years. Because of varied servicing support requirements, a support period (pass) may vary from five minutes to several hours.

Included in the next category are ballistic missiles and suborbital test vehicles usually launched from the Western Space and Missile Center at Vandenberg AFB, California. Tracking and telemetry data for ascent and mid-course flight phases are recorded by the appropriate remote tracking stations (RTS). Total support time varies from 10 to 30 minutes. This kind of support requires considerable planning and readiness testing from the AFSCN.

The AFSCN supports certain orbital vehicles during launch and ascent or during ascent only. Support may vary from 10 minutes to 16 hours (continuous), depending on a vehicle's orbital characteristics and the support requirements levied. Tracking and telemetry data retrieval is the primary support objective.

Satellite Operations Centers

The task of the satellite operations centers (SOC) is to provide prelaunch, launch, early orbit, anomaly resolution, and operational TT&C support to all assigned space vehicle mission. Twelve functions are associated with satellite control:

1. satellite orbit determination,
2. ephemeris data generation,
3. command load assembly,
4. pass planning,
5. pass plan brief to tracking station,
6. satellite acquisition and tracking,
7. satellite commanding,
8. telemetry data retrieval,
9. data analysis,
10. satellite health and status determination,
11. corrective action determination, and
12. satellite data transfer to users.[10]

SOCs consist of hardware, software, and personnel that interact to accomplish these space support operations: resource control, mission control support, and communications control functions. Certain SOCs at Onizuka AFB, California, provide backup capability to Falcon AFB SOCs, while others are dedicated to unique programs not part of the AFSCN. Each SOC provides service for one or more specific satellite programs. Although the capabilities of SOCs vary, each is configured to support multiple satellite contacts simultaneously and/or to carry out premission rehearsals or exercises based on assigned satellite programs.

SOCs are physically isolated from each other but are electrically connected to allocated range resources. The SOCs at Onizuka AFB are connected to the resource control complex (RCC) at Onizuka AFB, and the SOCs at Falcon are connected to the RCC at Falcon AFB. During a satellite contact, mission personnel exercise direct control of the assigned resources through on-line workstations in the SOC that access processing equipment, interactive controls, computer programs, and interfaces to internal and external elements. An SOC usually has two mainframe computers, one acting as a contact support processor and the other as a planning and evaluation processor. These processors, with associated software, carry out planning, contact support, evaluation, training and rehearsal, simulation, data base management, and system development.

Space Vehicle Support--Pass/Contact Description

SOC satellite operations divide into three distinct phases: planning, pass support (i.e., operational satellite contact), and evaluation. The usage of the termpass as inpass support evolved from early space operations history when satellites would "pass by" as they moved in orbit from horizon to horizon relative to the operators. The length of these phases, especially pass support, varies widely depending on the type of satellite supported, its orbital geometry, and individual mission support requirements (fig. 1). The following is an overview of these phases.[11]

Fig 1 (33K)

Source: Maj Theodore W. Burgner, "Space Handbook" (Paper provided as input for revision of *Space Handbook*, Operations Training Division, 45th Space Wing , August 1991), 37.

Figure 1. Satellite Support Functional Flow

The planning phase mainly involves activities conducted by the SOC and the RCC. The SOC develops an overall contact support plan (CSP) and identifies what is required to support a particular satellite contact. The CSP includes resource requirements, telemetry parameters, and command and ephemeris data. The SOC may simultaneously prepare multiple satellite support plans. The result of this planning effort is requests by the SOCs and other users to the RCC for AFSCN resources. The RCC then produces a schedule for all AFSCN satellite support based on resources and priorities. There are both long-range and near-term schedules that dictate what resources can support specific satellite passes. Resource scheduling is an ongoing activity. There are opportunities throughout the planning phase to deconflict complex satellite pass support requirements.

The pass support phase includes both prepass and satellite contact time. The SOC, RCC, RTS, and communications elements act in concert to configure all resources, conduct readiness testing, and place the systems into final configuration for the actual satellite support (pass).

The SOC mission control team (MCT) initiates the prepass by requesting that the network communications voice operator establish communications nets. When the operator establishes the nets, the MCT members log on to their respective computer terminals to configure hardware and software. The MCT crew commander provides a briefing over an operations (OPS) communications net and the MCT ground controller (GC) briefs over another communications net, termed the configuration net. The GC briefs the RCC resource controller (RC), the lead communications operator (LCO), the Defense Communications System/Satellite Control Facility Interface System (DSIS) operator, the wideband operator, and the RTS antenna operator on data rates, communications and data channel activity, and overall resource configuration for the particular support. Upon briefing completion, the LCO, DSIS, and wideband operators perform channel checks. The RC then performs commanding, telemetry, and antenna slaving tests. The GC then performs similar readiness testing. During the testing period, all of the above elements are involved in the prepass checks and assist in troubleshooting and reconfiguring, if necessary. The RTS antenna is then positioned in preparation for satellite acquisition. Satellite contact begins when the RTS acquires and tracks the satellite. RTS makes contact by either sending out a turn-on command to activate satellite signals or by simply receiving transmitted satellite signals. The RTS in turn relays satellite telemetry data to the SOC while the RCC and communications elements monitor the operations in progress. The MCT evaluates the telemetry data in real time and verifies user data reception. The MCT may send commands to the satellite via the RTS according to the pass plan. The support ends when the objectives are met and the MCT commander directs the RTS to terminate tracking of the satellite.

The evaluation phase is also the postpass phase. While the communications nets are still operating, the MCT crew commander discusses any support-related problems with the RTS, verifies the next pass time, and calls the network configuration voice operator to terminate the OPS net. The GC discusses any pass-related problems with people on the configuration net and releases the net participants through the RC. When the LCO notifies the RC that resources are normalized, and the MCT crew commander has directed the communications operators (wideband, DSIS, LCO, etc.) to terminate both nets, time-critical postpass activities are concluded, and the RTS and communications links are then available for another support. The MCT may continue such evaluation activities as analyzing payload data, satellite performance, data quality, and orbital parameters.

Remote Tracking Stations

Remote tracking stations provide the satellite-to-ground interface for satellite command and control; they provide the actual TT&C contact with any space vehicle supported by the AFSCN. The contact is accomplished under the direction of a SOC. The RTS relays satellite telemetry to the control complex, either generates commands for or relays commands to the satellite, and provides tracking data to the control complex. The specific RTS tasks vary depending on the communications interface and the mission. AFSCN RTSs are located worldwide and provide prelaunch, launch and early orbit, and on-orbit TT&C support for assigned US and allied satellites, ballistic missile launches, and the Space Transportation System (STS)--the space shuttle.[12]

RTSs are strategically located at nine sites with 16 antennas to maximize area coverage for timely and effective use of RTS resources as well as for flexible, multiple support capability (fig. 2). The RTSs are available to control complexes on a time-shared basis for supporting satellite operations and are a scheduled resource. Scheduling is accomplished by the RCC at either Falcon AFB or Onizuka AFB. The RCC allocates time to each RTS for operations, maintenance, and training.

Fig 2 (35K)

Source: Maj Theodore W. Burgner, "Space Handbook" (Paper provided as input for revision of *Space Handbook*, Operations Training Division, 45th Space Wing , August 1991),24.

Figure 2. Remote Tracking Station Locations

The RTSs within the AFSCN have been modernized as automated remote tracking stations (ARTS). ARTS sites may be a new site, such as the Colorado Tracking Station at Falcon AFB, or a modernized existing RTS site, such as the Vandenberg Tracking Station. All RTSs or ARTSs, while not identical in physical layout, function in approximately the same manner. Some

RTSs are configured with additional equipment to support unique missions. We can visualize an RTS's antenna coverage as a cone, widening as the distance from Earth becomes greater. With higher satellite altitudes, a wider selection of RTSs can support a given satellite contact.

RTSs are functionally equivalent to each other and are scheduled for operations based on satellite support needs and the visibility of the satellite to the RTS. Satellite operations events such as TT&C directives, vehicle status and health, and SV commanding data--all pass between the mission control centers and the RTSs over communications links. The RTS uplink transmits satellite command data upload and ranging data. Satellite telemetry and ranging are received in as many as four simultaneous downlinks and transmitted via the communications system to control complexes.

The telemetry function involves tracking in the reception of information on the health, status, and mission payload telemetry of a satellite. An RTS receives satellite telemetry data and transmits this data to a control center. The tracking function involves satellite location and velocity determination. Antenna azimuth and elevation pointing data direct the antenna for satellite acquisition. After acquisition, the RTS transfers range and range-rate data, antenna pointing data, and status information to the control centers, usually via the DSIS. The SOC uses control center tracking data to predict future satellite contacts and to generate antenna pointing data, for real-time acquisition by remote tracking antennas.

The command function includes transmitting coded signals to a satellite to do such things as fire thrusters, start or stop mission tasks, switch power sources, or update sequence programs. The SOC transfers encrypted or clear blocks of command data to the RTS for transmission to the SV. Verification and authentication for each command is normally within the satellite telemetry transmission to the RTS ground antenna and back to the SOC. The SOC then verifies that the satellite properly received the transmitted commands.

Remote Tracking Station Communications. Each RTS has communications capabilities that provide primary and alternate connectivity for data and voice circuits to and from control complexes. One capability is to encrypt and decrypt information and to communicate intrastation via intercom or telephone. Primary communication is accomplished using the DSIS, which links the RTS, via the Defense Satellite Communications System (DSCS) or commercial communication satellites, with either Falcon or Onizuka AFB. Alternate communications links carry digital voice and data, usually on leased commercial telephone circuits, between all AFSCN RTSs and external users. The capabilities of these links vary considerably depending on the support requirements of the different control complexes. An additional communications system used by the AFSCN is called Mission-22 (M-22). It uses DOD host vehicles that are in highly elliptical orbits. Just as the AFSCN is a complex assembly of elements supporting US space assets, the communications links required to carry out the AFSCN mission are a complex suite of networks within and between all elements of the AFSCN and external users. These communications links provide communications security, redundancy, data recording, and interface capability with communications satellites, land lines, fiber optics, and microwave circuits for transmission of data, voice, teletype, and facsimile information.

The wideband communications network provides the primary communications links used in the AFSCN between the control centers and the RTSs. This network uses the DSIS, which links the RTS via DSCS II and DSCS III satellites or commercial communication satellites with either Falcon or Onizuka AFBs. DSIS provides high data rate communications between the RTSs and the control centers. Narrowband communications are an alternative to the wideband system for data and digital voice capability. Additionally, the network uses M-22 communications satellites that provide the capability of minimum essential wideband support in the event of any wideband link outages to any RTS. Some RTSs have a data link terminal (DLT) to specifically utilize M-22. An RTS with two antennas, but no DLT, can still use M-22 for real-time transmission if one antenna tracks, while the other relays data via M-22. The M-22 data rate is limited, but its capability fulfills most present and future vehicle reception requirements.

Remote Tracking Station--Mission Unique Interfaces. RTSs also interface with dedicated elements within the AFSCN in support of specific requirements of the DMSP and GPS programs. Specific mission unique interfaces at the Thule (Greenland), Hawaii, and New Hampshire RTSs provide DMSP support. The RTSs provide an interface for command and telemetry data between the RTSs and the dedicated DMSP elements. The dedicated elements of the DMSP are the Multi-Purpose Satellite Operations Center and the Fairchild Satellite Operations Center. The RTSs provide an interface for primary mission data recovery for transmission to the Air Force Global Weather Central, as well as to the Navy Fleet Numerical Oceanography Center.

A mission unique enhancement at the Colorado Tracking Station (CTS) provides GPS program support. This mission unique interface provides the CTS with a GPS ground antenna command and telemetry processing capability--which allows the GPS SOC at Falcon AFB to directly control the CTS.

Command Centers

There are two command centers in the AFSCN: the Wing Command Post (WCP) located at Falcon AFB and the Group Operations Center (OC) at Onizuka AFB. The WCP exercises operational control over the AFSCN. The OC provides backup functions for the WCP and primary operational control over selected programs specific to Onizuka AFB.[13]

The Wing Command Post' s primary job is to support the 50th Space Wing commander, providing a command post for the 50th Space Wing and Falcon AFB. The wing commander requires this command post to fulfill responsibilities as the manager and operator of the unique worldwide AFSCN. The WCP also links assigned AFSCN assets into a fully responsive, integrated system supporting multi-service and multi-agency programs and serves as the focal point through which the Air Force Space Command (AFSPACECOM) commander exercises real-time combatant command over AFSCN forces. Some of the functions carried out by the WCP include

1. monitoring and reporting space system health, status, and readiness information of AFSCN elements including dedicated centers and AFSCN mobile resources,

2. implementing operations plans and contingency plans,

3. disseminating AFSCN element hostile attack warnings,

4. disseminating intelligence information affecting satellite control operations,

5. maintaining interoperability with the OC, and

6. conducting training exercises, both internally and in conjunction with other elements involved with US space assets.

The 750th Satellite Tracking Group OC, located at Onizuka AFB, serves as a subcenter of the WCP at Falcon AFB. The OC plays an active role in providing downward direction to the RTSs and in channeling information from the RTSs to the WCP. The OC provides a backup capability for command and control of the AFSCN if the WCP cannot sustain its mission. The OC also interfaces with control centers at Onizuka AFB that are dedicated to programs not supported by the AFSCN.

Network Control System

The network control system (NCS) is composed of RCCs located at Falcon AFB and Onizuka AFB. The RCCs provide dual-node resource scheduling capability necessary to support the other elements of the AFSCN. Functional equivalency between the two RCCs allows each complex to perform all AFSCN common-user resource scheduling and resource control functions.[14]

The NCS mission compromises four different categories: plans and analysis (P&A), resource scheduling (RS), resource control (RC), and inter-range operations (IRO).

The plans and analysis branch collects long-term resource utilization requests for flight preparation and nonflight activities. It then develops long-range forecasts and schedules and distributes them to affected elements. P&A also analyzes resource utilization, system performance, and other associated data.

The resource scheduling branch collects flight resource utilization requests and combines them in a common data base with requests collected by plans and analysis. RS schedules the common-user resources, identifies conflicts, and coordinates conflict resolution in the non-real-time planning period. RS also requests, when necessary, support of internetted resources from appropriate agencies. RS then publishes and distributes the established schedule, performs real-time changes and conflict resolution, and makes data base updates.

restoration status reports, coordinating maintenance activities, and initiating fault localization and isolation testing as required. RC also exercises control over the start, stop, and failure switchover of all scheduled communications link connectivities between the communications control complex (CCC) and AFSCN users.

Interrange operations organizations are located at both Falcon AFB and Onizuka AFB. IRO is the single operational interface through which external space agencies (e.g., NASA) without affiliated SOCs request and obtain support from AFSCN resources. IRO reports operationally to the WCP, but is functionally part of the NCS. IRO obtains early orbit determination and computation of miss-between-orbit data from the Space Defense Operations Center (SPADOC) and provides predictive avoidance data support to SPADOC . The IRO also performs satellite management support and radio frequency interference analyses and predictions.

The NCS consists of hardware, software, personnel, operational procedures, and facilities that interact to provide for scheduling, allocating, configuring, and testing of AFSCN common-user resources. The NCS analyzes resource usage; monitors resource status; conducts fault detection, localization, and isolation for all network resources; and provides the interface for users and resources external to the AFSCN.

Communications System--Major Components

The communications control complex is one of the essential control complexes located in the common-user control centers. The CCC performs initiation of circuit connectivity, circuit monitoring, circuit restoration, and fault isolation for AFSCN communications between the common-user control centers and the common-user RTSs. The CCC is also the interface between the AFSCN and external users (for example, NASA). The CCC acts as the interface between the mission and mission support communications services required by the AFSCN.[15]

Falcon AFB currently does not have primary independent connectivity to the RTSs. An interim configuration called "Backhaul" connects Falcon to the RTSs by going through Onizuka AFB via a domestic satellite link.

The remote communications/telemetry areas (RC/TA) are the remote termination of the mission communications links at the RTSs. The RC/TA performs monitor, circuit restoration, and troubleshooting functions similar to a CCC at a control center.

Primary and alternate communications links internet the AFSCN control centers and the RTSs. These links provide interstation and intrastation communications to common-user elements. Interstation communications consist of primary and alternate communications links connecting control nodes with other AFSCN and external facilities. Intrastation communications distribute data and voice communications within various complexes, control centers, and RTSs.

A number of AFSCN communications functional areas should be highlighted. The recording, storage, and playback area is located at the RTSs and common-user control centers. This area serves as a backup for real-time receive activities and as non-real-time playback for satellite support activities. Types of data involved are primary and backup telemetry, voice, time, and command/control/status signals. The CCC records information by exception; therefore, users must schedule any recording.

The AFSCN communications system provides the necessary interface equipment to permit access between satellite and various terrestrial communications agencies. This area, which includes communications satellite links, interconnect facilities, leased common carrier communications links, and commercial telephone, provides the primary and alternate connectivity between the globally dispersed AFSCN elements.

Additional Systems

The Command and Control System (CCS) is the new operating system that was formerly known as Data Systems Modernization. When configured for CCS support, the RTS relays the entire telemetry stream back to a CCS-compatible SOC at either Falcon AFB or Onizuka AFB for telemetry processing. The RTS also relays satellite commands from a CCS SOC to the space vehicle. The Air Force plans to transfer all of its space vehicle operations to the CCS.[16]

Force Enhancement

Force enhancement multiplies combat effectiveness. Space operations contribute directly to the combat effectiveness of our military forces within several mission areas: spacelift, surveillance and reconnaissance, navigation, communications, and meteorology.

Historically, the primary use of United States military space systems has been to support terrestrial forces. From their unique vantage point, satellites can perform and support many military missions more economically, effectively, and efficiently than terrestrial systems. In some cases, satellites are the only feasible means of performing the mission. In addition, the inherent global nature of orbiting satellites makes worldwide support of military operations possible.[18]

The US military relies extensively on space assets for many critical missions. Force enhancement space systems include capabilities that

- Provide real-time, survivable, and enduring communications, surveillance, environmental monitoring, navigation, and warning for unified and specified commanders (and their component commanders), the national command authorities, and the intelligence community.
- Provide the potential for rapid decision and response actions by the NCA and war-fighting commanders at all levels. Space resources can rapidly distribute information to forces worldwide. Space systems can aid commanders to reduce the time required for observation-orientation-direction-action feedback.
- Support national and international space rescue plans.
- Provide space environmental and life support capabilities over the full scope of aerospace operations.[19]

Spacelift

Spacelift provides the capability to emplace and replace critical space assets. Spacelift (or launch) operations deliver military space systems to the required operational orbit or location in space. The spacelift mission entails a wide variety of complex activities required to place the satellite into the proper operational orbit.

Spacelift includes preparing the various segments of the space launch vehicle, erecting or stacking the launch vehicle on or near the launchpad, integrating the mission payload(s) with the launch vehicle, conducting a thorough prelaunch checkout of all systems, and conducting the actual operations of countdown, launch, and flight of the space vehicle into orbit.[20] Additional detailed information on various spacelift (launch) vehicles is in chapter 4 of this volume.

Surveillance and Reconnaissance

The following section provides information on two key US space systems that have a long history of success. These systems are only samples of US surveillance and reconnaissance satellite systems. Some of these technologically advanced systems are classified and this volume does not cover them.

Defense Support Program. The Defense Support Program (DSP) is an integral part of the nation's missile warning system operated by the US Air Force Space Command. The satellites report on real-time missile launches, space launches, and nuclear

Landsat. Landsat is a civil satellite system developed by NASA to provide land, surface, and ocean data. Initially developed in the late 1960s, the primary Landsat mission was to demonstrate the feasibility of multi-spectral remote sensing from space for practical Earth resources management practical applications. The overall system requirements were acquisition of multi-spectral images (MSI), collection of data from remotely located ground stations, and production of photographic and digital data in quantities and formats most helpful to potential users.[21] Another requirement was that Landsat take the data in a specific manner: repetitive observations at the same local time, overlapping images, correct locations of images to within two miles, and periodic coverage of each area at least every three weeks.

Currently, data from Landsat is collected at three US ground stations located in California, Alaska, and Maryland. Through bilateral agreements, ground stations located in Canada, Brazil, Argentina, Japan, India, Italy, Australia, Sweden, and South Africa are also receiving data.[22] All data for US consumption is sent to the Goddard Space Flight Center for preprocessing. After preprocessing, the data is transmitted electronically to the Earth Resources Observation System Data Center (EDC) in South Dakota for final processing. The resultant data is then available to users through EDC as photographic imagery or digital data tapes.

Landsat 4 and 5, the second generation of the Landsat series, carry two sensors: a multi-spectral scanner (MSS) and a thematic mapper (TM). The thematic mapper is a new sensor that has a ground resolution of 30 meters for the visible and near-infrared bands.[23] The MSS records four images of a scene, each covering a ground area of 185 kilometers (km) by 185 km at a nominal ground resolution of 79 meters.[24] The images are produced by reflecting radiance from the Earth's surface to detectors on board the satellite.

Two large applications of Landsat data are mapping land cover and monitoring change, both aquatic and terrestrial. The TM sensor is able to record four times as many radiance levels as the MSS sensor and has better resolution. This enhanced resolution and increased radiance level capability provides greater detail for vegetation absorbance, land/water contrasts, and geological discrimination applications.

The current Landsats take 16 days to cover the Earth (except the poles). Their data is relayed in near real time by using the geostationary Tracking and Data Relay Satellite and the Domestic Communication Satellite systems. This eliminates the need to rely on onboard tape recorders to store data for transmission. As a result, it takes approximately 48 hours from collection of raw sensor data to generation of MSI archival products.[25]

The Landsat program, originally under NASA, has suffered from a lack of a stable home in the competition between programs for funding. The National Space Council shifted the program to the Commerce Department in 1979 in a commercialization plan that would eventually place it under private ownership and operation. That effort brought in smaller revenues than expected and the program languished. If Landsat 4 and 5, launched in 1982 and 1984 respectively, had not exceeded their three-year-design lifetimes, the US would be without a civil Earth observation spacecraft. Landsat 6, scheduled for launch in mid-1992, should operate for five years, during which time Landsat 7 should be launched.

[Image 36K]

Landsat C

sensors capable of five-meter stereoscopic images, precise metric data, broad area collection, and a dedicated tracking and data relay antenna would make the Landsat an effective tactical military system for future conflicts.[27]

[Image 22K]

Global Positioning System Satellite

Navigation Systems

The Global Positioning System is a space-based radio navigation network operated and controlled from Falcon AFB. The Air Force launched the first research and development satellite in February 1978. As of February 1991, the GPS network consisted of six Block I R&D satellites, and 10 Block II operational satellites. This 16-satellite constellation should grow to 21 satellites plus three on-orbit spares by the mid-1990s.

GPS is a navigation system designed to provide US and allied land, sea, and air forces with worldwide, three-dimensional position and velocity information. The system consists of three segments: a space segment of satellites that transmits radio signals, a control segment of ground-based equipment to monitor the satellites and update their signals, and a user equipment segment of devices to passively receive and convert satellite signals into positioning and navigation information.

When fully operational, GPS will provide 24-hour, all-weather, precise positioning and navigation information from satellites circling the Earth every 12 hours and emitting continuous navigation signals. It will also provide such support to civilian users.

The Air Force launches GPS satellites from Cape Canaveral AFS, Florida, using a Delta II launch vehicle. The satellites are put into 11,000 nautical mile circular orbits. The GPS constellation will have six orbital planes with four satellites in each. Satellites will transmit on two different L-band frequencies. The design life of the operational satellites should be seven and one-half years.

The GPS master control station located at Falcon AFB monitors and controls the GPS constellation. Five widely separated monitor stations passively track the satellites and accumulate navigation signals. Three globally dispersed ground antennas act as the two-way communications link between the MCS and the satellites. Through these links, crews in the MCS update the satellites' computers, allowing them to maintain the health and orbit of GPS satellites, monitor and update navigation signals, and synchronize the satellites' atomic clocks.

GPS data aids land, air, and sea vehicles in navigation, precision weapons delivery, photographic mapping, aerial rendezvous and/or refueling, geodetic surveys, range safety and instrumentation, and search and rescue operations. This system provides military users highly accurate, three-dimensional (longitude, latitude, and altitude) position, velocity, and time information. With proper equipment, authorized users can receive the signals and determine their location within tens of feet, velocity within a fraction of a mile per hour, and the time within a millionth of a second. To obtain this information, the user set will automatically select the four most favorably located satellites, lock onto their navigation signals, and compute the position, velocity, and time.

Communications Systems

This section discusses the primary communications satellite systems used by the US Air Force. Communications systems that other services use extensively for specific purposes are not covered in this volume.

phases incorporating improved technology and enhanced capabilities with each phase.

Between June 1966 and June 1968 in Phase I of the program, the Air Force launched 26 small communications satellites, each weighing about 100 pounds. Each satellite had one channel and relayed voice, imagery, computerized digital data, and teletype transmissions. Designers planned for the satellites to last three years. Phase I satellites operated in a circular orbit 20,930 miles above Earth at a speed that nearly kept each satellite over a point on the equator.

DSCS II launched its first satellites in 1971 and is the second generation military communications satellite program. The 3d Satellite Control Squadron currently flies DSCS II satellites from Falcon AFB. DSCS II has increased communications load capability and transmission strength, and double the lifetime expectancy of the Phase I satellites. DSCS II has an attitude control system for orbital repositioning. Ground command can steer the two-dish antennas on DSCS II satellites and can concentrate the antennas' electronic beams on small areas of the Earth's surface for intensified coverage.

The third generation satellite is the DSCS III satellite. These satellites carry multiple-beam antennas to provide flexible coverage and resist jamming. They last twice as long as DSCS II satellites, have six active communications transmitter channels, and carry an integrated propulsion system for maneuverability. The Air Force launched the first DSCS III satellite in 1982. Antenna design for DSCS III allows users to switch between fixed, Earth coverage, and multiple-beam antennas. The latter provides an Earth coverage beam as well as electrically steerable area and narrow-coverage beams. In addition, a steerable transmit dish antenna provides a spot beam with increased radiated power for users with small receivers. In this way, operators can tailor the communications beams to suit the needs of different size user terminals almost anywhere in the world.[28] (See annex A *[not here]* for more information on DSCS's role in Desert Storm.)

NATO III. The NATO III satellite program is a four-satellite constellation. NATO III satellites are geostationary communications satellites designed to provide real-time voice and data links between members of the North Atlantic Treaty Organization (NATO). The program is directed by the NATO Integrated Communications System Operating Agency (NICSCOA), which is located at Supreme Headquarters Allied Powers Europe, Belgium. The AFSCN performs command and control functions on behalf of NICSCOA .[29]

NATO III is a cylindrical, spin-stabilized satellite with a design life of seven years. It is 86 inches in diameter, 110 inches in height, and weighs 783 pounds. Solar arrays cover the sides of the satellite body, and there are thermal shields on the top and bottom. The command and control antenna encircles the vehicle, and three communications antennas are atop the satellite on a despun platform. The communications payload is a repeater providing both narrowbeam and widebeam coverage of the North Atlantic region. This payload provides multiple carrier reception, frequency translation, amplification, and retransmission of X-band signals. The apogee kick motor and two axial thrusters are on the bottom of the vehicle. All electronic equipment, the hydrazine tanks, and radial thrusters are on the main equipment platform in the center of the vehicle. The AFSCN launched the NATO III satellites from the Eastern Test Range aboard Delta boosters between April 1976 and November 1984 and placed the four vehicles in elliptical transfer orbits of approximately 23 degree inclination. At approximately fifth apogee, an apogee kick motor fired, circularizing the orbit and reducing the inclination. NATO III will eventually take on a backup mission when NATO IV becomes operational in the early 1990s.

[Image 12K]

Fleet Satellite Communications System Satellite

the satellite. The span of the deployed solar array panels is 43 feet. In addition, three nickel-cadmium batteries provide power during eclipse operations at the spring and autumnal equinoxes. The design life of the satellite is five years.

[Image 20K]

Defense Meteorological Satellite Program Satellite

Meteorology

The Defense Meteorological Satellite Program has been operational since July 1965. Its military mission is to generate weather data for operational forces worldwide. The Air Force is the DOD executive agent for this program. The Department of Commerce's National Oceanic and Atmospheric Administration furnishes meteorological data to the civilian community.

Satellites in the DMSP meet unique military requirements for worldwide weather information. DMSP satellites provide meteorological data in real time to Air Force, Navy, and Marine Corps tactical ground stations and Navy ships. Through these satellites, military weather forecasters can detect developing patterns of weather and track existing weather systems over remote areas.

Data from these satellites can help identify, locate, and determine the intensity of such severe weather as thunderstorms, hurricanes, and typhoons. Agencies can also use the data to form three-dimensional cloud analyses, which are the basis for computer simulation of various weather conditions.

All of this quickly available information aids the military commander in making decisions. For example, data obtained through this program is especially valuable in supporting the launch, en route, target, and recovery portions of a wide variety of strategic and tactical missions. Air Force Space Command's 6th Space Operations Squadron (SOPS) at Offutt AFB, Nebraska, and Detachment 1 of the 6 SOPS at Fairchild AFB, Washington, provide command and control of DMSP satellites.

Current satellites in the DMSP are designated as the Block SD-2 integrated spacecraft system because the functions of the launch vehicle's upper stage and the orbital satellite have been integrated into a single system. This system navigates from lift-off and provides guidance for the spacecraft from booster separation through orbit insertion, as well as electrical power, telemetry, attitude control, and propulsion for the second stage. Block SD-2 has many improvements over earlier DMSP satellites, including more sensors with increased capability and increased life span. The satellites circle the Earth at an altitude of about 450 NM in a near-polar, Sun-synchronous orbit. Each satellite scans an area 1,600 NM wide and can cover the entire Earth in about 12 hours. Three reaction wheel assemblies, which provide three-axis stabilization, maintain pointing accuracy of the satellites. The SD-2 spacecraft has five major sections: a precision mounting platform for sensors and other equipment requiring precise alignment, an equipment support module that encloses the major portion of the electronics, a reaction-control equipment

- protection--the ability to protect friendly space assets. This mission is also referred to as defensive counterspace.
- negation--the ability to negate any hostile space asset. This mission is referred to as offensive counterspace.[33]

Space Surveillance

Space surveillance is essential to the space control mission and involves the functions and ability to monitor, assess, and inform. The nerve center of United States Space Command's (USSPACECOM) space surveillance mission is the Space Surveillance Center (SSC) located deep inside Cheyenne Mountain AFB, Colorado. A computer network in the SSC keeps a constant record of the movements of thousands of man-made objects orbiting the Earth. These objects include satellites (active and inactive) and pieces of space debris. The SSC computers receive a steady flow of information from the elements of the space surveillance network (SSN). The SSN consists of radars and optical tracking devices located around the world. Specific SSC responsibilities include:

1. Providing operational command and control of the SSN. These activities include tasking of sensors to provide tracking support for routine space catalog maintenance, space object identification, and special events monitoring.

2. Maintaining a catalog of orbital characteristics of all observable man-made space objects for position prediction.

3. Providing routine space operations information.

4. Providing orbital data to many users and informing the Space Defense Operations Center of any contributing factors affecting any degradation of performance within the SSN.[34]

When a sensor acquires a piece of orbiting hardware, it sends the information to the SSC computers. The SSC tracks the present position of these objects and predicts their future orbital paths. The SSC compares the observation with the predicted location of cataloged objects. Observed information which the SSC cannot verify or match with a known object may be an indication of a

Dedicated Sensors. Dedicated sensors support the space surveillance mission. They include three unique optical systems, a combined radio frequency (RF) and optical system, a phased array system, a mechanical tracker radar, and a "radar fence" operated by the Navy.

The ground-based electro-optical deep space surveillance system (GEODSS) is an optical system that uses a low-light-level TV camera, computers, and large telescopes. GEODSS tracks objects in deep space, or from about 3,000 NM out to beyond geosynchronous altitudes. GEODSS requires nighttime and clear weather tracking because of the inherent limitations of an optical system. There are currently four operational GEODSS sites with coverage areas as follows: Socorro, New Mexico (165W-050W); Maui, Hawaii (140E-010W); ChoeJong San, South Korea (070E-178E); and Diego Garcia, Indian Ocean (010E-130E). Each site has three telescopes, allowing GEODSS to track three objects simultaneously. All three telescopes are linked to video cameras. Two of the three telescopes are 40-inch aperture main telescopes, which are used primarily to search the deep sky for faint, slow-moving objects. The other, a 15-inch telescope, does wide searches of lower altitudes where objects travel at higher relative speeds. The only exception to this configuration is the Diego Garcia site, which has three 40-inch telescopes. The television cameras feed their space pictures into a computer that drives a display device. The computer automatically filters stars from the night sky backdrop, and the satellites appear on the display screen as streaks of light. GEODSS can transmit position and identification signature data to the SSC (in Cheyenne Mountain) in seconds. GEODSS sensors are responsible for over 65 percent of all deep space object tracking and surveillance, and provide almost worldwide coverage of the equator. Any sustained loss of a GEODSS sensor would have dramatic impact on the deep space surveillance mission and maintenance of the space catalog.[39]

The second optical system is the Maui Optical Tracking and Identification Facility (MOTIF) in Hawaii. MOTIF is a dual 1.2-meter telescope system on a single mount. One telescope primarily does infrared and photometric collection. The other performs low-level light tracking and imagery. MOTIF can track space objects in near-space and deep-space orbits and represents

Collateral Sensors. Collateral sensors have a primary mission other than space surveillance, but still provide support to the space surveillance mission. Collateral sensors include the following systems:

System	Type	Site
BMEWS	Phased Array Radar	Thule AB, Greenland
	Phased Array Radar	RAF Fylingdales Moor, United Kingdom
	Mechanical Tracking Radar	Clear AFB, Alaska
PAVE PAWS	Phased Array Radar	Cape Cod, Massachusetts
		Robins AFB, Georgia
		Eldorado, Texas
		Beale AFB, California
PARCS	Phased Array Radar	Cavalier AFS, North Dakota

Finally, another set of collateral sensors include three mechanical tracking C-band radars: Antigua, British West Indies, Kaena Point, Hawaii, and Ascension Island in the Atlantic Ocean. These radars are located on islands and primarily support test and evaluation of US ICBM and space launches. The three radars spend approximately 128 hours per week supporting the space surveillance mission. Antigua's position in the northern hemisphere near the equator allows accurate coverage of all low-Earth orbits; however, as a tracking radar, Antigua's FPQ-14 radar (operating between 5,400-5,900 MHz) has a limited search capability. Kaena Point's radar is nearly identical to Antigua's (operating in the same frequency range with a narrow beam width) providing accurate data with limited search capability. The final C-band radar, a TPQ-18, located on Ascension Island in the southern hemisphere near the equator, provides accurate coverage of all low-Earth orbits. In addition to this radar on Ascension, the US Navy is currently upgrading an FPQ-15 radar. When completed, this new radar will function in the X-band (8,000-12,500 MHz) frequency range and provide more accurate coverage.[44]

Contributing Sensors. The final group of sensors are referred to as contributing sensors. These sensors are not under USSPACECOM 's operational control; however, they provide observation data on satellites to USSPACECOM on a contributing basis. There is a total of five contributing sensors: four mechanical tracker radars and one electro-optical sensor. One mechanical C-band tracker, located at Kwajalein Atoll, Marshall Islands, tests and evaluates US ICBMs. The ALCOR radar, one of two radars located on Kwajalein Atoll, provides wideband imagery data at 5,672 MHz and can be used for near-Earth surveillance to meet USSPACECOM requirements. Also located on Kwajalein Atoll, is the ALTAIR A-B band radar (4l5-450 MHz). USSPACECOM uses this radar about 128 hours per week.[45]

warning messages.[49]

The primary method of secure connectivity between SPADOC and all space system owners/operators is the Space Defense Command and Control System (SPADCCS). SPADCCS is a communications network using hard copy messages to and from SPADOC and space system owners/operators.

Negation

The final space control mission--offensive counterspace--is categorized by the term negation. The ability to negate or destroy any hostile space system includes the use of an antisatellite(ASAT) system. The US does not currently operate a functional ASAT system. Any future system will serve as an integral part of USSPACECOM 's plan to achieve total space control.

An operational ASAT force would fulfill many objectives of space control. Operational ASATs would encourage the right of free passage through space, increase the options available to US commanders--especially during major war-fighting operations--and provide the capability, if required, to attack enemy military space assets to ensure space superiority and control of the high frontier. A comprehensive ASAT system would most likely consist of directed energy weapons, kinetic energy weapons, and possibly electronic warfare systems.[50]

Force Applications

For multiple ballistic missiles with multiple RVs , the region that potentially has the highest defense payoffs is the boost/ postboost layer. Viable technical approaches now exist for intercepting from space a ballistic missile during the boost portion of its flight. Inclusion of boost-layer defense would substantially discount the value of ballistic missiles with multiple independently targetable reentry vehicles (MIRV) and provide the threatening forces with incentives to accomplish the long-standing arms control objective of reducing MIRVed ICBMs. Intercepts in the boost phase also offer multiple engagement opportunities to ensure high levels of defense effectiveness. The synergism provided by layers of the defense significantly increases the task of designing and deploying effective offensive countermeasures.[55]

If missiles have fast-burn boosters to counter initial boost-layer defenses, the task of releasing decoys is more complicated, mitigating the requirement to design means of discrimination in the midcourse layer. Furthermore, follow-on defensive system concepts could block the fast-burn approach. Intercepts in the boost/postboost layer can also destroy the post-boost vehicle (PBV) before it releases decoys and other penetration aids designed to confuse the defenses, should such decoys and penetration aids be present.[56]

The major technical challenge in the midcourse layer is to develop a capability to discriminate RVs from accompanying decoys or other penetration aids. For example, using sensors in space to observe the operation of a PBV as it starts to release its payload could permit early identification of RVs among the clouds of decoys. This early identification in turn, could mitigate the problems associated with tracking and intercepting RVs from either space or the surface.[57]

spread of ballistic missile capabilities around the world.[63]

These technologies pose a threat today that is regional in character (e.g., shorter-range missile systems). However, the trend is clearly in the direction of systems of increasing range, lethality, and sophistication[64] The SDIO has assessed the proliferation of ballistic missiles and found that by the year 2000, some 24 nations will have a ballistic missile launch capability. Figure 3 represents an illustrative look at ballistic missile proliferation[65] the deployment of an entire system. Nor would the deployment of a GPALS system be contingent on the technical maturity of potential follow-on systems.

A GPALS system would consist of surface- and space-based sensors capable of providing continuous, global surveillance and tracking from launch to intercept or impact of ballistic missiles of all ranges. The use of space-based sensors would allow for a reduction in the size, cost, and number of surface-based weapons and sensors, while increasing their performance. In combination, the sensors would provide information to US forces and potentially to those of allies as well.

A GPALS system would also contain interceptors, based both in space and on the surface, capable of providing high-confidence protection to areas under attack. Space-based interceptors could provide a continuous, global interdiction capability against missiles with ranges in excess of 600 kilometers. The surface-based interceptors (located in the US, deployed with US forces, and potentially deployed by US allies) would provide local point and area defense.[68]

To illustrate the GPALS concept, figure 4 depicts an integrated system consisting of three interlocking pieces.[69] The size of each piece reflects the relative investment projected for the three main parts of the GPALS . Specific elements are discussed under the section on GPALS architecture.

illustrated in figure 5. Brilliant Pebbles, after receiving weapon-release authority, would be an autonomous space-based kinetic energy interceptor. BP would provide global detection of an attack and means to destroy ballistic missiles with ranges greater than 600 kilometers. In the GPALS architecture, BP would operate against both strategic and theater ballistic missiles. Current plans call for about l,000 BPs to support a GPALS architecture.[74]