CHAPTER 1

Before Sputnik:

The Air Force Enters the Space Age, 1945–1957

In the aftermath of World War II Air Force leaders laid the foundation for future operations in space by establishing a clear research and development focus for the new service. Commanding General of the Army Air Forces Henry H. "Hap" Arnold and his eminent scientific advisor Theodore von Kármán set the course through their policy statements, organizational decisions, and comprehensive analysis of Air Force scientific requirements for a technological future. Their legacy appeared endangered in the late 1940s when tight budgets and higher priorities confined space and long-range missile development to low level studies at best. Air Force leaders seemed intent on establishing Air Force responsibility for the as-yet-to-be-determined space mission, but unwilling to promote the development of satellites and booster missiles that would make possible such a mission.

By the early 1950s, however, change was in the air. New concerns about Soviet political activity and ICBM development compelled leaders to reexamine the country's defense posture. In doing so, missiles and satellites received new attention. Larger defense budget outlays and successful testing of thermonuclear devices offered the promise of a feasible ballistic missile and space booster. A number of government officials and Air Force officers who shared Arnold's legacy acted as catalysts for change by creating new organizational structures and promoting greater awareness of spaceflight opportunities. They faced strong opposition every step of the way. Yet on the eve of Sputnik, their considerable efforts helped bring the Air Force and the nation to threshold of space.

Rand Proposes a World-Circling Spaceship

In a postwar America, with armed forces undergoing demobilization and reassertion of domestic priorities, Arnold and other Air Force innovators quickly realized that it was one thing to advocate an imaginative, liberally-funded research and development program for the Army Air Forces (AAF) and quite another to have it put into practice by a conservative military establishment. The Air Force's initial involvement with artificial earth satellites illustrates the difficulty of gaining approval for a system of the future rather than the present.

In early 1946, the AAF found itself about to be outmaneuvered by Naval officers who had been pursuing satellite feasibility studies since the end of the war. Captivated by a space study written in May 1945 by German space scientist Wernher von Braun, as well as the horde of captured V-2 rocket components, Dr. Harvey Hall of the Navy's Bureau of Aeronautics Electronics Division proposed a testing program to determine the feasibility of artificial satellites. Based on a current Naval hydrogen rocket motor development program, Commander Hall's team formed a Committee for Evaluation of the Feasibility of Space Rocketry and envisioned launching a liquid hydrogen-oxygen single-stage earth satellite to conduct scientific testing. Naval leaders agreed, and Hall called on four companies, including GALCIT, for technical assistance with fuels, electronic components and structural characteristics. Early in the new year, all four agreed that a satellite could be placed in earth orbit if the Navy proved willing to provide sufficient funding.[1]

Unable to gain the required Naval financial support, Commander Hall proposed a cooperative space venture to AAF representatives at a 7 March 1946 meeting of the War Department's Aeronautical Board. Although AAF Board members questioned the high costs involved, they expressed interest and promised to consult with Major General Curtis E. LeMay, Arnold's Deputy Chief of Staff for Research and Development, before the Board reconvened on 14 May. After discussions with General Carl A. Spaatz, who replaced General Arnold on 1 March as commanding general, LeMay informed Hall that the AAF could not support the Navy project but nevertheless would continue discussions on the subject. Already AAF leaders had decided that artificial earth satellite programs should be an AAF responsibility based on the argument that military satellites represented an extension of strategic air power. For the first time air leaders outlined the rationale for an Air Force space mission that would appear haphazardly over the next ten years, then surface prominently during the roles and missions debates after Sputnik.

To forestall the Navy's initiative in the spring of 1946 and help establish AAF primacy in the field, the service needed to demonstrate competence equal to the Navy's. In April LeMay turned to Project Rand for the necessary technical expertise. In just three weeks, the Rand team of sixteen experts completed their justly celebrated 250-page engineering analysis of a "World-Circling Spaceship."[2] Based on both the current state of technology and expected future engineering developments, the Rand team argued that "technology and experience have now reached the point where it is possible to design and construct craft which can penetrate the atmosphere and achieve sufficient velocity to become satellites of the earth." Indeed, the report predicted that the U.S. could launch a 500-pound satellite into a 300-mile orbit within five years at a cost of $150 million. Rand's analysts declared that even their most conservative engineers agreed, and they supported their prediction with a series of detailed studies in two chief areas.

One comprised technical feasibility studies dealing with such satellite-related issues as propulsion options, risks posed by potential meteor strikes, trajectory analyses, the important "re-entry" challenges posed by the intense heat objects would encounter returning through the earth's atmosphere, and, in contrast to the Navy's single-stage rocket, the use of a three-stage liquid hydrogen-oxygen rocket booster. The analysts argued that no technical challenge they investigated seemed overwhelming.

In a second area, noted radar expert Louis N. Ridenour examined a number of potential military satellite uses in a chapter titled "The Significance of a Satellite Vehicle." Focusing on defense support or "passive" military uses of satellites, he described satellites as nearly invulnerable observation platforms that could provide weather and bomb damage assessment data. He went on to describe the satellite as a communications relay station, in which satellites could be positioned at an altitude of approximately 25,000 miles so that "their rotational period would be the same as that of the earth." For the first time, a serious satellite proposal projected launching satellites into geosynchronous orbit for effective, worldwide communications.[3] Ridenour devoted most of his chapter to the satellites' scientific role in supplying important data unaffected by atmospheric conditions. As an aid to research, the satellite could facilitate the study of cosmic rays and provide precise gravitational measurements, as well as considerable astronomical data. Moreover, instrumented satellites could furnish important bio-astronomical information for medical scientists concerned with life in an acceleration-free environment.

Despite Ridenour's coverage of "passive" defensive military functions, he briefly raised the possibility of using satellites as offensive weapons. Given the onset of the missile age, he argued, satellites could provide both accurate guidance for missiles and serve as missiles themselves. He based his argument on the compatibility between missile and satellite technology as well as launch velocity requirements. As he explained,

> There is little difference in design and performance between an intercontinental rocket missile and a satellite. Thus a rocket missile with a free space trajectory of 6,000 miles requires a minimum energy of launching which corresponds to an initial velocity of 4.4 miles per second, while a satellite requires 5.4. Consequently, the development of a

> satellite will be directly applicable to the development of an intercontinental missile.[4]

In short, if you produce an ICBM, you also have a satellite launcher. In the future, however, the technical relationship between long-range missiles and satellites would remain largely unexploited. Even missile advocates normally argued that satellite development interfered with the greater need to accelerate missile programs. Later, closer examination would show that satellite technology could be applied to missile guidance systems and thereby contribute to missile development. The missions identified by Louis Ridenour would become a part of the Air Force and the national space program from the Eisenhower administration forward. Unfortunately, many of the Rand study's predictions and analyses would be forgotten in the years ahead. David Griggs, for example, in the report's introduction turned his vision to the future:

> Though the crystal ball is cloudy, two things seem clear: 1. A satellite vehicle with appropriate instrumentation can be expected to be one of the most potent scientific tools of the Twentieth Century. 2. The achievement of a satellite craft by the United States would inflame the imagination of mankind, and would probably produce repercussions in the world comparable to the explosion of the atomic bomb.[5]

Armed with the Rand study, General LeMay formally declined the Navy offer of a joint Navy-AAF program at the May meeting of the Aeronautical Board and staked out the AAF's claim to potential satellite operations. At the same time board members decided that the costs of developing and operating a satellite did not justify a major effort on a project of questionable military utility. The Board agreed to permit both services to continue their studies, with the jurisdictional assignment of satellite responsibility left unresolved.

The 1946 Rand report established the technical feasibility of orbiting a satellite but ruled out its likely use as an offensive weapon because available propulsion systems could not launch heavy atomic weapons into earth orbit. Given this restriction, the problem became establishing a credible role for an orbiting satellite that could justify the enormous cost and quiet the skeptics of "push-button warfare." During the next several years, Rand's satellite proposals would continue to founder on the criticism of cost and utility, while greater interest in developing guided missiles served to retard satellite progress further.

The Air Force Shuns Ballistic Missiles

The analysts at Rand underscored the relationship between satellite and missile development. Not only would progress with satellites promote greater interest in missiles as boosters, but improvement in satellite technology could benefit missile development as well. Yet, the Air Force establishment, which focused on its bomber fleet, seemed unaware of the potential for mutual benefits, and later in the 1950s, when missiles promised additional strategic firepower for the nation's arsenal, critics of a forceful space program argued that satellites must not be allowed to interfere with missile development. The Rand analysts also might have noted that the missile-satellite relationship meant that any progress with satellites would depend on developments in the higher priority missile field. In the years after the Second World War, however, neither subject drew significant attention from the Truman administration and the defense establishment. As with satellite proposals, initial postwar interest in long-range guided missiles soon succumbed to an Air Force policy that relied on strategic bombers carrying air-breathing missiles, interservice conflicts over roles and missions, and administration-imposed budget ceilings that compelled Air Force planners to focus on present needs.[6]

General Arnold was not the only military leader impressed by the German V-2 achievements during the war. In the flush of victory, all the services sought to build on the wartime experience by conducting rocket and guided-missile experiments based either on aerodynamic, jet-propelled "cruise" missile principles, or the German V-2 short-range liquid-propellant ballistic rocket technology. Operation Paperclip brought nearly 130 leading German rocket scientists, a vast array of data, and approximately 100 dismantled V-2s to White Sands, New Mexico. There, under Project Hermes, the Army Ordnance Division conducted upper atmospheric research into airborne telemetry, flight control, and two stage rocket capability with representatives from the Air Force, the Air Force Cambridge Research Center, the General Electric Company, the Naval Research Laboratory, and a number of scientific institutions, universities, and government agencies. From 1946 to 1951, participants received valuable data from 66 V-2s that first carried various scientific instruments then, later, primates.[7]

By early 1949 the Army, which viewed rockets as extensions of artillery, had successfully used a V-2 as the mother vehicle to launch the Jet Propulsion Laboratory's WAC Corporal second-stage rocket to an altitude of 250 miles. As Frank Malina noted, "the WAC Corporal thus became the first man-made object to enter extraterrestrial space."[8] These early V-2-based Bumper-WAC experiments set the stage for the Army's future missile and space program involving the Redstone, Jupiter, and Juno boosters developed by the von Braun team under Army supervision after it moved in 1950 from Fort Bliss, Texas, to the Redstone Arsenal at Huntsville, Alabama. Postwar naval rocket research led by the Applied Physics Laboratory of Johns Hopkins University and the Naval Research Laboratory in Washington, D.C., produced two reliable and effective sounding rockets: the fin-stabilized Aerobee, a larger version of the WAC Corporal modified for production as a sounding rocket, which achieved a height of 80 miles; and the more sophisticated Viking, which would reach an altitude of 158 miles in May 1954. A modified Viking eventually would provide the booster for the four-stage Project Vanguard, the nation's first "civilian" space program.[9]

Despite General Arnold's interest in developing long-range missiles of the V-2 type, the Air Force followed the path charted by Theodore von Kármán, which stayed within the atmosphere and the initial Air Force domain. Short-range jet-propulsion weapons seemed to offer faster development and better range and payload capabilities. They also directly complemented the strategic bomber fleet, the nation's intercontinental strike force of the day. In October 1945 the Army Air Forces solicited proposals from seventeen aircraft companies for a ten-year research and development program for pilotless aircraft, and the fiscal year 1946 budget included an impressive twenty-six different projects. Yet only two involved missiles in the 5,000 mile range, and one of these consisted of a Northrop Aircraft supersonic turbojet vehicle. The other, a supersonic ballistic rocket design from the Consolidated Vultee Aircraft Corporation (Convair), would serve as the precursor of the future Atlas ICBM.[10]

If the Army Air Forces seemed devoted to shorter-range air-breathing missiles, it could not abandon long-range missile development to the Army or Navy. All three services jealously guarded their prerogatives and jockeyed fiercely with their rivals over roles and missions in the new postwar world. As it looked to a future as an independent service, the Army Air Forces proved particularly sensitive to new, unproved weapon fields such as rockets and missiles. While General LeMay in early 1946 staked out the AAF's claim to any prospective satellite mission, he also became embroiled with Army and Navy representatives over which service should be responsible for what types of missiles. Above all, the Army Air Forces took special interest in missiles it considered strategic.

Confusion and friction about missile development and operational control first emerged during the war in the competition within and among the services. A number of Army Air Forces offices asserted their "special" interests, while attempting to ward off the Army Ordnance Command and various elements in the War Department. A directive issued by Lieutenant General Joseph T. McNarney, Deputy Chief of Staff of the Army, on 2 October 1944, attempted to clarify the situation by assigning the AAF responsibility for "all guided or homing missiles launched from the ground which depend for sustenance primarily on the lift of aerodynamic forces." Although this ruling appeared to award the Army Ordnance Department (the Army Service Force) the ballistic missile mission, the AAF, which sought primary responsibility for all missile "programs," continued to complain of Army encroachment into the aerodynamic field.[11]

Conflict persisted into the postwar era as each of the services pursued its own guided missile program while keeping a wary eye on its competitors. In a revealing memorandum in September 1946 to AAF chief General Spaatz, General LeMay expressed his concerns about the Air Force maintaining its rightful "strategic role." Admitting that the "long-range future of the AAF lies in the field of guided missiles," he cautioned that the Army's success in controlling guided missiles might embolden its leaders to seek control not only of close support but strategic aircraft as well. After all, he noted, the "stated opinion" of the Army Ground Forces is that guided missiles are extensions of artillery. LeMay saw the possibility of the Air Force losing control of a weapon system that might replace manned aircraft in the future. Yet control of the weapon did not necessarily mean that it should be developed, at least at the present time. Meanwhile, the Navy entered the contest for preeminence. Given AAF aspirations and its strategic mission, Naval leaders joined their Army counterparts in arguing that each service should have the freedom to develop missiles in response to its particular needs.

On 7 October 1946 the War Department's Assistant Secretary of War (Air), W. Stuart Symington, attempted to settle the dispute by awarding the AAF responsibility for research and development activities pertaining to all guided missiles. The directive remained silent, however, on the important question of ultimate operational assignment. The issue lay dormant until after September 1947, when the establishment of an independent Air Force reopened the competition. A year later the Defense Department achieved a modicum of peace when the Air Force relinquished its responsibility for conducting research and development work for the Army. In return, the Air Force received authority to develop strategic missiles, while the Army became responsible for tactical missiles. Meanwhile, the Air Force continued its pathbreaking ballistic missile defense studies, Projects WIZARD and THUMPER. Although the latter was cancelled in March 1948, Project WIZARD continued until early 1958, when then Secretary of Defense Neil H. McElroy reacted to persistent feuding over ballistic missile defense responsibilities by awarding the Army the mission of strategic defense and merging WIZARD with the Army's NIKE-ZEUS anti-ballistic missile system.[12]

The problem of interservice rivalry over missiles received little help from the defense committees most responsible for providing direction. With passage of the National Security Act of 1947, the Research and Development Board replaced the Joint Research and Development Board. Dr. Vannevar Bush continued as chairman until his retirement in October 1948. Neither he nor those active on subordinate committees, like the Committee on Guided Missiles, possessed the authority needed to provide the firm direction. Too often they allowed the complex committee system to work to their disadvantage and avoid decisive action.

Throughout the conflict over roles and missions, the Air Force demonstrated more interest in gaining and preserving its prerogatives than moving ahead with a strong missile research and development program. Paradoxically, as the Air Force's commitment to develop an ICBM diminished, its determination to be designated sole authority responsible for long-range missiles increased. Even with long-range cruise missiles, for which Air Force leaders sought exclusive control based on the service's strategic mission, it normally chose not to implement programs leading to operational missiles. Efforts to garner exclusive control of missiles would continue. In

September 1948, for example, the Defense Department awarded the Air Force operational control of surface-to-surface pilotless aircraft as well as strategic missiles. Two years later, in a very important March 1950 decision, the Air Force received official responsibility for developing long-range strategic missiles and short range tactical missiles. Later, near the end of the Truman administration, the Air Force successfully defeated the Army's bid to develop the Redstone rocket's range beyond 200 miles. The strategic mission would remain with the Air Force.[13]

In the late 1940s Air Force leaders signaled their attitude about research and development when forced to respond to the Truman administration's drastic economy drive that began in late 1946. Compelled to choose between supporting the forces of the present and those of the future, the Air Staff ignored the admonitions of General Arnold and Dr. von Kármán by focusing on manned aircraft to the detriment of guided missiles. As a result, Air Force research and development programs for missiles suffered drastically in the late 1940s.

Budget figures help tell the story of decline. Air Force leaders needed to show a firm commitment to research in terms of policy advocacy and budget allocation. As expressed by General Benjamin W. Chidlaw, commander of Air Materiel Command, "Many people have given lip-service to the magic phrase 'Research and Development.' Very few of us have really fought for it—and made sacrifices for it."[14] Without such a commitment, the Truman economy drive was bound to seriously erode research and development funding and projects. The fiscal year 1946 Army Air Forces budget allocated $28.8 million for research and development, with half earmarked to support the twenty-six guided missile programs sponsored in 1946. The initial fiscal year 1947 budget reflected the importance of research with a grant of $75.7 million, $29 million of which was dedicated to guided missiles research. Then the budget ax fell. Under pressure from the Defense Department, in December 1946 the Air Force cut the missile budget by $5 million and eleven missile projects. Additional funding cuts in May led planners to eliminate five more programs.[15]

Faced with drastic reductions in the guided missile program, the Air Materiel Command decided to protect those programs promising the earliest tactical operational availability, and in June 1947 General Hoyt S. Vandenberg approved the AMC recommendations. This criterion effectively eliminated the only long range guided missile project, the MX-774, and the Air Force terminated the Convair contract on 1 July. That same month the Air Staff established development priorities for managing the smaller budgets they expected in the future. The subsonic bomber and air-to-air and air-to-surface missiles received top priority. In the belief that long-range surface-to-surface missiles would be prohibitively expensive and require ten years to develop, build and launch, long-range ballistic missiles stood at fourth priority.[16]

By 1947 the pressure to downgrade the development priority of long-range missiles proved overwhelming. In the growing Cold War conflict the administration increasingly looked to strategic bombers, supported by cruise missiles, and the atomic bomb as the country's main line of retaliatory defense. Moreover, manned aircraft remained the heart of the Air Force, and advocates of a new, if potentially revolutionary, weapon and "push-button" warfare found themselves outmatched in competition for funding. Critics focused on the technological challenges of missile development. The budget slashers argued that putting scarce funds into a research program that might not be realized for a decade or possibly never could not be justified in light of current priorities. Therefore one must continue with a cautious step-by-step approach to any long-range missile program. Missile advocates found themselves victims of a circular argument: missiles seemed too challenging technologically, but no funds could be spent on solving the technological dilemmas; so the problems would go unresolved and the missile would remain "impossible." To questions about the logic of budgeting for missile programs, the answer always seemed to be the dogmatic response: "the time is not right" for an expanded program.

The Air Force's devotion to aerodynamic missiles like the intercontinental Navaho, with its combination ramjet-booster rocket propulsion, and the subsonic Snark and Matador missiles also must be seriously questioned. Planners consistently offered the rationale that aerodynamic research benefited ballistic missile research. This proved correct to a point, as shown by the transfer of the Navaho Rocketdyne engines for use in the Redstone and Atlas systems. Yet cruise missile guidance systems offered little commonality, while aerodynamic vehicles could provide no help with the ICBM's high-speed reentry from space into the upper atmosphere. Sadly, Air Force scientists never reexamined the assumptions so forcefully established in the 1945 von Kármán reports. Moreover, not one of the reports called for research and development to achieve strategic reconnaissance.[17] Although the Air Staff reassessed guided missile priorities in 1948 and 1949, it elected not to change them. Fortunately, Convair decided to use its own funds to continue the MX-774 project under imaginative Karel Bossart. Bossart's team persevered with their innovative experiments involving swiveling engines, internal fuel storage and tank design, and various means of separating the nose-cone warhead as a solution to the formidable reentry problem. All would prove important in designing the Atlas ICBM in the early 1950s. Meanwhile, in the late 1940s the outlook for the long-range guided missile project appeared bleak.

Ballistic Missiles Receive New Life

The first serious signs of a change in attitude toward research and development in general and guided missiles in particular appeared in 1949. Faced with growing criticism, General Vandenberg requested the Scientific Advisory Board to examine the state of Air Force research and development. It appointed a special committee chaired by widely respected Louis N. Ridenour. Throughout the summer of 1949 he and his committee examined research and development programs, then on 21 September submitted a highly critical report. The committee determined that "existing organizations, personnel policies, and budgetary practices do not allow the Air Force to secure the full and effective use of the scientific and technical resources of the nation." Its major recommendations included ensuring better assignment and promotion opportunities for technical officers and reorienting budget priorities because "if war is not imminent, then the Air Force of the future is far more important than the force-in-being and should, if necessary, be supported at its expense." The Ridenour Report is best remembered, however, for its organizational recommendations: the creation of a deputy chief of staff for research and development on the Air Staff, and a new major Air Force command for research and development.[18] This was von Kármán's wish, too.

Because of expected opposition within the Air Force to a "civilian" report that called for radical change, sympathetic officers like Major General Donald L. Putt, the Director of Research and Development in the office of the Deputy Chief of Staff for Materiel, helped create a parallel, senior-level military group that would undertake a review similar to the Ridenour study and thereby promote broader acceptance for its recommendations. Their efforts produced the Anderson Committee, named for its chairman, Air University's General O. A. Anderson, which conducted extensive interviews throughout the Air Force before issuing its report on 18 November 1949. The Anderson Report strongly supported the Ridenour Committee's findings, and used the effective argument that failing to implement the recommendations might easily lead the Army and Navy to "take over responsibilities abdicated by the USAF."

The powerful arguments for change convinced General Vandenberg to promptly implement the organizational recommendations. On 23 January 1950, the Air Force created the Office of the Deputy Chief of Staff, Development, and the Air Research and Development Command (ARDC) with headquarters at the Sun Building in Baltimore, Maryland. Yet it would take the "personal salesmanship" of Lieutenant General James H. ("Jimmy") Doolittle, acting as special assistant to General Vandenberg a year later in the spring of 1951, to end Air Materiel Command's foot-dragging. In late March General Vandenberg ordered the immediate transfer of AMC's Engineering Division and other designated responsibilities and functions to the new command, and reassignment of ARDC directly to Air Force headquarters rather than AMC. If the new arrangement divided responsibility for weapons acquisition between the two commands, it nevertheless served to highlight the importance of the research and development function in contrast to the heretofore production-oriented Air Materiel Command. Significantly, the Air Staff assigned the guided missiles program to the new command.[19]

While the Air Force made organizational changes in the early 1950s, events on the international scene contributed to major reassessments of the country's defensive posture. News that the Soviet Union had successfully detonated an atomic bomb in

August 1949, communism's triumph in China, and alarming reports of Soviet progress in missile development led to calls for increased military preparedness both in and outside the administration. The outbreak of the Korean War in June 1950 served to heighten the growing sense of national weakness. In the summer of 1950, for example, Under Secretary of the Air Force for Research and Development John A. McCone submitted reports on America's vulnerability to Soviet attack to Secretary of the Air Force Thomas K. Finletter, advocating a "Manhattan-type" program for missiles under the "most capable man who can be drafted." In late August 1950 President Truman responded to calls for action by appointing T. K. Keller, chairman of the Chrysler Corporation, "Director of Guided Missiles." Unfortunately, Keller approached his job as missile "czar" on a part-time basis, and focused largely on cruise-type missiles and the Army's tactical Redstone missile. Convair's low-priority Atlas ballistic missile project received little attention. Nevertheless, the McCone reports contributed to the movement for action on guided missiles.[20]

Other efforts to enhance defense proved more significant. President Truman early in 1950 authorized immediate development of the hydrogen or thermonuclear bomb, while after the outbreak of the Korean War, Congress authorized a 70-group Air Force and nearly doubled the administration's defense budget request from $14.4 to $25 billion. Armed with its new wealth, the Air Force reconsidered Convair's long-range rocket proposal. The company's presentations led to a contract in January 1951 for project MX-1593, whereby Convair would examine both the ballistic approach and the "glide" vehicles which use rocket power to reach the outer atmosphere then use their wings to glide through the atmosphere to their targets. The boost-glide approach reflected continued Air Force interest in the postwar "X"-series of high-altitude rocket-powered aircraft.[21]

Convair's six-month contract to conduct a "study and test program" for two types of missile propulsion hardly represented a ringing endorsement of the ICBM concept. Nevertheless, by late summer 1951 the Convair engineers had selected the ballistic-type rocket largely because it represented a weapon considered unstoppable for the foreseeable future, while they believed the formidable technical problems solvable by the early 1960s. ARDC, which had responsibility for the guided missiles program, agreed that the missile deserved greater support. Convincing Air Force headquarters to award it sufficient funding and project priority, however, proved next to impossible. In the fall of 1951, the Air Staff's Research and Development Directorate rejected ARDC's request for increased funding and directed a slowed-down five-year test program before considering further commitments. Convair continued to lobby Air Force headquarters in late 1951 and early 1952, while ARDC's new commander, General Putt, in a letter to his former office of Research and Development, argued that the ballistic missile project should be approved immediately because of its total "invulnerability to all presently known countermeasures and because of the relative simplicity of the entire weapons system." Putt also warned that the Soviets appeared to be pursuing development of such a weapon. In the spring of 1952 Air Force headquarters referred the ARDC request to the Guided Missiles Committee of the Defense Department's Research and Development Board. The Committee authorized only continued studies and component testing, not the complete Atlas system.[22]

Despite growing evidence to the contrary, skeptics on the Air Staff and in the Defense Department continued to view the intercontinental ballistic missile as a weapon system too complex and likely impossible ever to reach the operational stage. Much of the criticism focused on the old issue of warhead weight. Yet by 1950 the Atomic Energy Commission affirmed the existence of a sufficient number of atomic weapons small enough to be carried in guided missiles. Moreover, President Truman noted that in early 1950 his military service chiefs proceeded with elaborate plans to use the H-bomb on the assumption that the tests he had just authorized would be successful. Test results at Eniwetok in November 1952 proved the feasibility of thermonuclear technology and confirmed their optimism. Based on the test results, ARDC petitioned the Air Staff to reassess the overly restrictive weight and accuracy parameters for the Atlas. In response, a Scientific Advisory Board ad hoc committee chaired by Dr. Clark Millikan reviewed the technical issues. Although the Millikan Committee concluded that anticipated warhead yields called for reducing accuracy and guidance requirements, it saw no need to accelerate the program. Rather it recommended a "step-wise" project that would guarantee "a review of the project at appropriate intervals." A sense of urgency remained absent.[23]

At the end of the Truman presidency strategic bombers and cruise missiles represented the key elements in the nation's offensive arsenal, while the ICBM project moved painfully forward as a cautious, low-funded, phased study and test program that reflected the traditional skepticism of the Air Staff. Given the fate of ballistic missile development over the course of the Truman years, satellite proposals could be expected to garner even less support. Most decision-makers remained blissfully unaware that missile propulsion, guidance, and reentry technologies could be useful for early stages of space exploration, while the response to guided missiles suggests that such knowledge would have had little bearing on satellite developments.

The Air Force Studies Satellites

In postwar America satellite development followed a pattern similar to that of guided missiles. Initial interest faded under budget austerity, and serious government action only began to appear in the early 1950s. Although critics of ICBMs could stress their technological challenges, the German experience of World War II had demonstrated their potential military worth. Satellites, however, not only suffered from association with the "fantastic," but left many unconvinced of their military utility.

Back in 1946, while service jurisdiction over satellites remained undecided following the May meeting of the Aeronautical Board, Rand continued with its remarkable series of satellite studies. In February 1947, the "think tank" produced a second, multi-volume study that expanded on the initial 1946 report.[24] Led by James E. Lipp, head of Project Rand's Missiles Division, it provided detailed specifications for a reconnaissance satellite comprised of a three-stage rocket booster with a gross weight of 82,000 pounds, orbiting at 350 miles, and costing $82 million. Accompanying documents covering a variety of technical subjects from "Flight Mechanics of a Satellite Rocket" to "Communication and Observation Problems of a Satellite" offered contractors guidance for their own design work. The Rand analysis also identified for further development various component areas such as guidance control, orbital control, communications equipment and procedures, and reliable auxiliary power sources. Solar power and miniaturized electronic equipment had yet to be developed.

Two reference papers provided particularly insightful comments on the potential importance of reconnaissance satellites. In one, Yale astronomer Lyman Spitzer, Jr., addressed tactical satellite support of naval operations and the vulnerability of satellites to attack. Most interesting, he proposed satellites as communications relay stations and the application of astronomical telescopic principles to space reconnaissance. His work would contribute later to experiments using long-focal-length panoramic camera systems for surveillance purposes.

James Lipp's "The Time Factor in the Satellite Program" proved especially significant in light of future developments. He described the importance of satellites for scientific research, for military operations, for encouraging development of long-range rockets, and for providing the nation psychological and political benefits. Among his observations, he discussed polar orbits for recurring surveillance, geostationary orbits to compensate for the earth's rotation, and the use of television equipment and special telescopes for transmitting electro-optical images to ground stations. Several of Lipp's perceptive political and psychological assessments would prove hauntingly accurate. Noting that other nations would likely pursue satellite development, he argued that satellite feasibility had been proven, and "the decision to carry through a satellite development is a matter of timing, depending upon whether this country can afford to wait an appreciable length of time before launching definite activity."

Fully aware of the danger in waiting too long to develop satellites, he echoed the warning of David Griggs the year before by declaring: "The psychological effect of a satellite will in less dramatic fashion parallel that of the atom bomb. It will make possible an unspoken threat to every other nation that we can send a guided missile to any spot on earth." The importance of orbiting satellites outweighed the expense, he argued, and a "satellite development program should be put in motion at the earliest time."

Air Force leaders did not share James Lipp's sense of urgency. Six months passed before they requested Air Materiel Command to evaluate the Rand reports. In its late December 1947 evaluation, AMC officers offered a judgment that became commonplace in the years ahead. While they affirmed the technical feasibility of the reconnaissance satellite, they questioned both the high costs and lack of clear military utility. Constrained by "scarce funds and limited component scientific talent," the Air Force should not risk supporting a satellite development program when guided missiles deserved research funding priority. Characteristically, the Air Staff called for more studies on requirements and desired design specifications. In view of the severe missile program cuts in the fiscal year 1947 and fiscal year 1948 budgets, satellite advocates had no reason for optimism. With the only ICBM research program eliminated in July 1947, satellite studies represented the most proponents could expect and the least skeptical Air Staff planners needed to offer. Even so, during the next three years defenders of satellite utility studies needed to work hard to protect the "fantastic" elements from the budget ax.

Even though Air Force leaders proved unwilling to promote satellite development, they were not averse to campaigning for "exclusive rights in space." In January 1948, Chief of Staff Vandenberg became the first service chief to issue a policy statement on space interest when he declared that

> The USAF, as the service dealing primarily with air weapons—especially strategic—has logical responsibility for the satellite. Research and Development will be pursued as rapidly as progress in the guided missiles art justifies and requirements dictate. To this end, the program will be continually studied with a view to keeping an optimum design abreast of the art, to determine the military worth of the vehicle—considering its utility and probable cost—to insure development in critical components, if indicated, and to recommend initiation of the development phases of the project at the proper time."[25]

Although Vandenberg's statement might be faulted for its lack of clarity, clearly, once again, progress in the satellite field would depend on advances in missile technology without recognition that satellite technology might benefit the missile engineers. At the same time, funding would remain a major determinant. With sufficient money available, the Air Force, like the other services, would likely pursue a new mission to increase its share of the budget.

General Vandenberg's declaration appeared at a most opportune time for Air Force interests because Defense Department officials had decided once again to address the organizational squabble over roles and missions. Since September 1947 responsibility for satellite issues in the Defense Department belonged to the Research and Development Board's Committee on Guided Missiles. In December 1947, the latter formed a Technical Evaluation Group to assess satellite feasibility. Two months following Vandenberg's policy dictum, the Committee issued a report that verified the technical feasibility of satellites, but proceeded to assert that "neither the Navy nor the USAF has as yet established either a military or a scientific utility commensurate with the presently expected cost of a satellite vehicle." In hindsight it seems difficult to appreciate the question about military use, especially after the comprehensive, technical Rand report of 1947. At the same time, the satellite represented a "passive" weapon system that seldom elicited the interest of planners worried about supporting conventional strategic weapons. After all, they argued, what could the satellite do that aircraft could not, and at lower cost? Several years of analysis and promotion seemed to be required to establish military satellite utility. Significantly, the Committee recommended continuing with utility studies at Rand and allowing the research agency permission to consult with industry on system and component designs for a reconnaissance satellite.[26]

Satellites Receive New Life

While Air Force leaders might have been disappointed that the committee did not endorse Vandenberg's policy statement, at least the Rand studies continued to receive Defense Department funding. The Navy attempted to join the Air Force as joint sponsor of the Rand project but failed to overcome the opposition of LeMay and other Air Force leaders. By the end of 1948, the Navy had "suspended" its satellite work. The Army, meanwhile, would not reenter the satellite arena until its Redstone rocket team proposed Project Orbiter in 1954. This left the Air Force alone on the satellite field, such as it was. Based on the findings of the Technological Capabilities Committee, Rand proceeded to develop a satellite project with component analyses for "eventual construction and operation of a satellite vehicle." Rand's research and study subcontracts would be subject to AMC's approval and the availability of funds. The key question involved utility. Rand's 1947 study had shown the serious complications associated with designing a recoverable space vehicle. This drew their attention in the years ahead almost entirely to instrumented satellites rather than manned spaceships. The issue for instrumented satellites then became what equipment would be necessary and what military purposes would they serve?

Rand analysts addressed these questions in several 1949 studies, including one entitled "Utility of a Satellite Vehicle for Reconnaissance," and in a study conference in 1949 it sponsored on the military usefulness of satellites. The conference produced an unusually convincing argument for developing a reconnaissance satellite. Noting that technology did not yet permit satellites to operate as destructive weapons, conferees emphasized the passive satellite roles of communications and reconnaissance—especially as political and psychological weapons designed to alter Soviet political behavior. After establishing a list of eight basic satellite characteristics, the analysts assessed the possible functions such a satellite would likely perform. They concluded that as a surveillance instrument it could serve as a major element of political strategy. As a vehicle capable of penetrating the secrets behind the Iron Curtain, it could provide intelligence that might be used in various ways to modify Soviet actions. As the conferees concluded, "no other weapon or technique known today offers comparable promise as an instrument for influencing Soviet political behavior." The study group recommended that Rand impress the Air Force with the surveillance potential of such a satellite.[27]

This Rand study, too, produced few immediate results. As one more study, however, it helped foster growing awareness of reconnaissance satellite capabilities and helped lay the groundwork for passive surveillance applications when Rand commenced its component studies and designs in 1950 after the Air Force received authority to develop booster rockets. Advocates hoped the new concern with Soviet missile advances and the Korean War would generate increased interest in strategic satellites as it seemed to do for missiles.

In late November 1950 Rand recommended the Air Force authorize extension of Rand's research into specific areas of the reconnaissance satellite mission. With Air Force approval, Rand investigators produced two reports in April 1951: "Utility of a Satellite Vehicle for Reconnaissance" and "Inquiring into the Feasibility of Weather Reconnaissance from a Satellite Vehicle." The reconnaissance portion drew the most attention from the Air Force. Based on detailed analysis, it advocated "pioneer reconnaissance," or extensive coverage using television with a resolution of between 40 and 200 feet, in a 1,000-pound payload with a space vehicle weight of 74,000 pounds. With improvements in television technology, the researchers expected to achieve the 40-foot dimension in the near future. They hoped this would permit satellites to conduct all military reconnaissance and finally satisfy the skeptics.

The newly activated Air Research and Development Command enthusiastically supported the Rand findings and authorized Rand to recommend measures needed to begin development work in the reconnaissance program. Eventually this research would lead to the milestone Project Feed Back report of 1954. Rand began in 1951 by subcontracting key subsystems such as orbital sensing and control to North American Aviation, and optical systems, television cameras, and recording equipment to the Radio Corporation of America (RCA). In November 1951 the Air Force contracted with the Atomic Energy Commission to study small nuclear reactors as satellite power sources. By June 1952 the Commission reported encouraging results from preliminary testing, and Rand moved forward with its Feed Back research, which focused on designing and evaluating satellite components.[28]

The findings of the Air Force Beacon Hill Study reflected the state of these efforts at the close of the Truman era. In early 1952, the Air Staff authorized a study group, chaired by Eastman Kodak's Carl Overhage, and consisting of fifteen prominent reconnaissance specialists, including Polaroid's Edwin Land, Louis Ridenour, and Lieutenant Colonel Richard Leghorn, USAFR, considered by Rand one of the few "integrative" thinkers concerned with so-called pre–D-Day reconnaissance. The report called for various improvements to obtain strategic intelligence, and specified refinements to sensors lofted in high-altitude aircraft and balloons, sounding rockets, as well as long-range air-breathing missiles like the Navaho. The group also recognized the need for high-level approval for any overflight of foreign territory, an issue that would dominate political space policy debates during the Eisenhower administration. Although the Study addressed important issues, Rand officials referred to the Beacon Hill Report as "Reconnaissance without Satellites," and considered it a setback for reconnaissance satellites. Not a single Beacon Hill briefing or study addressed either weather reconnaissance or electro-optical reconnaissance, important applications Rand had been considering for years.[29]

On the eve of the Eisenhower administration, satellite advocates had cause for both hope and dismay. The Air Force-sponsored Rand studies had identified a mission, strategic reconnaissance, and produced increased technical justification for developing a military satellite. Feed Back research involving several hundred scientists and engineers seemed well underway by the end of 1952 and promised at long last to set the stage for satellite development. Renewed Air Force interest in the Convair long-range ballistic missile also indicated that large satellite booster rockets might soon be available. Yet the Rand reconnaissance proposal remained a planning project, and the ICBM program moved forward at a very leisurely pace. At the beginning of 1953, it remained to be seen how strongly the new Eisenhower regime would support both satellites and missiles.

Reviewing the course of missile and satellite development in the Truman years, clearly both satellites and missiles fell victim to skepticism about their practical, military use and to economic retrenchment that grew unabated through the 1940s. In a sense, General Arnold's retirement in March 1946 left no one of his stature in either the Air Force or the defense establishment willing to challenge national policy that favored strengthening the forces in being at the expense of future capabilities. Nor did Air Force leaders in the late 1940s question seriously the service's gradualist approach to guided missile development or the priority accorded aerodynamic, cruise missiles rather than long-range ballistic missiles. By the 1950s, however, heightened security concerns and technological change offered the prospect of breaking with the past and accelerating the satellite and missile programs.

Eisenhower Faces the Threat of Surprise Attack

President Dwight D. Eisenhower took office in January 1953 determined to implement a "New Look" defense policy that stressed strategic nuclear striking power at the expense of conventional forces.[30] In order to do this and roll back the Truman administration's Korean War budget from nearly $45 billion to $35 billion, he charged his Defense Department to end waste and duplication throughout the services. Missile and space programs could be expected to absorb their share of Defense Department cutbacks. Indeed, in early 1953 the administration expressed no particular interest in accelerating either program. Yet in the space of just four years, the regime would come to preside over a costly expansion of both military missile and satellite programs and a civilian satellite project that together represented the birth of the American space program. These events have left their mark on the nation ever since.

The rapid growth in space activities under Eisenhower, however, became lost in the wake of the Sputnik launches of October 1957. Critics contended that the administration had allowed the nation to be humiliated and endangered by failing to appreciate the political and psychological importance of being first into space and the demonstration of Soviet leadership in large operational boosters and ICBM technology. The public sensed a directionless program.

In fact, on the road to a national space policy, Eisenhower and his advisors followed a far more sophisticated, secretive, and complex path than many at the time appreciated. Early in the administration, they decided to follow what amounted to a dual space program that focused on launching a civilian scientific satellite to establish the principle of unimpeded overflight in space for the military satellites to follow. The administration had no intention of "racing" the Soviets in space affairs and gambled that the low priority and modestly funded civilian satellite venture could be completed in time for launch of the International Geophysical Year (IGY). Meanwhile, the major defense effort would be devoted to developing ICBMs for the "New Look" doctrine of "massive retaliation" as soon as possible. Given these priorities, the military reconnaissance satellite momentarily represented the odd man out in the space program.

The Eisenhower space program remains an impressive achievement, if not entirely preplanned. Early in the administration, three developments served to propel the nation to the threshold of space. One involved the President's determination to take all possible measures to forestall another "Pearl Harbor." Another concerned the technological "thermonuclear breakthrough" that solved much of the ICBM payload weight dilemma. Finally, several determined government officials risked violating bureaucratic routine to energize the decision-making process. Throughout the period, the Air Force remained divided between reform minded individuals who favored accelerated growth of missile and space programs, and more conservative officials who preferred a cautious, step-by-step approach leading to commitment well into the future. Although the reform group proved victorious, their members had to bypass traditional Air Force bureaucratic structure and procedures to achieve their goals.

Like General Arnold, World War II veteran General Eisenhower could never forget Pearl Harbor. As president, his scientific advisor, James Killian, remarked that Eisenhower remained "haunted"..."throughout his presidency" by the threat of surprise nuclear attack on the United States.[31] To avoid this horror, intelligence data on Soviet military capabilities became essential. Yet, neither news of Soviet advances in long-range bombers like the TU-4, or reports on Soviet long-range missile progress could be verified. At the same time, the development of a thermonuclear device and its testing in both the United States and the Soviet Union raised alarms about a potentially devastating surprise attack. A number of Rand studies in 1952 and 1953 heightened awareness by describing the vulnerability of strategic air bases to attack. The Rand assessments complimented the Central Intelligence Agency's (CIA) national intelligence estimates that forecasted imminent Soviet atomic weapons production and delivery capabilities.[32]

But reports remained confusing or contradictory, and the administration quickly realized that current intelligence methods could not provide meaningful data. Pre-hostilities intelligence information became increasingly essential, and all parties realized that aerial reconnaissance offered the most effective means to solve the dilemma. The near-term answer became the U-2 high-altitude reconnaissance plane, while the long-term solution would prove to be the military reconnaissance satellite. Meanwhile, the best potential satellite boosters also represented the best weapons to prevent surprise nuclear attack.

Trevor Gardner Energizes the Missile Program

While Eisenhower and his advisors worried about intelligence data, Trevor Gardner, the "technologically evangelical" Assistant Secretary of the Air Force for Research and Development, made it his mission in public life to convince the government that the nation must pursue a crash program to develop an operational Air Force ICBM or face nuclear disaster.[33] Ironically, he assumed his office with the mandate to implement the expected economy program in the Defense Department by ending waste and duplication in the Air Force missile program. Assistant Air Force Secretary Gardner was to have a profound influence on the nation's missile program, but he and his allies felt compelled to go outside established Air Force and Defense Department structures to carry out their goals.

In April 1953 Gardner called for review of all Air Force missile programs. He instinctively rebelled against ARDC's cautious approach and the Air Staff's persistent delaying tactics. Their reasoning reflected the dilemma of the self-fulfilling prophecy: missiles represented too costly an investment for an "impossible" system. But no development money meant that the problems would continue unsolved and the missile remain "impossible." Gardner, who had heard reports of the "thermonuclear breakthrough," knew that, now, accuracy and guidance performance requirements could be relaxed and the missile no longer need be considered "impossible."[34]

Fortunately, Gardner found willing allies to accelerate missile development among middle echelon ARDC and Air Staff officers, as well as the Convair group promoting Atlas. At the same time, the Joint Chiefs of Staff, as part of its military posture review for the incoming administration, called for a broad-based reexamination of the entire Defense Department missile picture. Gardner received the assignment to review the country's missile programs based on Secretary of Defense Charles Wilson's drive to eliminate waste and duplication among the services.

At this point Gardner decided to bypass the Air Force bureaucracy and appoint a full-time group of experts on whom he would rely for advice. Late in the fall of 1953 he convened the Strategic Missiles Evaluation Committee (SMEC) under the chairmanship of renowned Princeton Institute for Advanced Study mathematician and activist John von Neumann. This group, which came to be referred to as the von Neumann Committee, comprised an impressive assemblage of scientists and engineers, all of whom had been handpicked by Gardner for their "progressive" views on ICBM requirements as well as their technical brilliance. Trevor Gardner charged von Neumann's committee to determine the measures necessary to accelerate development of the Atlas missile.[35]

While von Neumann committee members deliberated, a Rand Corporation group directed by Bruno W. Augenstein neared completion of a similar study on mounting thermonuclear weapons atop ICBMs. Responding to Air Force direction to investigate aerodynamic systems, Rand analysts had produced a number of reports on missiles in the early 1950s that favored ramjets and boost-glide rockets over ballistic missiles. When nuclear weapons were made smaller, Rand concluded that ICBMs represented the optimum surprise-attack weapon, which heightened the challenge to produce pre-hostilities strategic intelligence. At the same time, an accelerated ICBM program would mean having space boosters available at lower costs. Rand evaluators worked closely with the von Neumann team, and Augenstein briefed von Neumann Committee members personally in December 1953 on his findings. To no one's surprise, the two groups reached similar conclusions in their final reports, which appeared two days apart in early February 1954. These reports would help convince President Eisenhower to convene that spring the Surprise Attack Panel or, as it was soon renamed, the Technological Capabilities Panel, chaired by James Killian.[36]

The von Neumann report confirmed the Rand analysis by calling for a drastic revision of the Atlas ICBM program in light of Soviet missile progress and newly available thermonuclear technology. Referring to the recent Operation Castle tests in the spring of 1953, von Neumann predicted the advent of thermonuclear warheads weighing only 1,500 pounds with a yield of one megaton. This meant that performance criteria for the Atlas could be reduced, making its development more feasible within the state of the art.[37]

Critical of Convair's management practices and design, which envisioned an enormous five-engine rocket to boost the earlier, heavier warhead, the committee recommended a thorough study of various alternate design approaches and the establishment of a new development-management agency in the Air Force authorized to provide overall technical direction. Committee members considered this agency more important than all the technical guidance, warhead weight, and reentry problems yet to be solved. Finally, panel members urgently recommended the project be given high priority and substantial funding. The von Neumann report would stimulate the revision necessary to develop the large boosters required for military reconnaissance satellites.[38]

Armed with the findings of the Rand and von Neumann Committee studies, Gardner set off to win support throughout the Air Force hierarchy to expedite an expanded ballistic missile development effort. After gaining approval from Chief of Staff General Nathan Twining and Secretary of the Air Force Harold Talbott, Gardner could successfully counter any disapproval from key air staff agencies and Air Research and Development Command. The traditional Air Force bureaucracy did not favor this civilian-sponsored initiative that proposed creating a separate development-management agency that would bypass established administrative channels. In the end, the Air Staff supported the Gardner-engineered initiative, perhaps because disapproval might result in appointment of a new missile "czar" completely outside the Air Force framework. If not all that the Gardner group desired, the results nevertheless proved "revolutionary." In April 1954 the Air Staff proceeded to create a new Air Force headquarters position, an Assistant Chief of Staff for Guided Missiles, with responsibility for coordinating all Air Force guided missile activities. The following month, Air Force leaders took a more significant step by directing ARDC to form a West Coast project office at Inglewood, California. Organized as the Western Development Division (WDD), the latter represented the central von Neumann committee recommendation, and Gardner insured that the new organization's chief would be his ally, Brigadier General Bernard Schriever. Shortly after the Western Development Division began functioning in August, General Schriever arranged for the Air Force to contract with the Ramo-Wooldridge Corporation as full-time technical consultant to his command. Schriever proved to be a splendid choice to head a crash ICBM program. A young disciple of Hap Arnold, whom he considered "one of the most farsighted persons" he had ever known, he had joined Trevor Gardner's reform group in early 1953 while serving on the Air Staff as Assistant for Development Planning in the office of Deputy Chief of Staff for Development. He used his intelligence, patience, and superb negotiating skills with military, government and private industry leaders to become an effective advocate for missile and space systems causes.

In order to produce an operational missile by the end of the decade, Schriever's command adopted a number of managerial innovations that would become common practice for the Air Force in future years. Help again came from the von Neumann committee, which had been reconstituted in April 1954 as the Atlas Scientific Advisory Committee. Together with Ramo-Wooldridge, the committee convinced Convair and the Air Force to design a smaller missile capable of carrying the lighter, powerful hydrogen warhead. Given the time constraints, the planners chose to develop a "light-weight" three-engine rocket with a thin metal air frame skin housing the liquid-fuel and oxidizer tanks made rigid through overpressure. The crash program called for special management techniques, too. In the summer of 1954 the ICBM committee recommended that the Western Development Division award alternate subsystem contracts, whereby each Atlas component would be "backed up" by an alternate relying on different technology. This more costly parallel development approach meshed effectively with the new "concurrent" procedures pioneered by Schriever and his staff. Under concurrency, all measures necessary to construct and deploy the system would be completed simultaneously. Still skeptical of Convair's capabilities, however, Air Force officials applied the parallel development concept on a larger scale by producing at the same time a second, more-sophisticated "back-up" ICBM, the Titan. Designers configured the new Titan as a two-stage liquid-propellant missile, with a more advanced guidance system, and rigid frame to permit underground deployment. Parallel development allowed Atlas and Titan program managers to replace subsystems in case of failure or technological breakthrough, while advanced designs could be pursued without risk to the overall ICBM program. It served as an effective risk mitigation approach that proved its worth when the Air Force launched both Atlas and Titan missiles successfully by the end of the decade.[39]

General Schriever could hardly have expected such future success when he surveyed the state of his command in the spring of 1954. Indeed, he faced a major battle within the Air Force to retain control of his project. Despite his relatively independent status under ARDC with responsibility for system planning, technical direction, and budgeting, the Air Materiel Command continued to control the major funding areas of system production and procurement. To do the job assigned, General Schriever believed he needed authority over all aspects of missile acquisition, from design, research and development, through production. The Air Staff, however, refused to compromise on this issue, and AMC maintained its production prerogative by establishing a Special Aircraft Project Office at Western Development Division to handle ICBM procurement. According to General Schriever, initial friction soon gave way to a reasonable "partnership" arrangement after the general established good rapport with the AMC officers. This far from optimum division of system management responsibilities would continue until the creation of Air Force Systems Command during the organizational reform of 1961.[40]

Managerial problems with the Air Materiel Command proved only the tip of the iceberg. Even though the Secretary of Defense had declared Atlas of "critical importance" in early 1955, the bureaucratic labyrinth at the Air Staff and the Defense Department continued to cause bottlenecks and delays because of the multiple program review levels. Once again Trevor Gardner—encouraged by General Schriever's active support—decided to bypass the Air Force bureaucracy by going directly to Congress. Meetings with Senators Clinton Anderson and Henry M. Jackson, the two most influential members of the Joint Committee on Atomic Energy, and congressional visits to Schriever's suburban Los Angeles headquarters, convinced the congressmen to support streamlined management procedures to eliminate the bureaucratic obstacles. At the same time, additional reports of new Soviet long-range bombers and missile tests picked up by radars in Turkey raised fears that the United States might be falling behind in the ICBM race.[41]

The congressmen wrote President Eisenhower in late June 1955 about their concerns and recommended immediate action on the Atlas program to avoid funding delays, overcome interference from major Air Force commands, and bypass the multiple review levels. By fall the President had designated the Atlas ICBM the "highest national priority" weapon system. Still, procedures remained unchanged, prompting Trevor Gardner again to seize the initiative by directing Hyde Gillette, Air Force Deputy for Budget and Program Management, to form a committee to devise new, more effective procedures for the missile program. In October 1955 the Gillette Committee's recommendations led to the establishment of a ballistic missiles committee at both Air Staff and Defense Department levels to function as the sole reviewing authorities for Western Development Division programs. Gone were the various separate offices that Schriever had to consult individually. Now he submitted a yearly development plan to a single committee, made up of representatives from the offices concerned with the ICBM program. Although not entirely able to overcome all Air Staff skeptics and AMC opponents, the Gillette procedures removed many bureaucratic bottlenecks, and the ICBM program moved ahead rapidly.[42]

By 1955 the momentous procedural and organizational decisions for ICBM development proved to have a major impact on the military space "program" as well. Gardner and Schriever, given their focus on missile requirements, could not be expected to devote their energies to lower-priority satellite activities. In fact, they viewed the military satellite space program as a competitor for personnel, funds, and contractors. Nevertheless, the relationship between satellites and missiles had become better understood as rockets with sufficient thrust soon would be available to launch the heavier satellites preferred by the Air Force. If the Western Development Division were to gain responsibility for the Air Forces' advanced reconnaissance satellite project, advocates hoped that the Gillette procedures would benefit satellite development as they promised to do for the ICBM.[43]

The Air Force Commits to the First Military Satellite

While Secretary Gardner and General Schriever worked on missile issues in the spring of 1954, the military satellite project also cleared major hurdles. Now, with ICBMs representing a practical option, Rand's studies on satellite systems received new life, as the Eisenhower administration sought solutions to the intelligence dilemma of providing accurate data on Soviet offensive capabilities.

Rand studies had proceeded on the assumption that the Atlas ICBM would provide the space booster required to launch a reconnaissance satellite. Rand also assumed that spaced-based sensing systems offered the best means of quickly relaying important intelligence data to ground stations. By the spring of 1953, Rand satellite studies of the previous two years—now referred to as Project Feed Back—began to draw a wider audience in view of new high-level interest in Soviet missile advances. Promising results from Atomic Energy Commission tests on nuclear power for satellites encouraged the Air Force in May to direct further study of the matter and to have ARDC begin "active direction" of the reconnaissance satellite program advanced by Feed Back. In the fall of 1953 Rand officials discussed satellite issues with a number of important government officials and military officers and, based on realistic near-term operational feasibility, recommended the Air Force issue a design contract within a year leading to full system development. By year's end ARDC had published a management "Satellite Component Study," and assigned it weapon system [WS] number 117L. Project Feed Back would place the satellite on the sure path of development.[44]

Authored by analysts James E. Lipp and Robert M. Salter, Jr., Rand's Feed Back report appeared in March 1954 in the midst of deliberations about the optimum ICBM organization.[45] It drew together findings from the previous two years' intense study of reconnaissance satellites. The "milestone" Feed Back study proposed an electro-optical reconnaissance satellite with a television-type imaging system projected to achieve a resolution of 144 feet from an altitude of 300 miles. The report readily admitted that this resolution could not deliver the accurate intelligence required and encouraged the Air Force to foster a competition among industrial firms to develop a higher resolution system based on long-focal-length, panoramic camera technology. It also discussed newly analyzed operational issues dealing with subsystems, cost projections, likely international political reactions, and a host of additional engineering requirements. With this "blueprint" in hand, Rand encouraged the Air Force to proceed on a full-scale basis with this "vital strategic interest" by implementing a seven-year development program budgeted between $165 and $330 million. In the next few years, while Air Force scientists and project officers worked to develop techniques for safe reentry of space payloads through the atmosphere, Rand engineers would stress two types of non-recoverable reconnaissance systems: one relied on television technology and "immediate" data transmission to ground stations; the other used tape storage of sensed data that would be transmitted at a later time.

After some initial hesitation, the Air Force agreed to pursue the Feed Back recommendations further, and in May 1954 directed Air Research and Development Command to review the military applications of the Rand satellite concept. Meanwhile, Rand and ARDC met with various Air Force, Defense Department, and industry leaders to "sell" the Rand proposal. At the same time ARDC proceeded with analyses of intelligence processing options, solar-electrical energy converters, auxiliary power sources, and guidance and control mechanisms. Following approval from the Defense Department's Coordinating Committee on Guided Missiles, the command issued a system requirement on 27 November 1954. With this decision, the Air Force in late 1954 clearly signaled its intention to develop an operational reconnaissance satellite system.[46]

The command followed up in March 1955 with a formal General Operational Requirement.[47] Now referring to the WS-117L reconnaissance satellite as the Advanced Reconnaissance System (ARS), the requirement prescribed continuous surveillance of "preselected" areas, especially aircraft runways and missile launching sites. In contrast to the Rand study's target resolution parameters, specifications now called for providing visual coverage of objects no larger than 20 feet on a side, and specified electronic and weather coverage capability, too. With an eye to continued technological advances, the scheduled operational date of 1965 seemed achievable. By August, ARDC had named as system project officer Colonel William G. King, Jr. In November he awarded $500,000 contracts to three firms—the Radio Corporation of America, Lockheed, and Glenn L. Martin—for a one-year satellite design competition under the code name "Pied Piper."[48]

Although by late 1955 space advocates might rejoice that at long last a military satellite program seemed underway, a number of long-standing, troublesome issues remained to be solved. One of the most important involved potential competition between satellites and missiles for scarce resources. Trevor Gardner resolved to insure that the Atlas ICBM schedule would not be compromised by satellite requirements. Back in November 1954, he had taken his worries to von Neumann's ICBM Scientific Advisory Group. The members asked General Schriever to assess the challenge of developing simultaneously satellites, Intermediate-Range Ballistic Missiles (IRBMs), and the "high priority" ICBM programs. Meanwhile, in January 1955 von Neumann's group, in an attempt to ease pressure on the ICBM program and accelerate satellite development, recommended that satellite work be confined to the spacecraft and its likely components rather than include booster elements, too. ARDC commander General Thomas S. Power agreed that satellite development not involve booster integration for the present. Nevertheless, the ICBM Scientific Advisory Group continued to worry about potential satellite competition with the ICBM schedule and addressed the issue again in June 1955. It cautioned that conflict could not be avoided because of satellite dependence on components developed through the ICBM program.[49]

General Schriever's analysis of the missile program convinced him that only centralized management of all military satellite and missile programs could minimize the problem of competition for scarce resources and avoid schedule delays. During his investigation, Schriever relied on the advice of Simon Ramo of Ramo-Wooldridge, the Western Development Division's technical consulting firm. Dr. Ramo met with von Neumann's Scientific Advisory Group and the Air Staff's Lieutenant General Donald Putt, Deputy Chief of Staff for Development to warn that the satellite program competed with the ICBM program for the same personnel and launch capabilities. Ramo strongly advised relocating management of the satellite program from the Wright Development Center at Wright-Patterson Air Force Base in Ohio to Schriever's Inglewood, California, complex.[50]

By the fall of 1955, with work on the satellite underway at the Western Development Division, General Power agreed to the management transfer, although not until February 1956 would the actual move begin from Wright-Patterson Air Force Base to the suburban Los Angeles facility. That the reassignment took nearly a year and a half to complete from the time Trevor Gardner raised the alarm suggests the reluctance of those concerned. General Schriever, in particular, would have preferred to focus on the ICBM program and not deal with IRBM and satellite competitors, while ARDC understandably preferred to keep the development program at its primary research facility in Ohio. In the long run, centralized management under the Western Development Division seemed the best alternative. At least Schriever's team could provide better management of risk and program scheduling with its "concurrency" approach to systems development and streamlined administrative procedures with higher headquarters. At the same time, satellite development could be expected to benefit from transfer out from under a research facility largely devoted to aeronautics to a "space"-oriented command located in the heart of the missile and satellite environment.

During the course of their deliberations on the ICBM program, Air Force planners and consultants had ample justification for concern over the attention their program would receive from the administration. Not only did they face the challenge of managing their burgeoning satellite and missile programs with limited resources, a new competitor for funds and development priority emerged in the summer of 1955. For over a year, the government had been considering sponsoring a scientific earth satellite to be launched during the International Geophysical Year (IGY), which was scheduled to extend from July 1957 to December 1958. Trevor Gardner and his fellow Air Force advisors kept a wary eye on these discussions of proceeding with an additional satellite program, which certainly contributed to their own concerns about satellite-missile relationships. In July 1955, once the administration formally agreed to sponsor a civilian satellite development program, this potentially high-profile competitor threatened to interfere with Air Force efforts to focus sufficient Defense Department attention and funding on both ICBMs and the Advanced Reconnaissance System.

The Administration Commits to the First Civilian Satellite

The decision to support a civilian satellite program reflected a genuine interest in promoting science, strong advocacy from certain elements in the scientific community, and the administration's national security concerns—especially the challenge of eliminating the possibility of a surprise nuclear attack on the nation. For most of Eisenhower's advisors, the civilian scientific satellite never represented solely an altruistic, international scientific venture.

By early 1954 Eisenhower expressed grave concerns about inadequate intelligence to the National Security Council (NSC). The President also followed with great interest the work on the country's strategic missile program undertaken by Trevor Gardner and the civilian scientists serving on the Scientific Advisory Committee in the While House Office of Defense Mobilization. In late March he called to the White House a number of prominent scientists, including committee chairman Lee A. DuBridge, president of Cal Tech, and requested their help on the problem of surprise attack. They responded in August by establishing a Technological Capabilities Panel (TCP), chaired by James Killian, president of the Massachusetts Institute of Technology (MIT). After five months of deliberations, in February 1955 it issued a momentous report titled, "Meeting the Threat of Surprise Attack."[51]

The Killian Panel projected changes in the relative posture of American and Soviet strategic forces. Confirming the vital need for pre-hostilities strategic intelligence on Soviet military capabilities, the panel supported development of the Lockheed U-2 high-altitude reconnaissance plane, the solid-fueled Polaris sea-launched ballistic missile, and more rapid construction of the Distant Early Warning (DEW) line across northern Canada. The report advocated an accelerated ICBM program, and rapid development of IRBMs as a stopgap security measure until the ICBM force became operational. The President in September 1955 endorsed their findings together with those of von Neumann's Strategic Missiles Evaluation Committee and assigned to the Atlas and Thor and Jupiter programs the highest possible priority. To the initial consternation of Gardner and Schriever, in December President Eisenhower declared the IRBM programs to be coequal with the ICBM.[52]

As for satellites, the Killian report responded to the growing satellite interest in the scientific community and the panel's strategic intelligence concerns by recommending immediate development of a small scientific satellite that would establish the precedent of "freedom of space" for military satellites to follow. Although government officials and Rand analysts had worried about satellite overflight in international law earlier, here, for the first time, advocates identified the requirement for a "civilian" satellite to establish the overflight precedent. Focused on Project Aquatone, the U-2 project that promised immediate results, the military satellite program received little interest or support from Killian and his experts. At that time, he considered the Air Force's reconnaissance satellite a "peripheral project." This attitude from one so influential helps explain the less than enthusiastic administration support of the Air Force's Advanced Reconnaissance Satellite in the two years preceding Sputnik. Despite the growing need for strategic intelligence and awareness that the U-2 represented a temporary solution, Killian declined to actively support the military satellite until after the launch of the first Sputnik. He believed an American scientific satellite had to precede the launch of a military vehicle to provide the overflight precedent for military satellites to operate with minimum international criticism.[53]

That spring of 1955 Eisenhower and his advisors acted further on the Panel's satellite and overflight recommendations by outlining a policy for outer space analogous to that of the high seas, whereby flight in space would be available to all without legal restriction. At the same time, the President attempted to redefine the legal regime already established for airspace when, on 21 July 1955 at the Geneva summit conference, he called on the Soviet leaders to join him in providing "facilities for aerial photography to the other country" and mutually monitored reconnaissance overflights. Although the Soviets rejected his offer, he continued to advocate his "Open Skies" doctrine, while moving forward to assure the nation of sufficient intelligence to avert surprise attack. The emerging Eisenhower policy on space seemed to accord nicely with the scientists' proposal for launching an experimental scientific satellite during the International Geophysical Year.[54]

Interest in experimental satellite research originated from several sources. Although the satellite studies done by the Navy in 1945 and Rand in 1946 focused more on scientific than military characteristics, only in 1948 did the larger scientific community become aware of this research when portions of the Rand analyses appeared in the so-called "Grimminger Report" in the October issue of the *Journal of Applied Physics*. The report generated widespread interest among various small national rocket societies as well as upper atmosphere research scientists who increasingly worried about continuing their work once the wartime stock of captured V-2 rockets had been used. Another interested group involved space enthusiasts who found a wider audience at proceedings like the Second Congress of the International Astronautical Federation and the First Symposium on Space Flight held in the fall of 1951. By the early 1950s a number of activists offered specific satellite proposals, too. Dr. Fred Singer, University of Maryland physicist, and members of the British Interplanetary Society, for example, proposed the launching of a "Mouse" (Minimum Orbital Unmanned Satellite, Earth) which attracted attention on both sides of the Atlantic. More important for subsequent developments, Wernher von Braun, the chief of the Army's Guided Missile Development Division at the Redstone Arsenal in Huntsville, Alabama, had mounted a campaign in and outside military circles for an experimental satellite using the Army's Redstone rocket as a first-stage booster. He also offered visions of a manned future space station in a series of articles in *Collier's* magazine, which attracted considerable attention. Eventually, interest in von Braun's proposals led the military services to offer their own satellite projects for the International Geophysical Year.[55]

Growing support for launching a scientific satellite led a group of prominent scientists in 1954 to discuss the idea with leading government and congressional leaders. In August of that year, Congress authorized IGY participation by the United States and proposed $10 million to support the American satellite entry. In early 1955, the various scientific satellite proposals arrived at the office of the Assistant Secretary of Defense for Research and Development, Donald Quarles. These included a formal proposal from the United States National Committee for the IGY, appointed by the National Academy of Sciences, along with the Air Force's WS-117L program and the Army's Project Orbiter. Quarles referred all the IGY proposals to his Advisory Group on Special Capabilities for review and recommendations. In early May, the director of the U-2 project, Richard M. Bissell, Jr., met with the director of the Central Intelligence Agency, Alan Dulles, and the director of the National Science Foundation, Alan Waterman, to decide how the scientific satellite initiative could best meet the Killian Report's "freedom of space" objective. Acting on their advice, on 20 May Quarles submitted a draft space policy to the National Security Council for review. The decisions reached at the NSC's 26 May 1955 meeting, issued in the form of NSC Directive 5520, rank among the most important of the early Eisenhower presidency for space policy. Affirming Quarles' recommendations, the NSC declared that an IGY satellite must not interfere with the "high priority" ICBM and IRBM programs then underway, and that the satellite launched for "peaceful purposes" should help establish the "freedom of space" principle and the corresponding right of unimpeded overflight in outer space. The NSC also agreed that the scientific satellites would serve as precursors of later, military satellites. Finally, the NSC showed itself fully aware of the prestige and psychological benefits likely to accrue to the first nation to launch a satellite into orbit. As Nelson Rockefeller, Eisenhower's Special Assistant for Foreign Affairs, noted in a forceful appendix to the directive, "The stake of prestige that is involved makes this a race that we cannot afford to lose."[56]

During the post-Sputnik hysteria, in late 1957, the administration publicly attempted to distinguish between its so-called peaceful satellite project and that of the military-oriented Soviet counterpart by emphasizing the separation of the civilian scientific satellite project from the country's long-range missile program. Yet, the deliberations of the National Security Council clearly show that separation of the satellite and missile program hardly occurred as part of an internationalist, altruistic policy of promoting "pure science." The administration's declaratory policy of "peaceful purposes" purposely obscured its real intentions. When the President publicly announced on 29 July America's participation in the International Geophysical Year effort, he pledged that this scientific venture would remain unconnected to the current military missile development programs. The National Science Foundation would direct the project, with the National Committee for the IGY responsible for the satellite. The Defense Department would furnish the rocket booster and provide logistic and technical support. He gave no hint of the underlying purpose of his emerging space policy for the civilian and military satellite projects then underway. The civilian satellite would serve as a stalking horse to establish the precedent of "freedom of space" for the military satellite, but the administration maintained great secrecy on the latter so that attention would remain focused on the former.[57]

In late 1954, Congressional approval of funding for the IGY project had opened the way for von Braun and others to submit competing satellite proposals. The Defense Department favored a joint service-IGY effort to avoid interservice rivalry, but only the Army's Ordnance Department and the Office of Naval Research could agree to cooperate. Led by the Redstone team of Major General John B. Medaris and von Braun, Project Orbiter envisioned launching a small inert satellite "slug" using a Jupiter IRBM booster with three Loki upper-stage solid-fueled rockets. While the Army developed the booster , the Navy assumed responsibility for satellite, tracking facilities, and data analysis. The Project Orbiter team had vigorously lobbied the Defense Department for their project since early 1955. The Naval Research Laboratory, on the other hand, countered in late spring with Project Vanguard, which specified adapting a Viking sounding rocket as booster for three new upper stages. The Vanguard project included an impressive Minitrack radio-tracking and telemetry system, which would support the scientific focus of the IGY proposal.[58]

The Air Force initially had declined to participate in the IGY competition because it might conflict with its long-range goal of developing heavier, military reconnaissance satellites. However, after Quarles had directed all three services to offer proposals, the Air Force in July submitted its own "World Series" project—an Atlas C booster and a modified Aerobee-Hi space probe rocket. Faced with the dilemma of selecting from among the three rival entries, Quarles appointed an Advisory Group on Special Capabilities in May 1955 under the chairmanship of Homer J. Stewart of JPL. Following a contentious assessment process, the Stewart Committee ultimately selected the Navy's Vanguard proposal, and the Secretary of Defense confirmed this decision on 9 September 1955, just over a month after the White House publicly committed the nation to launching a satellite during the IGY. Although the Air Force entry showed great promise, committee members realized use of the Atlas as booster could conflict with the ICBM schedule. The Army cried foul, claiming that the Vanguard selection represented a major development effort, while von Braun asserted that his Redstone rocket team could launch an 18-pound payload as soon as January 1957, and well under the Vanguard's budget.[59]

Critics of the Vanguard decision argued that the Committee's concern that its choice not "materially delay other major Defense programs" tilted the balance against Project Orbiter.[60] Perhaps so, but the selection issue proved more complex. While the criterion served to rule out the Air Force Atlas ICBM booster, Orbiter's Redstone did not cause similar consternation. Chrysler Corporation was about to begin production of the missile, and the Huntsville group did not receive the Jupiter IRBM assignment until well after the end of the IGY satellite selection process. Von Braun's Redstone team was available. In fact, the non-interference criterion ranked only sixth among nine criteria used by the Stewart Committee. The Committee clearly questioned Orbiter's reliability and its limited potential for future scientific space exploration, and found attractive Vanguard's "maximum scientific utility" and superior tracking system and satellite instrumentation. Rather than merely a question of selecting a "non-military" Navy system over a "military" Army one, the choice reflected efforts to combine the best scientific applications with a launch system that could not avoid military connections in any case.[61]

By the fall of 1955 the administration was supporting two satellite programs, WS-117L and the civilian Project Vanguard. Nevertheless, the Air Force's experience following the decision suggests that the door remained open for a possible military-oriented alternative regardless of the desire to maintain a civilian focus. Problems experienced by Project Vanguard most likely account for the Defense Department's extended review of an alternative Air Force proposal for a scientific satellite.

The Air Force Reconsiders a "Civilian" Satellite

For well over a year following the Vanguard award, the Air Force became involved with alternative "civilian" satellite proposals while challenged to develop an operational military satellite. The process reveals ambivalent attitudes about accepting a civilian project that threatened to compete for resources not only with the military satellite but the ICBM program as well. Throughout the course of events, Air Force planners seem to have operated without full knowledge of the ground rules, that had effectively eliminated a "military" project from the start, and the degree of seriousness the Defense Department attached to their proposals.[62]

From the start of their involvement in the IGY competition, Air Force planners worried that any Air Force scientific satellite that used an Atlas could interfere directly with the Atlas weapon ICBM schedule, while the competition's ground rules did not seem to exclude military criteria. Although ARDC might have thought the subject closed when the Stewart Committee selected Vanguard in August 1955, on 31 August Air Force headquarters directed ARDC to prepare another proposal that would integrate a scientific satellite with the WS-117L military reconnaissance satellite program. Then, on 14 October, with the new proposal still unfinished, ARDC halted that work, explaining it lacked sufficient funding and, in any case, the decision had been made in Vanguard's favor. In another reversal, the command resumed planning for a scientific satellite on 1 November, and the Western Development Division on 14 January 1956 submitted a scientific satellite variant of WS-117L, a 3500-pound satellite made from ARS components that could be launched by August 1958 atop an Atlas C at a cost of $95.5 million. General Schriever's proposal also specified a number of scientific experiments dealing with atmospheric density, solar radiation, and the upper atmosphere-near space effects on communications. The Schriever proposal reflected a consistent Air Force view that any satellite should serve a specific scientific or military purpose rather than merely serve as a public demonstration of the capability of launching a satellite into orbit.[63]

Most importantly, General Schriever advised that the scientific satellite could be developed without "significant compromise" to the military satellite program—

provided the operation be accorded sufficient funding, personnel, and resolve. He also established criteria to preclude interference with the ICBM program, but warned that any small delay in the Atlas schedule might mean a satellite launch beyond the IGY "window of opportunity." The general's caveats notwithstanding, ARDC forwarded the proposal to the Air Staff in January 1956. After a number of briefings on the subject, the proposal languished at Air Force headquarters in Washington throughout the remainder of 1956. Then, in early 1957, the Air Force notified General Schriever that the Defense Department had decided not to submit it to the Stewart Committee, which continued to oversee Project Vanguard. Evidently, by 1957 the Committee had decided to forego the luxury of a "back-up" satellite for Vanguard.[64]

General Schriever always maintained that his command could have handled development of both missiles and satellites. Yet the Western Development Division, which was redesignated the Air Force Ballistic Missile Division on 1 June 1957, would have required considerable additional resources from a parsimonious Defense Department to support three major long-range missile programs as well as two satellite projects. As for the civilian satellite planning effort during late 1955 and throughout 1956, Schriever and his staff affirmed that it did not significantly interfere with planning or funding for the military satellite. Once again, the so-called "non-military" criterion for an IGY satellite did not seem important enough to rule out lengthy consideration of the most "military" of satellite proposals. If concern for possible delays in the sensitive Atlas ICBM program again proved decisive, the story of the Air Force scientific satellite proposal also suggests that Air Force leaders felt compelled to remain involved in a potential program of questionable value. In view of the Air Force's aspirations to dominate the space mission, it could not remain uninvolved.[65]

Retrenchment on the Eve of Sputnik

While some Air Force planners labored on proposals for a civilian variant of the WS-117L reconnaissance satellite, work continued on the technical requirements for the military satellite. Following the program's transfer to the Western Development Division in early 1956, General Schriever appointed as project officer Colonel Otto J. Glasser, who directed preparation of a full-scale system development plan based on the winning design entry submitted from the three "Pied Piper" firms. By April the plan had been completed and approved by General Schriever and ARDC commander General Power. In June 1956, the Air Force selected the design from Lockheed's Missile Systems Division and awarded the firm a formal contract in October. The Lockheed choice surprised no one because the company had hired the majority of existing space research specialists, including former Rand analyst James Lipp.[66] Relying on the Atlas C booster, Lockheed proposed building a huge second-stage booster satellite, initially termed Hustler, that could provide high pointing accuracy from its stabilized orbit position. Eventually, this booster satellite would become the workhorse "Agena" that, together with its Atlas booster, would launch the heavier Air Force payloads. Lockheed's winning payload entry also included a unique feature proposed by engineer Joseph J. Knopow for an infrared radiometer and telescope capable of detecting missiles and aircraft from their hot exhaust "signatures." Offering the potential for "real time" data, the infrared system element of the Advanced Reconnaissance System would emerge as a separate missile launch detection alarm system (MIDAS) satellite project designed to provide early warning of missile launches. The Air Force plan predicted an initial orbit date of May 1959, with the complete system, including ground installations, expected to be operational in the summer of 1963.[67]

The advance of technology in 1956 and 1957 served to emphasize the Lockheed proposal's merits. Research on wider and slower reentry vehicles with ablative surfaces offered a solution to the old problem of aerodynamic heating when objects reenter the atmosphere and fostered renewed interest in retrievable reconnaissance systems. Recoverable film containers held the prospect of avoiding image degradation that might occur through TV sensing and transmission through the atmosphere. At the same time, current experiments with panoramic cameras with long-focal-length lenses offered both broad-area coverage and high ground resolution.[68]

Research in new technology promised to be costly, and funding for WS-117L had been a sensitive subject from the start. From General Schriever's perspective, the Advanced Reconnaissance System suffered from guilt by association with the troubled Vanguard project. Although neither satellite program received adequate support, Vanguard's priority status brought it the lion's share of satellite monies. When the civilian satellite experienced management and budgeting problems, the military reconnaissance satellite also encountered difficulties receiving the attention and funding its supporters believed it deserved.

The scientists themselves were largely to blame for Vanguard's problems. Their interest in maximizing the scientific output not only led to additional costly instrumented experiments which Eisenhower criticized as "gold plating," but served to make secondary the essential requirement to establish basic vehicle technology before adding sophisticated payload experiments. The scientists also wanted to increase the number of test launches from six to twelve, which drove up costs and contributed to schedule delays that poor management practices only exacerbated.[69]

In fact, Vanguard had been underfunded from the beginning. Even before the Stewart Committee selected Vanguard, Secretary Quarles indicated his skepticism about the initial Vanguard budget figure of $10 million by raising the satellite budget to $20 million. Even so, the Vanguard budget rose continually from an initial $28.8 million in September 1955 to $110 million by May 1957. Had the Vanguard team payed attention to the early Rand studies, they might have developed a more realistic budget. Nine years earlier, James Lipp proposed a similar satellite at a cost of between $50 million and $150 million, depending on the payload. More attention paid to the Rand reports would also have alerted the scientists to the importance of international prestige associated with the country first into space. Instead, the scientists focused on costly experiments that played havoc with the development schedule. As for the experiments, Vanguard scientists did not clarify for President Eisenhower the important contributions their satellite work offered for ICBM development. Had the scientists done so, they might have been able to convince the administration to elevate satellite priorities in the name of missile progress. Ike, after all, listened to "his" scientists. A higher priority for Project Vanguard might correspondingly have benefited the military satellite and ICBM programs.[70]

Without strong intervention from the scientists, Project Vanguard's managers proved unable to stifle the concerns of an administration that was becoming increasingly exasperated with the spiraling costs. What made matters worse, the administration faced a larger problem brought on by the enormous costs and excessive duplication associated with building two ICBMs and three IRBMs simultaneously. With all five missiles in development in fiscal years 1957 and 1958, the budget for guided missiles reached more than $1.3 billion, an enormous increase from $515 million in fiscal year 1956, $161 million in fiscal year 1955, and only $14 million in fiscal year 1954. In 1957 Eisenhower feared that the spiraling missile costs would force defense spending beyond his fiscal year 1958 ceiling of $38 billion and directed a budget review of all programs. By August Secretary of Defense Wilson had cut the research and development budget by $170 million, reduced overtime work in the Atlas program, accorded Titan a lower priority than Atlas, cut spending on the Navy's Polaris project, and called a temporary halt to Jupiter and Thor production.[71]

The WS-117L satellite program did not prove immune to the budget slasher. Air Force satellite program officers had hoped to obtain $39.1 million of the estimated $114.7 research and development budget for use in fiscal year 1957. In August 1956, however, ARDC received only $3 million to launch the project. On 17 November 1956, General Putt briefed Donald Quarles on the newly approved WS-117L program. If he expected to obtain additional funding from the Secretary, he was disappointed. Secretary Quarles directed the Air Staff's research and development chief to ensure that the Air Force halt its military construction schedule and produce no fabrication mock-up or initial satellite without his express permission.[72] General Schriever felt compelled to vigorously lobby the Air Staff and the Defense Department for an additional $10 million:

> I can recall pounding the halls of the Pentagon in 1957, [he said later,] trying to get $10 million approved for our [USAF] space program. We finally got the $10 million, but it was spelled out that it would be just for component development. No system whatever.[73]

Even so, in July 1957 Secretary Quarles applied additional spending limits to the WS-117L as part of the Defense Department-wide budget slashing exercise that summer. This came after he had received intelligence information that spring predicting that the Soviets would be capable of launching a satellite before the end of the year. Quarles' actions should be viewed in terms of the administration's agenda for military satellites and space operations. The previous year, administration spokesmen had declared that no government officials were to speak publicly about spaceflight. General Schriever found to his dismay that the administration meant business after a February 1957 speech he gave in San Diego, California. Discussing the importance of studying potential military offensive functions in space, he declared the time ripe for the Air Force to "move forward rapidly into space." The following day Secretary of Defense Wilson instructed him to avoid the word "space" in all future speeches.[74]

The administration remained determined that the military satellite would under no circumstances precede the civilian satellite into space. It also opposed any discussion of military space operations that might generate a worldwide debate on the "freedom of space" for military spaceflight. This issue had to be avoided to maintain the declaratory policy of "peaceful purposes" as well as the action policy of having Vanguard provide the precedent for military space operations. As a result, before Sputnik the country supported two modestly funded space programs that did not interfere with ICBMs or other high-technology programs. Neither received the support its advocates sought. Yet neither permanently suffered from the 1957 budget cuts, which proved little more than an embarrassment after the launching of Sputnik on 4 October brought massive increases for satellite and missile programs. Although not of the administration's choosing, *Sputnik I* established the precedent, freedom of space, and underscored the administration's basic space policy.

Retrospective From the Threshold of Space

On the eve of the Sputnik flights, the Air Force and the nation finally had reached the threshold of space—a full decade after the intrepid Rand analysts first offered the Air Force the prospect of launching an observation earth satellite in five years' time. During the course of the decade Rand produced increasingly convincing analyses of solutions to technical problems, potential military functions, and the important political benefits and prestige that would accrue to the United States. Armed with the Rand studies, Air Force satellite champions repeatedly worked to convince their leaders and the Defense Department and administration officials of the wisdom of their cause. What they confronted, however, proved to be a decade-long pattern of disinterest, inaction, and dogmatic unwillingness to accept change. As a result, the Soviets became the first to launch an orbiting satellite.

President Eisenhower has received considerable criticism for allowing the country to be humiliated and its national security endangered. Yet, if the Eisenhower administration failed to launch the first satellite, Sputnik nonetheless established emerging United States space policy. With unimpeded overflight assured, a clandestine military space program could proceed apace with less scrutiny by domestic and international critics. Civilian spacecraft had set the precedent for the military satellites to follow—even if the pathbreaker proved to be Sputnik and not Vanguard. The failure of the administration's actions lies not in overlooking the importance of prestige, but in assuming that Vanguard, with all its problems, still would be first. Determined that the civilian scientific satellite would take precedence, administration officials remained unwilling to provide the WS-117L program the commitment its supporters desired and expected. Yet the real delay in the reconnaissance satellite program occurred during the Truman years, when the Russians began a serious program and the United States did not. The Soviets had an eight-year start by 1954, when Project Feed Back set the satellite on the sure path to development.

During the Truman era, satellite proposals continually fell victim to the logic of "realism" and higher priorities. The administration argued that national security in the postwar world could be best achieved by strengthening the forces in being, namely strategic bombers and subsonic cruise missiles. Budget austerity after 1946 meant that research programs for forces of the future suffered most. Problematical programs like missiles and satellites faced the severest cuts. The administration's argument received strong support from the scientific community. Experts like Dr. Vannevar Bush dismissed missiles as "fanciful" because they would require a decade of incredible expense to overcome technical problems of guidance, propulsion, and reentry. Bush was far from alone in his pessimism. After all, it would have taken a particularly insightful individual to foresee the incredible advances over the course of the pre-Sputnik decade in chemical fuels, rocket engine combustion technology, instrumentation, and missile frame construction.[75] Postwar America offered too few men of vision like Hap Arnold and Theodore von Kármán in positions of authority. And for all his achievements, von Kármán led the Air Force down the lesser, aerodynamic path of development.

Von Kármán's tenure as chief of the postwar Scientific Advisory Board suggests that Arnold, had he continued to lead the postwar Air Force, would have achieved only modest success against the forces of institutional inertia and intransigence. The newly independent Air Force benefited most from the Truman defense strategy. While General LeMay and others might admit that intercontinental ballistic missiles represented the strategic force of the future, the logic of the present seemed to favor the forces that could best ensure the survival of an independent Air Force and the security of the nation. When those forces happened to be manned aircraft and missiles supporting those aircraft, long-range guided missiles understandably became relegated to the distant future. Satellites suffered a similar fate. Satellites and missiles represented "new" and potentially "revolutionary" change for a service that traditionally viewed itself in terms of the airplane. Even in the early 1950s, when it became clear that technology had made ballistic missiles more feasible and Soviet actions precipitated a major budget increase for research and development, Air Force decision-makers persisted in resisting the acceleration of satellite and missile projects.

On the other hand, the Air Force remained ever vigilant in protecting its authority over satellite and missile development. If it neglected its space programs, it nevertheless kept a wary eye on Army and Naval efforts to weaken the Air Force's claim to exclusive rights to these programs. The fierce contest for control of roles and missions proved to be a running theme throughout the pre-Sputnik decade, and clearly prevented faster progress. While the service squabble centered largely on missiles, on the eve of Sputnik the Air Force faced a competitor for its embryonic satellite program in the guise of Project Vanguard. Although Eisenhower's dual space program remained unclear to many in the mid-1950s, the "civilian" Vanguard satellite represented a future challenge for the Air Force in terms of civil-military roles and missions.

On the eve of Sputnik, the observer of early space events might be tempted to view the previous decade pessimistically as one of frustration and delay. The Air Force experience, however, also suggests a much more positive assessment. Many central characteristics of the future Air Force space mission emerged during the "dawn of the space age." For one, the Air Force made a strong bid for the preeminent military role in space matters, and by 1957 had carved out a relatively strong position with its Atlas and military satellite program. The emphasis on demonstrating military satellite utility served to intensify efforts to define and justify satellite operations in terms of providing better data more effectively than competing systems.

As for research and development, the Arnold and von Kármán legacy appeared far more secure after the downswing in the late 1940s. Reorganization provided research a greater focus, while General Schriever's command arrangements demonstrated impressive flexibility and effective improvisation. To be sure, it took activists like Trevor Gardner and his band of reformers working "outside" the system to facilitate change. Yet, in a sense, the Air Force established a tradition of going outside—to industry, scientists, research laboratories—that von Kármán's *Toward New Horizons* recognized and supported.

Considering both the failures and the achievements, the pre-Sputnik decade is best viewed as the conceptual period of the "New Ocean," during which the new ideas of space had to be tested and inertia and opposition overcome. After all, only a generation separated the upper-atmosphere explorers of the NACA and the early rocketeers from the Atlas and WS-117L teams on the eve of Sputnik. Few are blessed with the vision of Arnold and his disciples or the perceptiveness of the Rand analysts of 1946, who consulted their crystal ball and guessed correctly. Even by late 1957 the path ahead for most seemed unclear. With the nation on the threshold of space, the challenges for the Air Force remained formidable.