[redacted] ~~CONFIDENTIAL~~

THE THRESHOLD OF SPACE:

THE AIR FORCE IN THE NATIONAL SPACE PROGRAM 1945-1959

(U)

1390

group 3

by

Lee Bowen

September 1960
USAF Historical Division Liaison Office

[redacted]

~~CONFIDENTIAL~~

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
SEP 1960		**00-00-1960 to 00-00-1960**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
The Threshold of Space: The Air Force in the National Space Program 1945-1959	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **USAF Historical Division,600 Chennault Circle,Maxwell AFB,AL,36112-6424**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**65**	

Ah, but a man's reach should exceed
his grasp,
Or what's a heaven for?

- Robert Browning

FOREWORD

The Threshold of Space is a brief study of the national space program from 1954 through 1959 with emphasis on the role of the Air Force. It was originally prepared as a chapter for inclusion in the *History of Headquarters USAF, Fiscal Year 1959*. Because of the importance and timeliness of the subject, the chapter is being issued as a separate study to make it more quickly available throughout the Air Force.

Based chiefly on official documents, *The Threshold of Space* is a precis of a much more detailed history on the space program currently being prepared. Rather than confining itself to fiscal year 1959, the present study reaches back to the beginnings of space research in the 1940's and carries the story forward to January 1960. This was necessary to provide the proper perspective for an understanding and appreciation of this vital area of national activity.

It was impossible in a study of this length to cover all facets of the space program, whether national or Air Force. There had to be a choice of topics such as policy, the selection of projects for development, and the widespread distribution by the Department of Defense of systems and subsystems among the three services for research and tests. Other topics almost equally important had to be excluded. Among the latter there were such subjects as interservice rivalry for control of the satellite-detection fence and the Navy-Air Force dispute about the Pacific Missile Range. It was also necessary to omit coverage of the valuable work done by the Air Force in the field of space medicine and in the establishment of international agreements for the construction of bases outside the United States. These and other subjects will receive thorough treatment in the more comprehensive history now under way.

C O N T E N T S

Space Work Prior to Sputnik. 1

Evolution of a National Space Policy, 1954-58. 8

Air Force Space Policy to 1959 16

USAF Plans and Projects, 1957-59 19
Directorate of Advanced Technology. 20
USAF Space Program and ARPA 22
ARPA-NASA Partition of Projects 28

Major Readjustments, April-December 1959 31

Significance of X-15 and Dyna Soar 34

Funding the Space Program, 1957-59 38

Space Program in December 1959 43

Notes. 49

Glossary 58

Appendix
Satellite Launchings, 4 Oct 1957 to 26 Nov 1959 . . . 60

[redacted] ~~CONFIDENTIAL~~

THE THRESHOLD OF SPACE
(THE AIR FORCE IN THE NATIONAL SPACE PROGRAM, 1945-1959)

In October 1957 the Soviet Union staked out for itself historical primacy in space by launching Sputnik I--the first man-made satellite to orbit the Earth. This triumph went to Russia by default, for the United States could have been first to place a satellite in orbit. To many Americans, it seemed that, more than anything else, our failure was the result of national complacency. And there is much in the record to support this explanation of events.

Space Work Prior to Sputnik

The will to trespass upon space is as old as mythology, but it remained a fantasy until the Germans dramatized the power of rocketry with the V-2 in World War II. It seemed clear that this propulsion, if properly developed, could break the restrictions of Earth's gravity and reach both orbital and escape velocities. Equally important for a space vehicle was the rocket's independence of the atmosphere. Structurally free of aerodynamic requirements--unless needed for controlled reentry--and breathing the oxygen of its own fuels, the rocket could travel to literally unlimited distances in the near vacuum of space. At first it seemed that to increase the size of the rocket engine would be to increase the thrust proportionately. However, it was soon apparent that combustion flames behave differently in chambers of different dimensions,

and there was no easy ratio between the size and thrust of engines.[1] Consequently, rocket engineering took its place among the rigidly established propulsion sciences, and the long years of patient research continued.

Immediately after the war the Army, Navy, and Air Force, moved both by the German success with the V-2 at Peenemünde and the less impressive results of American endeavors, carried forward experiments at White Sands Proving Ground and Holloman AFB. They used left-over V-2's as well as new, inexpensive, and specially designed small missiles for scientific exploration of the upper atmosphere. Progress was swift. At the same time the military services, and especially the Air Force, turned to industrial contractors for the rocket-propelled ballistic missiles that they could already foresee as great weapons of the future. As far as the proposed intercontinental and intermediate-range ballistic missiles (ICBM's and IRBM's) were concerned, progress was slow because of slim budgets and the cost of current military requirements. The ICBM's and IRBM's were too costly to serve as carriers of high explosive bombs, and fission bombs were too costly to risk the inaccuracies of unmanned delivery. Consequently, in 1947, Air Force hopes for a program of long-range ballistic missiles had to be suspended [2] and could not be resumed for a number of years. Even the early fusion bomb models of 1951 and 1952 were of no help. Though their great radii of destruction could be reconciled with the circular probable error (CEP) of missiles, the bomb designs did not fit missile configurations.

The great change came in 1953 when Los Alamos Scientific Laboratory, after prolonged thermonuclear research, promised a fusion bomb of small size and high yield. This warhead could justify ICBM and IRBM delivery, and the Air Force was free at last to undertake, with the consent of the Administration, an all-out ballistic missile program. The Air Research and Development Command (ARDC) entrusted the work to its Western Development Division (WDD), activated especially for that purpose in 1954 and subsequently redesignated Air Force Ballistic Missile Division (AFBMD). The program soon came to include the Atlas and Titan ICBM's and the Thor IRBM.

Even before 1954 there could have been plans for a space program utilizing the Army Redstone missile as booster in a multi-stage combination with small missiles. By 1954, or 1955 at the latest, there was an inventory of at least 11 missiles in service or development suitable for multi-stage vehicles. The Army Redstone and Jupiter and the Air Force Atlas, Titan, and Thor were 5 possible boosters to be combined with any of the 6 small missiles then available*--1 belonging to the Air Force and 5

*The characteristics and 1957 status of these 11 missiles:

Missile	Max Thrust (in lbs)	Velocity (mph)	Alt/Range (in miles)	1957 Status	Sv Origin
Corporal	20,000	1,800	100 ma	In service	Army
Aerobee	4,000	3,000	70 ma	In service	Navy
Aerobee Hi	4,000	3,000	120 ma	In service	Air Force
Aerobee Hi	5,000	4,500	160 ma	In service	Navy
Viking	20,000	4,500	100 ma	In service	Navy
Sergeant	70,000	1,900	100 ma	Dev & Pdn	Army
Redstone	75,000	10,000	250 mr	Pdn & Sv	Army
Jupiter	165,000	15,000	1,500 mr	Pdn & Sv	Army
Atlas	300,000	15,000	5,500 mr	Dev & Pdn	Air Force
Titan	300,000	15,000	5,500 mr	Dev & Pdn	Air Force
Thor	165,000	15,000	1,500 mr	Dev & Pdn	Air Force

belonging to the Army and Navy. Yet not 1 of the 11 had been designed specifically for space purposes. This fact, not infrequently charged to a hit-or-miss policy followed by the Department of Defense, constricted the American space payloads for a long time after the space program began.

The Russians followed a quite different policy. It seems certain that they pursued atomic and missile programs simultaneously. Assuming that sooner or later there would be a breakthrough to relatively small thermonuclear weapons, the Soviets produced a rocket engine that was tailored neither as a carrier of thermonuclear warheads nor as a booster of space vehicles but one that could serve both purposes. The policy may indicate poor planning as far as the optimum ICBM is concerned, but in 1957 it gave the Soviets a fine space vehicle. The Russian rocket engine possessed a thrust beyond anything then being planned for the American arsenal, including the Atlas and Titan, and permitted the use of large payloads.

The failure of the Americans to develop either a high-thrust booster or one specially designed for space vehicles did not mean that the military departments had had no interest in space. In 1945 the Navy began a study of satellite feasibility. The project moved slowly, however, and its completion was anticipated by a similar Air Force undertaking. Early in 1946, Headquarters USAF directed RAND to investigate the feasibility of man-made satellites. In accordance with instructions, RAND completed a basic study in May 1946, and in February 1947 released

12 additional studies suggesting a space program that was largely of scientific interest.[3]

In December 1947 the Engineering Division of the Air Materiel Command (AMC) evaluated the RAND 13 studies, concluded that a satellite was technically possible, and recommended establishment of an Air Force satellite project. Headquarters USAF was sympathetic but could do little in the way of support during the decade 1947-57. Distraction was attributable in part to limited funds throughout the postwar years of recovery and retrenchment, to operational emphasis and requirements during the Korean War, and, after 1953, to an Administration-Defense Department policy that discouraged extensive investments in basic research. Although there was no written directive against research, public statements by high officials served to deter the military services from pursuing research and development work as actively as they desired.[4]

Yet no policy could hide from discerning minds that a technological revolution was under way. The air-breathing aircraft was approaching the limit of its potentialities; the ballistic missile offered new orders of velocity and range; and space--though only reluctantly recognized by some--was opening up as a new world of adventure. Russia boastfully pursued advanced technology, and there were frequent and verifiable reports of Soviet space plans. Some American voices warned against the passivity of the United States, but they had little effect. In June 1955, Lt. Gen. Donald L. Putt, DCS/Development, protested against the "small size of our national effort in basic research." Two months later, Trevor Gardner, Assistant Secretary of the Air Force (Research and Development), said that

the research and development budget for fiscal year 1957 and beyond should be doubled "to maintain our technological superiority." In December, Gardner declared that $200,000,000 more was needed if the Air Force was to meet the Soviet challenge.[5]

The warnings remained unheeded, and Headquarters USAF was caught between the high cost of defense and limited budgets. In this same period, however, the Administration afforded a small measure of relief by making no sharp distinction between "basic research" and "development." Occasionally, the latter term could be used to cover work that was essentially research, as was done with new engines and new fuels needed for navigation and communication satellites.[6]

In a more specific area of space planning high policy was less lenient. On 15 March 1955, Headquarters USAF issued General Operational Requirement (GOR) No. 80 calling for a satellite weapon system. By this time RAND had long since abandoned its 1946-47 thesis that the space venture would be chiefly of scientific value. In 1956 RAND proposed three feasible projects of military significance--the Advanced Reconnaissance System (ARS); the Man-in-Space (MIS) Project, and the Ballistic Weapons Research and Supporting System (BALWARDS). The latter, using Atlas, Aerobee, and Sergeant missiles, looked toward landings on the moon and flights in the vicinity of Venus and Mars. Both ARS and MIS were approved as possible projects. The Air Staff also approved BALWARDS, but in May 1957 the Office of the Secretary of the Air Force required the deletion of the interplanetary missions. In its new and shrunken version BALWARDS became the near-space project known as the Ballistic Research and Test System (BRATS).[7]

The change of BALWARDS into BRATS did not discourage RAND. In September 1957 the corporation recommended a "missile-space program" of 10 projects. Among these were five projects that pertained solely to space: reconnaissance satellites; cislunar systems; interplanetary systems; navigation satellites; and communication satellites.[8]

During these same two or three years before Sputnik, when Headquarters USAF was thinking in terms of GOR No. 80 and RAND was proposing military space projects, many Air Force officers in widely scattered field units, and without coordinated plans, were likewise concerning themselves with the same problem. Small groups at Headquarters ARDC, at the Ballistic Missile Division, at Holloman AFB, and at Wright Air Development Center (WADC) sensed danger in the Government's unwillingness to give the new technology the urgent support they felt it deserved. Acting independently of Headquarters USAF, the groups separately prepared a number of papers advocating research plans that might span the next 15 or 20 years. Among other things, the proposed programs called for organized space experiments "at the earliest practicable date." There were discussions also of expendable and recoverable Earth orbiters, the latter to be both of the manned and unmanned variety, a manned space station, and an expendable vehicle for lunar landing.[9]

Thus, prior to the launching of Sputnik in October 1957, Headquarters USAF, together with RAND, AMC, ARDC, AFBMD, WADC, and other field units, had evidenced a widespread interest in astronautics and a sophisticated grasp of its technology. On the other hand, at no level within the Air Force, the Department of Defense, or the Administration had there been a

clear statement of the ultimate objective of a space program or a systematic evaluation of the disparate aims of the suggested projects.

The basic goal of any national space program, civilian or military, must inescapably be the establishment of habitable stations in space. But to think of going beyond the limits of interplanetary areas with mid-twentieth century knowledge and techniques would be unrealistic and verging on the fantastic. Even the small-scale enterprise beyond the Earth would take man into an unknown realm of danger and adventure. It could not be attempted without costly and carefully prepared exploratory projects to discover the nature of the space environment and to test the feasibility of using space immediately for practical purposes. This idea was doubtless present in many minds long before Sputnik, but it had seldom been expressed specifically before 1957. Its absence as a guiding principle in space policy may have contributed to the undisciplined efforts to counter the Russian success with a frugal program.

Evolution of a National Space Policy, 1954-58

Top-level indifference to the importance of space was of long standing. In December 1948, James Forrestal, Secretary of Defense, passingly referred to a "military interest in a possible Earth satellite," but the Department of Defense took no concrete actions in the years that followed. In December 1954, another Secretary of Defense, Charles E. Wilson, was told that the Russians might place a satellite in orbit before the Americans could do so, and he replied, "I wouldn't care if they did."[10] Between 1954 and 1957 there were innumerable warnings, official and unofficial, that the Soviets would attempt to launch a satellite before the

end of 1957. Sputnik I therefore did not come as a surprise to informed people in or outside of the Government. In his State of the Union Message delivered to Congress on 9 January 1958, the President himself reflected the general indifference that had previously prevailed when he admitted that "most of us did not anticipate the intensity of the psychological impact upon the world of the launching of the first satellite."[11]

The failure to appreciate the importance of being first in space is all the more unfortunate because the United States had already undertaken to place a satellite in orbit in the near future. By 1955 the three services were all thinking of a possible satellite, and the Army and Navy even requested official approval of their joint project, known as Orbiter, to use a Redstone missile as a booster for a small payload. At the same time the Administration determined to develop a scientific satellite as an American contribution to the International Geophysical Year (IGY), scheduled for 1 July 1957-31 December 1958. This decision prompted the Secretary of Defense to disapprove Orbiter "in the interest of IGY policies." He then directed the three services to submit proposals for a scientific satellite that was dedicated wholly to peaceful ends.[12]

The Army and Navy united in proposing a modified version of Orbiter, but once again this was ruled out. The use of Redstone, a military missile, would create security problems and might suggest a motive that was not purely scientific. Because of these objections the Navy proposed on its own a backup vehicle that would utilize a modified version

of the Viking, long ago produced by Glenn L. Martin for naval participation in the White Sands experiments. The Air Force, with no adequate nonmilitary missile at its disposal, could do only one of two things--recommend the production of a new rocket engine, an undertaking that might interfere with the ballistic missile program, or suggest the use of an Atlas ICBM, which would be as objectionable as a Redstone. Unwilling to risk interferences with the missile program, the Air Force proposed an Atlas-boosted satellite, knowing that the project would go by default to the Navy.[13]

On 29 July 1955 the President announced that the United States, as part of its IGY contributions, would attempt to launch a number of 21-pound satellites without the use of military missiles. The project, known as Vanguard, although organized in the Department of Defense under Navy management, would be divorced from military significance.[14]

The U.S. decision to exclude the use of a military booster became a significant factor in the 1957 Soviet space victory. There were two reasons: first, the Navy turned to Martin for the Vanguard modification at a time when that company was engaged in a reorganization of the Viking development team; second, the Office of the Secretary of Defense caused further delays because it had little enthusiasm for the space program, withheld "first importance" status from the project, granted "dribbling" support, and released funds at an inadequate rate.[15]

The day after the President announced Vanguard, the New York Times noted that "the United States and Russia now appear to be in a race for

the glory of making the first major step toward interplanetary flight. . . . Soviet determination to achieve this objective was announced last 15 April."[16] Most Americans, however, were impervious to the Russian threat, inexplicably skeptical of Soviet technology. The United States ran no race. When time passed and Vanguard obviously slipped from its schedule, there was deep concern among space protagonists. One periodical commented in July 1957:[17]

> Eulogized and advertized ad nauseum as mankind's greatest adventure, there is still no assurance that any of the VANGUARD attempts will be successful during the 18 months of the IGY. It's the nature of the still-young state of the rocket art. Even if VANGUARD is ready it still may not be first. Reports point to a Russian try within ten weeks. And to the south the . . . [Army Ballistic Missile Agency or ABMA] team [which] everybody tries to ignore may beat even that date.

In truth, as early as April 1956 ABMA had begged for permission to employ its Jupiter C* missile to launch a satellite, in view of Vanguard delays and increasing evidence that the Soviets would be first in space--an event certain to inflict "serious damage" to the prestige of the United States. The Army's proposals were rejected by the Department of Defense, presumably with the approbation of the Administration, still devoted as it was to the policy of exploration for demonstrably peaceful purposes.[18]

Coincidentally with the rejection of ABMA's plan, the Far Side project, directed by Col. William O. Davis and nurtured quietly within the

*The Jupiter C was an experimental stage-rocket device consisting of a Redstone booster and two stages of solid-propellant rockets. When fired in September 1956 it reputedly traveled 3,300 miles, with a peak altitude of 650-680 miles, and could have brought its payload into orbit if the final stage trajectory had been preset for that purpose.

Air Force Office of Scientific Research (OSR), ARDC, almost succeeded. It involved launching a missile from a balloon at an altitude of 100,000 feet to penetrate space for a distance of 4,000 miles with the purported purpose of gathering information of vital interest to the Air Force. Despite charges of inadequate coordination, subterfuge, mismanagement, and "utter misdirection of basic research funds," Colonel Davis persevered with his plans. In the spring of 1957 he obtained permission from the Air Force, the Department of Defense, and the Atomic Energy Commission to conduct the operations from the Eniwetok Pacific Proving Ground. In September 1957 the first shot failed. There were five others to be made. On 4 October the second missile tangled with the collapsing balloon at 70,000 feet, escaped from the wreckage, and reached a known altitude of 370 miles.[19]

The next morning, newspapers of the world bannerlined the 184-pound Russian Sputnik. National and international comments on the Soviet victory were not complimentary to the United States. Throughout the American press there was general condemnation of the "partial measures, hit or miss planning and confused organization that have marked our . . . work in this field."[20]

A number of high-ranking U.S. officials attempted to belittle the Russian satellite. Sputnik was unimportant because it was no surprise; it was a "neat scientific trick"; it was an "outerspace basketball game,"[21] The same thought appeared to be implied in the White House announcement of 9 October that the United States would not become engaged in a space race with other nations and that Project Vanguard would not be accelerated.[22] This meant that Vanguard would keep to its unhurried schedule.

Much of the press and public interpreted this belittlement of the Russian achievement as a sign of nervousness, and there was evidence to support the interpretation. Between 8 and 15 October there took place a number of high-level Government conferences to reevaluate the whole missile program. In late October, when there was a report that the third shot of the Far Side project had penetrated 4,000 miles into space, the Department of Defense hailed the erroneous claim as proof of a vigorous program in basic research. And yet again, on 3 November the 1,120-pound Sputnik II, complete with dog, was "no surprise to the President," who nevertheless directed further conferences on rocketry.[23]

In these uneasy days the Secretary of the Air Force, James H. Douglas, called upon a committee of distinguished scientists and USAF officers headed by Dr. Edward Teller to propose a line of positive action. The committee's report was completed 22 October 1957. Though the report went to high levels of the Government, its recommendation for a closely unified program was disregarded in favor of a divided program that, in the opinion of many, tended to dissipate rather than concentrate the expanded effort.[24]

The first major organizational development came on 7 November 1957 when the President added to the existing structure by appointing Dr. James R. Killian as Special Assistant for Science and Technology. On 12 November, Neil McElroy, the new Secretary of Defense, issued Defense Directive 3210.1 emphasizing basic research. About the same time, McElroy decided "to correct previous errors" by creating a new agency to

control, direct, and relate the missile and space programs. It was the belief of some highly placed officials that the Department of Defense already had the capabilities to do this work. The need was for firm guidance rather than a complication of the organizational framework. The Secretary of Defense was not convinced. After some delay, while considering the need for congressional approval, McElroy established the Advanced Research Projects Agency (ARPA) on 7 February 1958. The new office was headed by Roy W. Johnson and, contrary to the wishes of the Joint Chiefs of Staff (JCS), was authorized to direct the research and development projects within the Department of Defense that the Secretary might assign to it.[25] In practice ARPA would then reassign the projects on a contractual basis to the military departments, other Government agencies, or civilian institutions.

Although the White House and Department of Defense statements showed that the Administration saw the need for a space program, there was as yet no basic policy pronouncement to that effect. Then, on 26 March, the President's Science Advisory Committee affirmed that "space technology" was required by human curiosity, scientific knowledge, the maintenance of national prestige, and the defense of the United States.[26] This was the first official declaration by the Government that space was of military significance, but there was still no evaluation of space as a realm of military operations.

On 2 April the President asked Congress to approve the establishment of a National Aeronautics and Space Administration (NASA) to conduct

all space activities "except those projects primarily associated with military requirements." Though he did not say what these requirements were, it was clear that the military program would be less important than the civilian program.[27]

Congress acted with dispatch. On 29 July, the President signed the National Aeronautics and Space Act (Public Law 85-568) creating NASA. It had the effect of bisecting the space program into military and civilian segments. The same law brought into being a National Aeronautics and Space Council (NASC), to advise the President on space matters, and a Civilian-Military Liaison Committee (C-MLC) as a bridge between the military and civilian space agencies.[28]

Meanwhile, on 3 July 1958 the National Security Council (NSC) submitted to the President a policy statement on outer space. The Council stated that Russian superiority in astronautics would create an imbalance of power in favor of the Communist bloc. Moreover, there were immediate military requirements for weather, communication, and electronic countermeasure satellites. In the more distant future the armed forces might require satellites as bombardment vehicles, as maintenance and supply depots for outer space vehicles, and as reconnaissance stations. The President signed this paper on 18 August.[29]

By midsummer 1958 the Administration had established a space policy that called for dual programs, civilian and military. But the lines of demarcation were not sharp and there were certain to be wide areas of overlap, as well as competition for prestige and money.

Air Force Space Policy to 1959

The expression of policy is not limited to policy statements. It is present too, at least by implication, in many decisions of an operational nature. Certainly the Air Force was moved by a policy of careful investigation in 1946 when it directed RAND to study the feasibility of satellites and in 1947 when it instructed AMC to evaluate the studies. But there was no doctrine at the time to define the role that the Air Force should play in space. In December 1947, AMC's approval of the RAND studies and recommendation that the Air Force initiate a satellite project impelled Lt. Gen. Howard A. Craig, DCS/Materiel, to urge the Chief of Staff to define the Air Force position on space.[30] On 15 January 1948, Gen. Hoyt S. Vandenberg, Vice Chief of Staff, signed the following Space Policy Statement:

> 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 problem 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.

In the next nine years, 1948-57, the Air Force had no formally approved space program, but it never lost interest in the possibility of such a program and never rescinded the policy statement of 15 January 1948. Consequently when the nation's reaction to Sputnik made a national space program inevitable, the Air Force was in a position to develop from Vandenberg's statement a policy on space missions.

Air Force space policy came to consist of four major assumptions. First, any space program would depend upon a mushrooming space technology, and that in turn required extensive research and development. Second, because of its role in all operations above the surface of the Earth, the Air Force held an inherent right to a dominant role in space operations. Third, for the sake of clarity in military plans it was necessary to define the Air Force mission in space operations. And fourth, space would become more and more critical for the military security of the nation. This last point had been the heart of the 1955 GOR No. 80 that first called for a satellite weapon system.[31] Gradually the Department of Defense, and many members of Congress too, came to accept this same view.[32]

The Air Force naturally sought leadership in space military operations. In March 1958, Gen. Thomas D. White, Chief of Staff, USAF, reverting to Vandenberg's theme of 1948, wrote:[33]

> For all practical purposes air and space merge, form a continuous and indivisible field of operations. Just as in the past, when our capability to control the air permitted our freedom of movement in the land and seas beneath, so, in the future, will the capability to control space permit our freedom of movement on the surface of the earth and through the atmosphere.

Neither the Army nor the Navy admitted the Air Force claim to primacy in space, but Headquarters USAF constantly reaffirmed the doctrine. As a compact expression of air-space relationship, the Office of the Chief of Staff introduced the term "aerospace."[34] The meaning of the word was not understood immediately either within the Air Force or elsewhere.[35] Confusion led the Air Staff to seek a definition, and

the meaning of the term was expressed officially in AFM 1-2 in December 1959:[36]

> The aerospace is an operationally indivisible medium consisting of the total expanse beyond the earth's surface. The forces of the Air Force comprise a family of operating systems--air systems, ballistic missiles, and space vehicle systems. These are the fundamental aerospace forces of the nation.

Logically the doctrine of aerospace expressed the thought that airpower and space power are the same thing and should be vested in a single service which, whatever its official title, would be the aerospace force. Space vehicles would be another category of vehicles to be employed in the regions above the surface of the Earth to help deter war or, failing that, to help win the war.

Late in 1958 the Air Force attempted to specify its exact role in space for the sake of long-range planning and development, and Headquarters listed 15 projects pertinent to space missions that should be Air Force responsibilities.*[37] The problem was to have the missions assigned. As the time approached for the first session of the 86th Congress in January 1959, the Air Staff prepared a policy statement that emphasized reconnaissance, offensive, and defensive space operations as

*The 15 missions were: military reconnaissance with satellites utilizing optical sensors; the use of military satellites utilizing infrared sensors; the employment of military satellites for communications; military reconnaissance with electronic sensors; weather observation by military satellites; a satellite defense system; a manned maintenance and supply system for outer-space vehicles; manned defensive outer-space vehicles; manned bombardment space vehicles; manned satellites for a system of detection, warning, and reconnaissance; bombardment satellites; lunar bases; target drone satellites; satellites for electronic countermeasures; satellites as navigation aids.

essential to USAF space activities. Of course the Army and Navy too had space aspirations, and there developed a triservice struggle before the congressional committees. A further complication was the role of ARPA in shaping military space projects to meet the desires of the Department of Defense and the Administration. In March 1959 the Air Force arguments before the congressional committees were blunted by Roy S. Johnson, ARPA's director. He admitted a "possible" military need for lunar and planetary bases, but only in the distant future, "not in the span we are working in now." Johnson wanted current developments limited to communication satellites of 5,000 pounds at altitudes of 22,000 miles and military vehicles with maneuverability to altitudes of only 600 miles.[38]

Even in trying to establish a research and development program to overcome the lost opportunities of 1953-57 the Air Force encountered difficulties. Not only did the rapidity of technological breakthroughs preclude the assurance that any budget would be sufficient for the coming year, but the Air Force was not a free agent in such matters. The Bureau of the Budget itself could arbitrarily impose ceilings. Moreover, after February 1958, authority for space projects was centralized in ARPA. The Air Force therefore could do little more than urge funds for long-term projects; work to accelerate the production of Atlas, Titan, and Thor; proceed as swiftly as possible with near-space projects; and fight for favorable policies at high levels.[39]

USAF Plans and Projects, 1957-59

Within a matter of weeks after Sputnik the Air Force was engaged in two major undertakings related to space. The first was to establish a

[redacted]

Headquarters USAF agency to supervise the various projects already existing on paper. The second was to place the previously proposed projects in a formal program to be sanctioned by highest authority.[40] In neither effort was the Air Force successful. There came to be a paradox: the more attempted the less accomplished.

Directorate of Advanced Technology

In November 1957, Col. V. Y. Adduci, Assistant Director, Office of Legislative Liaison, urged the Air Force "to jump the gun on the problem of astronautics by appointing either a Director or Assistant Chief of Staff for Astronautics." In view of the growing opposition within Headquarters USAF to the further creation of assistant chiefs of staff there was little probability of placing the space agency at that level. Conceivably, it could have been located in the Office of the Assistant Chief of Staff for Guided Missiles, where there was already some capability for the work. The Chief of Staff decided, however, to place the agency under the Deputy Chief of Staff/ Development. On 10 December, General Putt announced the establishment in the DCS/Development of the Directorate of Astronautics, to be headed by Brig. Gen. Homer A. Boushey.[41]

The Department of Defense reacted adversely to this action. William Holaday, Defense Director of Guided Missiles, publicly stated that the Air Force "wanted to grab the limelight and establish a position." The Secretary of Defense expressed his opposition to use of the term "astronautics," which seemed to him an Air Force bid for popular support. Strong pressure on Headquarters USAF from above, verbal rather than written, made it advisable on 13 December for General Putt to cancel his memorandum of 10 December.[42]

[redacted]

In the weeks that followed, Headquarters remained aware of the need for central control of the Advanced Reconnaissance System and its subsystems and of other space projects that might be sanctioned. But the prospects of getting Department of Defense approval for the agency were poor for the time being. Since space vehicles were dependent upon ballistic missiles, Headquarters adopted the temporary solution of authorizing the Assistant Chief of Staff for Guided Missiles to coordinate USAF space activities.[43]

Not until 22 July 1958, after the National Security Council defined the space policy of the Administration, could the Air Force obtain OSD approval of a USAF space agency. Even then it appeared that the use of "astronautics" would be impolitic. Accordingly, when General White established the new office under DCS/Development on 29 July, effective 15 July, he called it the Directorate of Advanced Technology.[44] General Boushey became director of the new office, with functions as follows:[45]

> To supervise at the Air Staff level the formulation of the Air Force Advanced Technological Program; provide technical information and advice to the Air Staff on the process of development; maintain coordination with ARPA, the Department [sic] of Army and Navy and other interested government agencies; and maintain liaison with civilian educational institutions, industry, and representatives of foreign governments engaged in research and development activities.

Doubtless Headquarters hoped to make the Directorate of Advanced Technology the control point for all Air Force space projects. However, since the space projects were dependent upon missiles, the space program would necessarily involve AFBMD, which in turn was in contact with Headquarters through the Assistant Chief of Staff for Guided Missiles.

Under the circumstances it was imprudent to sever all ties between the guided missile office and the space program. A consequent division of authority between the Assistant Chief of Staff for Guided Missiles and the Directorate of Advanced Technology resulted in a number of embarrassing misunderstandings during the succeeding months.[46]

USAF Space Program and ARPA

At the same time that the Air Force was attempting to set up a Headquarters space agency, the Air Staff studied the military implications of Sputnik. The approaching space age could well demand a new strategy, for eventually astronautic supremacy might mean the control of all the land and sea areas of the Earth. The Free World could not concede such a contingency to the Soviets and survive. It was time for a dynamic national program that would bring with it the recovery of American leadership. In November and December 1957 the Air Force devoted much thought to this need.[47]

On 7 January 1958 the Department of Defense requested the three services to list their proposed space projects. It may be that the Department of Defense intended to use this information only to assist ARPA in assigning development missions among the Army, Navy, and Air Force. The Air Force, however, at least at the staff level, interpreted the request quite differently and believed that the Department of Defense intended to approve a USAF space program.[48]

DCS/Development completed the reply in two weeks. It listed 5 systems and 21 subsystems or projects that encompassed a variety of military missions "essential to the maintenance of our national position and

prestige." The Air Force hoped to keep these missions for itself, and the paper, signed by Richard E. Horner, Assistant Secretary of the Air Force (Research and Development) recommended "that the astronautical program be approved and the necessary resources sought to implement it."* Mr. Holaday received the paper on 24 January but made no comment or reply. This silence on the part of OSD was a disappointment to

*The proposed program consisted of the following systems and subsystems:

I. 609, Ballistic Test and Related Systems
   1. BRATS, Space Research and Experiments
   2. Aerial Survey and Target Locating System (Recon)

II. 447, Manned Hypersonic Research System
   3. X-15, Space Research and Experiment
   4. Advanced Hypersonic Research Aircraft (Manned Space Flight, Space R&D)

III. 464, Dyna Soar
   5. Manned Capsule Test (Manned Space Flight)
   6. Conceptual Test (Manned Space Flight, R&D)
   7. Boost Glide Tactical (Weapon Delivery)
   8. Boost Glide Interceptor (Countermeasure)
   9. Satellite Interceptor (Countermeasure)
   10. Global Reconnaissance
   11. Global Bomber (Weapon Delivery)

IV. WS-117 L Satellite System
   12. Advanced Reconnaissance Satellite
   13. Recoverable Data (Photo Capsule) (Recon)
   14. 24-hour Reconnaissance System
   15. Manned Strategic Station (Weapon Dev and Recon)
   16. Strategic Communications Station (Data Transmission)

V. 499, Lunar Base System
   17. Manned Variable Trajectory and Test Vehicle (Recon and Exper)
   18. Nuclear Rocket Test (Space Recon and Exper)
   19. Ion Propulsion Test (Space Recon and Exper)
   20. Lunar Transport (Manned Space Flight, Recon and Exper)
   21. Manned Lunar Base (Weapon Dev and Recon)

General Putt and his staff, some of whom felt that the plan had been pigeonholed to die--to be "overtaken by events," as was not infrequently said of other Air Staff proposals.[49]

Pessimism in the Air Staff deepened as the policies of ARPA came into silhouette during the spring of 1958. It was evident soon after 7 February that Johnson, with the approval of Secretary McElroy, would organize and operate the agency as a "fourth service" or possibly as a "special task force" within the Department of Defense. In either case Johnson would be independent of service wishes, but circumstances would not permit him to escape the role of arbitrator of service differences. Johnson's authority was further increased when the President decreed that ARPA would control civilian as well as military space projects until NASA began functioning.[50] Between 7 February and 1 October 1958, ARPA actually served as the "national" space agency.

On 27 March, Johnson informed the Secretaries of the Army, Navy, and Air Force that in order to "cut red tape" he would ignore normal channels of communication, bypass the service chiefs, and deal directly with the Army Ballistic Missile Agency; the Naval Ordnance Test Station (NOTS), at Inyokern, Calif.; and the Air Research and Development Command, including AFBMD and other centers.[51]

Certainly the services did not relish the suspension of established communication methods. The out-of-channel approach, though soon modified in some respects, gave ARPA a measure of control over Army, Navy, and Air Force units working on space projects. But as far as the Air Force was concerned, Johnson's breakdown of space projects and his

distribution of splintered parts were even more disturbing. For example, in March 1958 he directed the Naval Ordnance Test Station to develop a mechanical ground-scanning system to supplement the launching of three lunar probes assigned to the Air Force.[52] In this and other instances, Johnson abandoned the tested principle of concurrency used by AFBMD in the rapid development of ballistic missiles after 1953. Johnson, of course, saw the problem from the point of view of his own position and responsibilities, and presumably he was also under strong pressure from each of the three services. The explanation of his decisions is doubtless in ARPA files. It seemed to the Air Force that his division of project components obtained the efficient production of parts at the expense of greater efficiency for the whole; there seemed also a probable loss of time.[53]

Despite the turn of events the Air Force continued to hope and work for a space program of its own. During March and April, Headquarters USAF vainly sought approval by civilian authorities of a program that, in addition to the Advanced Reconnaissance System, would include a three-phased manned satellite to send consecutively a small animal, a large animal, and a man into space; a hydrogen-oxygen engine of 150,000-pound thrust;* a 1,500,000-pound-thrust engine; and a nuclear propulsion system.[54] Thus the Air Force showed a keen consciousness of three important aspects of space exploration--continued research in

*Rejected by ARPA as falling within the area of NASA responsibilities, and designated Nova.

[redacted]

the nature of space, plans for the conquest of space by man in space, and the development of propulsion systems that would be independent of the missile program.

Between January and July 1958, Headquarters USAF forwarded numerous requests, proposals, and draft space programs to Horner with the hope that he could obtain OSD concurrence. But Horner did not convince his superiors of the need for the proposed program. Few of these suggestions got beyond his office, where, it seemed to Headquarters USAF, they were "overtaken by events." [55]

Nevertheless the USAF proposals were not lost to the military though reshuffled by ARPA. In the spring of 1958, Johnson took over the Air Force proposal for Space Track, a 1,500,000-pound-thrust single-chamber engine, nuclear propulsion, the Advanced Reconnaissance System, and the three-phased satellite for man in space, along with others from the Army and Navy.* Although he redistributed the projects

*The projects transferred to ARPA, and the dates, were as follows:

Project	Date of Transfer to ARPA
1. Argus (nuclear explosion in exosphere)	4 Apr 58
2. Satellite and Outer Space Programs including Vanguard	1 May 58
3. High Performance Solid Propellants	7 Jun 58
4. Minitrack Doppler Fence	20 Jun 58
5. Army and Air Force Ballistic Missile Defense Projects	20 Jun 58
6. Studies of the Effects of Space Weapons Employment on Military Electronic Systems	20 Jun 58
7. Nuclear Bomb-Propelled Space Vehicle	20 Jun 58
8. Super-Thrust Rocket Engines	20 Jun 58
9. WS-117L	30 Jun 58

The distribution of space projects by ARPA follows:

Project	Assigned to
1. Sounding Rockets and Ground Instrumentation for Argus	AFSWC & AFCRC

(contd)

[redacted]

among the three services, he did so on a contractual basis. ARPA retained technical control of the work, and the projects were organized and known as ARPA's program.[56]

Thus Air Force plans for a space program had been taken over by ARPA by the time that the Directorate of Advanced Technology came into being. The new agency had little to supervise other than seven space studies* and a few near-space activities. The willingness, indeed the determination, of ARPA to reassign most of the former USAF space projects to Air Force field units on a contractual basis did not soften the fact that Headquarters USAF had lost its space program.[57]

One of the more important of ARPA's early decisions was to continue development of Saturn. This Army project promised to be of great significance for future military and civilian space programs. It was likewise one to which the Air Force had earlier made indirect but

(contd)

2.	Weapon System to Control Hostile Satellites	ARDC
3.	Nuclear Bomb-Propelled Space Vehicle	ARDC
4.	Effects of Space Weapons on Military Electronic Systems	ARDC
5.	WS-117L	ARDC
6.	Lunar Probes	AFBMD
7.	Reentry Studies	ARDC
8.	High Energy Propellants and Liquid Hydrogen-Liquid Oxygen Propellants	ARDC
9.	Project Score (conceived in 1958 to broadcast the President's voice from space)	ARDC
10.	1,500,000-pound booster	AOMC
11.	Meteorological Satellite	AOMC
12.	Inflatable Sphere	AOMC

* The seven items of the space study program were: Strategical Orbital Studies (SR 181), Strategic Lunar System Studies (SR 192), Global Surveillance Studies (SR 176), 24-hour Reconnaissance Satellite (SR 184), Lunar Observatory Study (SR 183), Strategic Interplanetary Studies (SR 182), and Satellite Interceptor System Studies (SR 187).

important contributions.

In the first decade of the postwar period the Air Force had sponsored the aerodynamic, air-breathing Navaho missile to be equipped also with a rocket booster. The latter was designed and produced by North American Aviation, Inc. Though Navaho was canceled in July 1957 the booster engine was of high excellence and its modified versions became the booster for Redstone and Jupiter as well as Atlas and Thor. Sometime before Sputnik the Army Ordnance Missile Command (AOMC) hit upon the idea of using yet another version of the Navaho engine in clusters of eight to create a thrust beyond the requirements of warhead delivery. In this way Saturn was a step toward propulsion units intended specifically for space vehicles. In 1958, ARPA assumed the technical direction of Saturn but reassigned the project to AOMC for actual development.

ARPA-NASA Partition of Projects

In July 1958 the military services found their space prospects disheartening. They had lost managerial control of the development of the vehicles. Still greater discouragement was at hand. Through the end of fiscal year 1958 the whole program had been kept within the Department of Defense. It was now certain that by January 1959 the new civilian agency, NASA, under the direction of Dr. T. Keith Glennan as Administrator, would claim not only the nonmilitary projects but also those of borderline importance to both the military and civilian programs. The time had come, as the President and his scientific advisers had previously determined, for the services to surrender all space activities except the few that were "primarily associated with military requirements."[58]

In the spring of 1958, ARPA, acting as the national space agency pro tempore, had organized its space projects into four programs--I: Missile Defense Against ICBM's; II: Military Reconnaissance Satellites; III: Developments for Application to Space Technology;* and IV: Advanced Research for Scientific Purposes.† It was the intention of ARPA to transfer only Program IV to NASA when the latter came into being, but this hope suffered a serious blow.[59]

On 28 July the President decided to emphasize the civilian space program by giving to NASA such nonmilitary projects as lunar probes and scientific satellites initiated by ARPA, along with Project Vanguard. In accordance with Executive Order No. 10783, the transfer began immediately after the activation of NASA on 1 October.[60] Under this arrangement NASA got Program IV and cut deeply into Program III by claiming all those projects pertaining to Man in Space (redesignated Project Mercury), special engines, satellite tracking, communications,

*Program III included eight projects:
1. Man in Space
2. Special Engines
3. Special Components for Space Systems
4. Project Argus
5. Satellite Tracking and Monitoring Systems
6. Satellite Communications Relay, Meteorological Reporting, Navigational Aid Systems
7. Bomb-Powered Rockets
8. Solid Propellants

†Program IV included four projects:
1. ABMA/JPL Program for Four Scientific Space Vehicles to be Launched in 1958
2. AFBMD Program for Three Lunar Probes
3. NOTS Program, a one-frame television with a mechanical scanner to get "a first look at the other side of the moon"
4. Follow-on Program, vaguely defined as "more of the same"

meteorology, and navigation. The ARPA military program then consisted of nothing more than Program I, Program II, and the plans for a nuclear-bomb-powered rocket, as a remnant of Program III.[61]

In September 1958, shortly before the activation of NASA, ARPA redefined the Advanced Reconnaissance System and broke it down into separate projects with different designations. The reconnaissance aspect became Sentry. The vehicle tests, biomedical flights, and recovery experiments were grouped together as Discoverer. And the infrared sensing system became Midas. In the last months of 1958, ARPA assigned these three projects to ARDC-AFBMD with the usual contractual arrangements. Between 19 December 1958 and 29 April 1959, NASA requested ARDC to accept responsibility for Space Track research and development, the design of an engine test stand at Edwards AFB, and the construction of facilities at Eglin AFB for vertical space probes.[62]

At the end of June 1959 the Air Force was still without a space program of its own but was obligated to support a large part of the ARPA program and some NASA projects as well.* The work made serious demands

---

* Space projects wholly or partly entrusted to AFBMD by mid-1959:

1. Discoverer
2. Sentry
3. Midas
4. 6-Hr Comm Sat
5. 24-Hr Comm Sat
6. Deep Probes
7. Transit Nav Sat
8. Tyros Cloud Cover
9. Courrier Passive Army Comm Sat
10. HETS
11. Mercury (MIS)
12. Willow
13. Outer Space Weapon Test
14. Centaur
15. Saturn
16. Manned Sat & Intcp and Inspec System
17. Geo-Astro-Physical Program
18. Hustler Engine
19. Aerojet 104 Engine
20. Delta
21. Vega

upon the personnel and facilities of AFBMD, which, to the concern of its commander, had no managerial control over the 21 space projects being developed for ARPA and NASA.[63]

Major Readjustments, April-December 1959

In the spring of 1959, widespread dissatisfaction with the progress made by the space program led to changes in organization that were of far-reaching consequence. On 13 April 1959, Headquarters USAF issued the equivalent of a charter that gave the Directorate of Advanced Technology authority to coordinate within the Air Staff all USAF space activities. The Assistant Chief of Staff for Guided Missiles retained no space responsibility except the coordination of requirements for ballistic missile resources including boosters, static test facilities, and range and launch facilities.[64]

Still another change occurred on 9 November 1959 when DCS/Development redesignated the Director of Advanced Technology as the Assistant for Astronautic Systems. The Chief of Staff approved the shift to Assistant status in December but would not permit use of the term Astronautic Systems. In his new position the Assistant for Advanced Technology had overall responsibility within DCS/Development for policy guidance and program direction in the broad areas of ballistic missiles or vehicles, ballistic missile warning and defensive systems, and vehicles and systems to operate in space, including those for detecting and tracking.[65]

Simultaneously with these USAF organization changes, differences among the military services came into the open. In late April 1959 the Chief of Naval Operations, "in a bold bid for a major share" in the

military space program, urged the JCS to sanction a single military space agency to coordinate all pertinent facilities and functions. The Army concurred on the theory that space activities would transcend the exclusive interests of any one service. The Air Force Chief of Staff found the proposal contrary to the established practice of integrating weapons within unified commands.[66] In the midst of these discussions ARPA recommended in June a Mercury Task Force to assist NASA, and the Secretary of Defense requested JCS advice in assigning operating responsibilities for several projects, including Midas and Sentry--the latter soon to be redesignated as Samos.[67] In the months that followed, the services held their positions. The Army and Navy wanted a Mercury Task Force and a Defense Astronautical Agency to control the space systems. The Air Force objected to both.[68]

The discussion continued through the summer of 1959. In September the Secretary of Defense made three important decisions. He disapproved the proposed Defense Astronautical Agency. He quashed the move for a Mercury Task Force but as a substitute selected Maj. Gen. Donald N. Yates, USAF, Atlantic Missile Range commander, to "direct military support" for the project.* [69] And finally, McElroy reversed his established policy on ARPA by dividing the military space program among the three services. True, advanced research for missile defense remained with ARPA, but booster development went to the Air Force, and the development of space payloads was assigned to the

*By 1960, General Yates had drawn up his plans for a Mercury support organization that was a task force in everything but name.

Army, Navy, and Air Force on the basis of competence and primary interest. Under this arrangement, Midas and Samos were marked for the Air Force, although formal transfer did not follow immediately. Likewise Transit, a more recently planned navigational project, would go to the Navy and a Notus family of four communication satellites to the Army.[70]

The ruling practically removed ARPA from participation in astronautics. The swing of the pendulum was almost complete from February 1958 when the agency had possessed sole responsibility for the national space program. The ruling also removed the Army from booster development. Presumably, therefore, Saturn would go to the Air Force.[71]

For three reasons cogent to Administration leaders, the Air Force did not get Saturn. First, the military space program had retained no specific requirement for an engine with a 1,500,000-pound thrust. Second, the civilian agency could place better claims on Saturn as needed for long-term developments. And third, the nature of NASA's claim satisfied the Bureau of the Budget that there would be no immediate demands for increased allocations of funds. The Joint Chiefs of Staff urged that Saturn be kept within the Department of Defense, but in vain. On 21 October 1959 the Deputy Secretary of Defense, Thomas S. Gates, signed an agreement with Dr. Glennan for the transfer of Saturn to NASA, and the President gave prompt approval.[72]

The actual transfer of Samos and Midas occurred in late November 1959. To the surprise of many, ARPA also relinquished Project

[redacted]

Discoverer to the Air Force, something not mentioned in the September decisions.[73]

Significance of X-15 and Dyna Soar

During the two critical years of 1957-59 there were frequent references to the X-15 and Dyna Soar, projects intended originally to employ the boost-glide principle to take man to the fringes of space and return him safely to the Earth.

The concept had been suggested in the course of World War II by Dr. Eugen Sänger as a possible means for the Germans to bomb New York. Soon after the war, the Air Force became interested in the principle and inaugurated the X series of research aircraft with a small plane, the X-1, to test the applicability of the theory. In time, other X aircraft served the same purpose. These small planes, equipped with rocket engines, were taken aloft by large bombers and released at high altitudes to reach yet higher altitudes under their own power. When their fuel was exhausted the research aircraft glided back to Earth. In 1954 the Navy, the Air Force, and the National Advisory Committee for Aeronautics (NACA)* signed a contract with North American for the X-15. Unveiled in October 1958 the X-15 was destined to set new records in speed and altitude for manned aircraft. In less than two years, test flights established a speed of more than 2,000 mph, and an altitude of approximately 25 miles. The Air Force hoped that new engines would permit a speed of 4,000 mph and an altitude

*NACA was absorbed by NASA in Oct 1958.

[redacted] ~~CONFIDENTIAL~~

[redacted] CONFIDENTIAL

of 50 miles or more.[74]

As early as May 1955 the Air Force had issued GOR No. 92 calling for a magnified version of the X-15. Development began under three separate projects known as the Bomber Missile or Bomi, soon to be redesignated as the Rocket Bomber or Robo; the very high altitude reconnaissance weapon system known as Brass Bell; and the boost-glide research vehicle called Hywards. On 30 April 1957, Headquarters USAF directed that these three projects be brought together under the single name of Dyna Soar, derived from dynamic soaring.[75]

Sputnik had its effect here, too, and on 25 November 1957, Development Directive No. 94 authorized ARDC to proceed with the work. The boost-glide system promised a breakthrough beyond the speed, range, and altitude of existing aircraft to accomplish manned missions of strategic reconnaissance and bombing. After several months of further planning the Air Force announced on 16 June 1958 its selection of the Boeing and Martin companies as dual contractors for the Dyna Soar early design phase.[76] By that time the Air Force could foresee the importance of Dyna Soar:[77]

> It is intended that the DYNA SOAR program will constitute a major Air Force effort to develop a weapon system to succeed turbojet-powered manned strategic bomber and reconnaissance systems. Weapon systems growing out of the DYNA SOAR program should complement other weapon systems planned for availability in the same time period and although the program is to be undertaken with the strategic mission primarily in view, other mission potentials should not be overlooked. Weapon systems that evolve from the DYNA SOAR development could operate as aerodynamic, boost-glide vehicles, as short term satellites or satelloids, or as satellites in relatively stable orbits. Further, they could be manned or unmanned and, if unmanned, recoverable or unrecoverable. Combinations of any of these vehicles could be included in the final DYNA SOAR weapon system.

[redacted] CONFIDENTIAL

[redacted]

In brief, Dyna Soar, though not then specifically a space vehicle, could contribute techniques, components, and equipment to the man-in-space system as well as aerial reconnaissance systems beyond the capabilities of the X-15. At the same time, Dyna Soar would continue to serve the traditional strategic missions of the Air Force.

The new interest in Dyna Soar led to a telescoped schedule for the project. Yet troubles remained. In addition to the ever present problem of funding,[78] there was ARPA's determination to take over USAF space projects and the certainty of ARPA-NASA partition of the space program. Thus there was the possibility in the summer and autumn of 1958 that Dyna Soar might be taken from the Air Force, and even pass completely from military control. Such a shift was averted by the fact that Dyna Soar, though probably capable of orbital velocity, was nevertheless of immediate importance because of its suborbital aspects as a military research vehicle.[79]

Nevertheless, the early designs submitted in April by Boeing and Martin showed the full potentialities of Dyna Soar as an aerospace vehicle, and the Scientific Advisory Board (SAB) lent full support to the project. Gradually opposition dwindled, both within the Department of Defense and outside, and the Air Force was less constrained in its advocacy of the boost-glide principle. By the late autumn of 1959, Dyna Soar had emerged as a possible operational vehicle that might meet the aerospace requirements of the Air Force.[80]

Dyna Soar was drawn as a manned, delta-wing, aeronautical vehicle that could be boosted into orbital velocity without loss of maneuverable reentry and controlled landing. These characteristics appealed

[redacted]

strongly to the Air Force. They meant that Dyna Soar could be manned and utilized for reconnaissance, offensive, and defensive purposes at altitudes beyond the atmosphere--and if necessary remain aloft indefinitely as a satellite. Moreover, the vehicle's capacity for safe reentry and its use of conventional landing gear would permit it to use the vast empire of ground facilities constructed by the Air Force before the beginning of the space age. In brief, Dyna Soar might serve as a transition between the existing Air Force and the Aerospace Force of the not so distant future.

The ever increasing value of Dyna Soar gave the Air Force much the same potential for the future that the atomic submarine-Polaris system gave the Navy. But in 1959 there was still no adequate booster that could meet the aeronautical, missile, and space requirements of the vehicle. In some ways Saturn seemed a logical booster candidate, but the Air Force preferred the 1,500,000-pound-thrust engine. On the other hand, the Army was eager to marry Saturn and Dyna Soar, since the big booster had no defined mission in 1959 beyond its early developmental shots. Wernher von Braun made several proposals to seal this marriage, and as a result the Air Force almost lost Dyna Soar to NASA when the latter took over Saturn in October 1959.[81] With the passing of this hazard, it seemed unlikely that the Air Force would lose Dyna Soar in the future.

Up to this point there had still been no selection of a contractor for the manufacture of the Dyna Soar, and the project seemed stalled in negotiations between USAF agencies and interested industries. In

the midst of these delays, General White expressed dissatisfaction with the lack of progress, and directed that the project "get off dead center."[82] Within a matter of days, lower echelons resolved the remaining contractual difficulties, and on 9 November 1959 the Secretary of the Air Force announced once more the choice of Boeing and Martin as contractors, this time to manufacture respectively the vehicle and the booster. There was widespread satisfaction within the Air Force and elsewhere at the turn of events. As one civilian writer expressed it, the Air Force "soared back" into astronautics with an aerodynamic and maneuverable space ship that would orbit the Earth at a velocity of 14,000 mph, meet the needs of reconnaissance and bombing missions, intercept enemy satellites, and perform a successful reentry and safe landing at the will of the pilot.[83]

Funding the Space Program, 1957-59

The funding of the space program for fiscal years 1958-60 was very complex. Since Sputnik came after the fiscal year 1958 appropriations were already in effect, adjustments to the new requirements were difficult. Later on, complexities increased with the multiplication of space agencies and the transfer of funds among them.

Even within the Air Force it was difficult to unravel the tangle of funding because in preparing the budget Headquarters USAF did not distinguish the space program within the overall USAF program for research and development. Nor did funding plans draw a sharp line between aeronautic and astronautic projects. And finally, the space program, though distinct from the missile program, was dependent upon

the use of ballistic missiles. Thus the space and missile programs overlapped.[84]

Although the Air Force had long entertained space plans, up to October 1957 little money had been allocated to the projects. Through 30 June 1957, BALWARDS (BRATS) had received hardly anything; the Advanced Reconnaissance system got $4.7 million in fiscal year 1956 and $13.9 million in 1957. During these same years the predecessors of Dyna Soar--Bomi-Robo, Brass Bell, and Hywards--received minor allocations. The budget for fiscal year 1958, which had come into effect three months before the advent of Sputnik, allocated $1 million to Brats, $3 million to Dyna Soar and $65.8 million to the Advanced Reconnaissance System--an approximate total of $70 million for space and near-space.*

In January 1958, three months after Sputnik, when the Air Force presented its first systematic plans for a space program, Headquarters proposed that an extra $155 million be added to the original $70 million to make a total of $225 million for fiscal year 1958. The additional $155 million could be obtained from a reorientation of less important aeronautical projects, from the DOD emergency fund, and from supplementary appropriations of $61 million. However, since OSD ignored the plan, the proposal was of importance only insofar as it indicated the trend of USAF thinking and what might have been.[85]

The emergence of ARPA in February 1958 changed all these hopes. Thereafter the Air Force could do no work on its own in space research

*Corresponding Army and Navy statistics have not been available.

and development without specific approval from ARPA. The only exceptions to this general rule were studies costing less than $500,000, and the funding of some facility items such as buildings. Between March and October 1958 all the true space projects of the Air Force, together with funds, passed either to ARPA or NASA.* 86 Consequently the USAF budget allocations to near-space and space projects for fiscal year 1959 fell from the total of $500 million hopefully projected in March to a mere $8.7 million. About half of this sum was allocated to Dyna Soar and BRATS, and the remaining $4.7 million to space studies and lesser items. For fiscal year 1960 the total fell again, this time to a paltry $2.2 million.[87]

Funding was simple during the planning stage for the fiscal year 1960 budget because ARPA and NASA covered almost the entire national space program. The organizational changes of September-October 1959, however, caused a heavy shift in 1960 monies among the agencies. At once, NASA funding was almost doubled, ARPA funding was reduced by nearly four-fifths, and Air Force space funding was multiplied by

*The tabulation of NASA funding for fiscal year 1959 follows:

Inherited from NACA	$101,100,000
Supplementary appropriations	128,400,000
Transferred from ARPA	67,200,000
Transferred from USA (Jet Propulsion Lab)	4,000,000
Transferred from USN (Vanguard)	25,500,000
Transferred from USAF	57,800,000
Total	$384,000,000

88

approximately 120. These same ratios held for the fiscal year 1961 budget, as shown in the following table for the four-year period 1958-61:

Agency	FY 1958	FY 1959	FY 1960	FY 1961
Army	0	0	0	0
Navy	0	0	0	$ 1,300,000
Air Force	$70,000,000	$ 8,700,000	$ 2,200,000	249,700,000
ARPA	83,000,000	331,700,000	307,000,000	67,000,000
NASA	0	384,000,000	535,600,000	915,000,000
AEC				54,000,000 (nuc rocket prpln)

ARPA's total allocations for fiscal years 1959 and 1960 were $520 million and $445 million respectively. The differences between these totals and those listed in the above table represent the work done by ARPA in fields not related to astronautics.

The budget figures do not give an adequate picture of the total contributions made by the Air Force to space work and to the national space program. In fiscal year 1959, ARPA reassigned nearly $300 million to ARDC for work on the Advanced Reconnaissance System and its subsystems and for applied research projects.* Essentially the same thing was planned for fiscal year 1960 before the breakup of ARPA responsibilities. During fiscal year 1960, NASA likewise reimbursed the Air Force to the extent of approximately $100 million

*In the same year ARPA reassigned only $64 million to the Army and $24.9 million to the Navy.

[redacted]

for support of various projects in the civilian program. In addition, the Air Force carried on the following activities that bordered on the space program:

Project	FY 1959	FY 1960
Dyna Soar	$29,500,000	$35,000,000
HETS (Hypersonic Environment Test System, formerly known as BRATS)	4,100,000	3,900,000
Study Requirement Program	2,900,000	3,300,000
Applied Research in Aerospace	27,800,000	42,600,000
Total	$64,300,000	$84,800,000

In further evaluating USAF space activities, the importance of the contribution made by the ballistic missile program must be recognized. For fiscal years 1954-59 the ballistic missile program budgets, including Atlas, Titan, and Minuteman, totaled more than $5 billion. For this same program the 1960 budget was more than $2 billion and for 1961 about $2 billion. How much of these sums may be considered direct support of astronautics is quite impossible to calculate.

Finally, the Air Force made available to ARPA and NASA the vast USAF facilities that had been brought into existence to meet the technological requirements of aircraft and missiles. Again, an estimate of its proportionate worth to the space program is impossible, but without this immense capital investment--nearly $600 million in the Atlantic Missile Range alone--the space program would have been seriously handicapped.

[redacted]

[redacted] CONFIDENTIAL

When all these factors are taken into consideration it is clearly impossible to attempt even a rough financial estimate of what the Air Force contributed to the national space program prior to 1960.

Space Program in December 1959

The record shows that between 1945 and the time of Sputnik in October 1957 the military services were less conservative in their attitude toward space than either the Office of the Secretary of Defense or the Administration. Likewise, the Air Force seems to have been ahead of both the Army and the Navy in space plans. If the projects urged by RAND, AMC, and ARDC, and by some of the latter's development centers, could have been generously supported the Soviets would probably not have won first place for themselves in space.

The record shows also that even after Sputnik there was no immediately invigorated national space program. Months passed in which the policy-making officials of newly created agencies adjusted to new responsibilities. It seemed to the Air Force that the military space requirements could meanwhile have been met by the Department of Defense through existing capabilities and that there was no demonstrable need to segment the program by the introduction of NASC, NASA, ARPA, and other agencies.

Added to these complications was the apparent unwillingness of the Government to accelerate the program sufficiently to admit the United States was in a race with the Soviet Union. Moreover, the Government insisted that the space program should remain dedicated in large measure to science, a policy that severely limited the military projects. And

finally, the Administration's tight rein on funds prevented an accelerated production of available boosters, slowed the development of new boosters, and in general retarded the whole program.[89] Limitations on funds also held back research in such vital supporting areas as nuclear-propelled rockets, hydrogen-oxygen second-stage engines, and plasma and ion technology.[90] These programs were of great importance for the future.

In the first two years that followed Sputnik, however, the American space program suffered most from lack of sufficient thrust to loft large payloads. Of the 6 Soviet vehicles launched during that time--the Kremlin never admitted malfunctions--the payload increased from a minimum of 184 pounds to a maximum on the second shot of 1,120 pounds. On the other hand the Americans attempted 37 launchings of which 19 were either successful or partially successful. But the payloads ranged from a mere 3.5 pounds on the first shot in December 1957 to a maximum of only 372 pounds in 1959. Furthermore not one of the 19 American loftings could equal the spectacular nature of the 6 Soviets shots. The Russians could claim to have been first in space, first to send life into space, first to send a missile into the depths of the solar system, first to impact the Moon, and first to photograph the far side of the Moon.[91]

The Russian triumphs had great psychological-political significance. Dr. Glennan admitted as much when he said on 24 September 1959 that Americans still "play second fiddle in this space business." The President and the Security Council expressed the same view officially

and explicitly, but not publicly, when they acknowledged in January 1960 that the Russian "firsts" resulted in "substantial and enduring gains in the Soviet prestige."[92]

Yet despite the policy confusion and the technological handicaps that prevailed during 1958 and 1959, the Americans made noteworthy contributions to space science. Their success was due largely to the ingenuity of NASA, ARPA, Army, Navy, Air Force, and industrial scientists who devised miniaturized instruments to fit the small payload capacity of available rockets.

The 19 loftings were divided unevenly among five projects--Vanguard, Explorer, Pioneer, Score, and Discoverer. Their first launchings were attempted respectively on 6 December 1957, 31 January 1958, 17 August 1958, 18 December 1958, and 28 February 1959. Vanguard alone had received official approval before Sputnik and was intended to serve solely as a scientific contribution to IGY. Only 3 of its 11 shots were successful. Explorer was hastily conceived by the Department of Defense, primarily as a counterbalance to the Russian success and almost incidentally developed as a means of gathering scientific information for IGY. Actually the project was essentially that advocated by ABMA before Sputnik, namely orbiting a small satellite with a Jupiter C missile. Of 8 attempted launchings, 5 were successful. Pioneer was planned originally by ARPA as a 5-shot lunar probe to match the spectacular Soviet achievements. The first three shots were contracted to the Air Force. The first malfunctioned at launching, the second penetrated 70,000 miles into interplanetary space,

and the third malfunctioned also but not before traveling 963 miles toward the Moon. Of the two shots contracted by the Army, the first vehicle fell back into the atmosphere and burned after reaching an altitude of nearly 67,000 miles, and the second bypassed the Moon and entered solar orbit. Thereafter Pioneer came under NASA control, and in November 1959 a sixth shot ended in malfunction at the time of launching. Score was a single shot project, also conceived by ARPA for propaganda purposes to broadcast the President's voice in a Christmas message from space. Although Score was certainly not a military project, it was not transferred to NASA, and, unlike Vanguard, it was permitted to use a military rocket, the new Atlas of the Air Force.[93]

Project Discoverer was of a different order. Separated from ARS by ARPA in 1958, with AFBMD as contractor, it represented an important stride forward in the military space program. It was painstakingly planned to perform space research in support of advanced military reconnaissance. It could also be helpful in preparing the way for man-in-space projects whether civilian or military. It had six main objectives: test of the satellite airframe and guidance system; test of satellite stabilization equipment; control of satellite internal environment; biomedical experiments with mice and small primates; development of capsule recovery techniques; and test of ground support equipment and personnel proficiency.[94]

There was considerable overlapping in the payload instrumentation of the 19 lofted capsules. In general the five projects gathered scientific information of great value. Knowledge was acquired on such

subjects as cloud cover of the Earth; geodetic configurations; density of micrometeoric matter; the solar-Earth heating processes; the magnetic fields of the Earth and Moon, including the discovery of the Van Allen radiation belts; a wide field of radiation phenomena--cosmic rays, ionizing radiation, and X-ray radiation from the sun; erosion of exposed solar cells; shifts in the external and internal temperatures of the capsules; and biomedical environment.

There were even greater promises for the American program in 1960. Vanguard and Score were finished, but Pioneer and Discoverer were still important, and there were plans for additional Explorer study. NASA contracted the Air Force for further Pioneer space probes. There was a scheduled launching of a Thor-propelled planetoid into solar orbit in March. It was to be sensitively instrumented to serve as a space laboratory to expand the knowledge gained through the work of the two previous years. Conceivably, Pioneer V, as it would be known if it were successful, might become one of the great "firsts" in the history of science. The Air Force, independent now of ARPA, would continue the work with Discoverer to perfect the technique of recovery and other aspects of the advanced reconnaissance program.[95]

There were numerous other launchings scheduled in 1960. The Army's Notus or Advent, as it had come to be known, operating satellites on equatorial 24-hour orbits, would supply a reliable, all-weather, jam-proof communication system. The Navy's Transit would fulfill the need for an all-weather twentieth-century version of celestial navigation, relying on artificial satellites rather than stars. And NASA's Tiros

would give new dimensions to meteorology. All three projects would extend into space the range of time-honored activities previously earthbound. They were sure to be of inestimable value both for civilian and military purposes.[96]

There was also a most hopeful outlook for some of the purely military projects of immediate significance. The Air Force Samos and Midas were needed for reconnaissance, to help insure against surprise attack by photographing unusual enemy activity and by detecting with infrared technique the launchings of enemy ICBM's.

Yet the shadow of too-little-and-too-late continued to darken the national program as a whole. From the spring and summer of 1955 until October 1957 the Soviet Union and the United States were both supporting satellite projects, but the United States avoided a race with Russia, and the Russians took first place. Between October 1957 and December 1959 the Soviet Union and the United States both supported numerous space projects. Again the American Government disavowed the idea of a race with the Soviet Union. And since the latter had the great advantage of high-thrust rockets, the Kremlin was able to be first in many outstanding ventures. As 1959 drew to an end the United States and the Soviet Union were both planning to place a man in space as a step toward the ultimate aim of a manned space station. It could only be hoped that Russia would not once more be first.

Inevitably, and seemingly against the desires of the American Government, we have been drawn into a race for space. The Russian challenge cannot be ignored without forfeiting our position as the leader of the Free World. The prize is within our reach, but to grasp it we must have the heart for the race.

NOTES

1. For a discussion of this problem, see John L. Chapman, Atlas, the Story of a Missile (New York, 1960), p 24.

2. "Research and Rocket Roundup," Missiles and Rockets, Mar 57; Martin Caidin, Countdown for Tomorrow (New York, 1958), pp 139-50; Study by Mary Self, AMC Hist Div, The Development of Guided Missiles, dtd 1950.

3. RAND, RA-15021 through 15032 (S), Feb 47.

4. Ltr (S), Brig Gen Alden R. Crawford, Chief, Engr Div, AMC to DCS/M, Hq USAF, subj: Project RAND, Satellite Vehicle, 8 Dec 47; ltr, Ralph C. Lenz, Jr, D/Plans & Ops, WADD to Col Clyde D. Gasser, SAB, Hq USAF, subj: Air Force Space Program, 7 Apr 60, and Atch 4, Rpt (U), WADC Plans for Space Technology, 1955-58, w/App A (a brief history); Press Conferences with Charles E. Wilson, SOD, New York Times, 13 May and 7 Oct 53 and 16 Dec 54; Facts on File, 5-11 Jan 53; Addresses by Sen Stuart Symington, Congressional Record, 23 Jun 53 and 21 Jul 54, and Statement in Hearings Before Senate Cmte on Armed Services, 24 Feb 55.

5. New York Times, 14 Jun 55; Addresses by Trevor Gardner, Asst SAF (R&D), New York Times, 12 Aug and 9 Dec 55.

6. DOD Rpt to House Cmte on Appropriations, Procurement Policies and Practices, 21 Feb 56.

7. ARDC R&P Project Card (S), Abbreviated System Development Plan, 10 Oct 57; Lt Col F. J. Dillon Jr, Project Mercury, House Rpt 1228, 86th Cong, 27 Jan 60; memo (S) for Richard E. Horner, Asst SAF (R&D) from Herbert F. York, Chief Scientist, ARPA, subj: BAIWARDS Vehicle, 13 May 58; DOD Study (S), Recommendation Against Transfer of CENTAUR to NASA, 5 May 59; memo (S) for Hq ARDC from Hq USAF, subj: BAIWARDS, 15 May 57; ARDC Study (S), HETS, 18 May 58.

8. RAND, RM/2002 (S), 26 Sep 57.

9. WADC Rpt (SRD), The WADC Research Approach, 56 WCRA-504, Aug 56; WADC Rpt (SRD), An Approach to Space Endeavor in Relationship to Current and Future Capabilities of the U.S. Air Force, 57 WCRA-38, Jan 57; WADC Technical Notes (SRD), An Estimate of Future Space Vehicle Capability, WADC TN 57-224, Jul 57; WADC Rpt, WADC Plans for Space Tech, 1955-58.

10. Facts on File, 26-31 Dec 54; Wilson press conference, New York Times, 17 Dec 54.

11. Victor P. Petrov, "Sputnik Not So Secret," Missiles and Rockets, Mar 58; Report of the Teller Committee, 22 Oct 57 (S); John C. Schmidt, "CIA—Eyes and Ears of U.S.," Baltimore Sun, 12 Jun 60.

12. Memo (C) for Secys of Army, Navy, and Air Force from Wilson, subj: Earth Satellites, 28 Mar 55.

13. Memo (S) for Asst SOD (R&D) from Robert W. Cairns, Chmn, Coordinating Cmte of Gen Sciences, subj: Scientific Satellite Program in the Department of Defense, 4 May 55; memo (S) for SAF from Gardner, subj: Scientific Satellite, 17 May 55; Rpt by Surveys and Investigations Staff to House Cmte on Appropriations, "Project Vanguard," in Hearings Before Subcmte of House Cmte on Appropriations, 86th Cong, 1st Sess, Department of Defense Appropriations for 1960, p 6.

14. NSC 5520 (S), 25 May 55; New York Times, 30 Jul 55.

15. Memo (S) for Secys of Army, Navy, and Air Force from Ruben B. Robertson, Jr, Dep SOD, subj: Technological Program for NSC 5520, 9 Sep 55; memo (C) for Asst SN (R&D) from Gardner, subj: Air Force Missile Training Center, Patrick AFB, 10 Jan 56; Werner Buedler, The International Geophysical Year (New York, 1957), pp 49-52; Hearings, "Project Vanguard"; New York Times, 6 Oct 57; Clifford C. Furnas (former Asst SOD [R&D], 1955-57), in New York Times, 16 Oct 57.

16. New York Times, 30 Jul 55.

17. "Project Vanguard," Missiles and Rockets, Jul 55.

18. Lt Gen James M. Gavin, USA (Rtd), War and Peace in the Space Age (New York, 1958), pp 14-15; Testimony by Maj Gen John B. Medaris, USA (Rtd), in Hearings Before House Cmte on Science and Astronautics, 18 Feb 60.

19. Memo (S) for [?] Field, D/R&D from Col William O. Davis, Dep Comdr Ops, AFOSR, subj: FAR SIDE Project Justification, 12 Jul 57; Aeronautics Systems, Inc., Pub C-100 (C), Conduct of Far Side Phase II Experiments, 16 Sep 57; S.F. Singer, "Synoptic Rocket Observations of the Upper Atmosphere," Nature, 20 Jul 54; memo from S.F. Singer, ns, 24 Feb 56, in AFOSR files; memo for Col [?] Flickinger from Col W.O. Davis, subj: Project MOUSE, 30 Jul 54; ltr (S), Brig Gen H. F. Gregory, Comdr, AFOSR to Maj Gen W.M. Morgan, Comdr, CRC, ns, 17 Apr 57; AFOSR Status of Research Projects (S), Jul and Oct 56; ltr (S), Col W. O. Davis to Comdr, ARDC, subj: Coordination of Project FAR SIDE, 25 Oct 57; ltr (C), Brig Gen Alfred D. Starbird, DMA, AEC to Comdr, AFOSR, ns, 17 Apr 57; ltr (C), James H. Douglas, SAF, to Secys of State and Interior, ns, 3 Jun 57; ltr (C), S/State to SAF, ns, 21 Jun 57; AFOSR Management Rpt (C), FAR SIDE, 10 Oct 57.

20. Astronautics, Nov 57.

21. New York Times, 5-6 Oct 57.

22. White House Press Release, 9 Oct 57.

23. Facts on File, 10-16 Oct 57; Washington Post, 1 Nov 57; Facts on File, 31 Oct-6 Nov 57.

24. Rpt of Teller Cmte, 22 Oct 57; memo (S) for Lt Gen John Gerhart, DCS/P&P from Brig Gen W. Martin, Dep D/Plans, ns, 31 Oct 57; Asst C/S(I), Special Air Intelligence Estimate, The Soviet Earth Satellite, 22 Oct 57; Memo for Record, D/Plans, ns but quoting ABMA's proposal; "A National Integrated Missile and Space Vehicle Development Program, 10 Dec 1957," 4 Mar 58.

25. Trevor Gardner, "We Are Still Lagging," Life, 4 Nov 57; A.N. Wechsler, "How Good Are the Pentagon 'Czars'?", Space Aeronautics, Feb 59; Testimony by Dr T. Keith Glennan, Administrator, NASA, in Hearings Before Preparedness Investigating Subcmte of the Senate Cmte on Armed Services, Missiles and Space Activities, 30 Jan 59; memo (S) for SOD from JCS, subj: Department of Defense Special Projects Agency, 25 Nov 57, and JCS Memo (S) same subj, 6 Dec 57; PL 85-325, 12 Feb 58; DOD Directive 5105.15, ARPA, 7 Feb 58.

26. The President's Science Advisory Cmte, Introduction to Outer Space, 26 Mar 58.

27. Message of the President to Congress, New York Times, 3 Apr 58.

28. Ltr, Herbert F. York, Defense D/R&E to Charles F. Ducander, Chief Counsel, House Cmte on Science and Astronautics, ns, 30 Dec 59.

29. NSC 5814/1 (S), U.S. Policy in Outer Space, 18 Aug 58.

30. Ltr (S), Brig Gen Alden R. Crawford, Chief, Engr Div, AMC to DCS/M, Hq USAF, subj: Project RAND, Satellite Vehicle, 8 Dec 47; memo (S) for VC/S from Lt Gen H.A. Craig, DCS/M, subj: Earth Satellite Vehicle, 12 Jan 48.

31. Statement by Joseph V. Charyk, U-SAF, in Hearings Before House Cmte on Appropriations, 22 Mar 60.

32. Ltr, York to Ducander, 30 Dec 59; Statement by Roy W. Johnson, D/ARPA, in Hearings Before House Cmte on Science and Astronautics, Exec Session, 23 Mar 59.

33. Gen Thomas D. White, C/S USAF, "Air and Space are Indivisible," Air Force, Mar 58.

34. Statement by Gen White in Hearings Before House Cmte on Science and Astronautics, 3 Feb 59.

35. Statements by Lt Gen Samuel E. Anderson, Comdr, ARDC, and Brig Gen John A. Barclay, USA, CG/ABMA, in Hearings Before House Cmte on Science and Astronautics, 3 and 5 Feb 59.

36. Memo (C) for DCS/P&P from Col Sydney G. Fisher, Asst D/Policy, subj: Definition of Aerospace, 20 Mar 59; memo (C) for DCS/P&P from Col Richard H. Ellis, Asst D/War Plans, subj: Definition of Aerospace, 26 Mar 59; AFM 1-2, Aerospace Doctrine, 1 Dec 59, p 6.

37. Memo (S) for Gen Gerhart from Brig Gen Homer A. Boushey, D/AT, subj: Air Force Missions In Space, 7 Jan 59.

38. Memo (S) for Gerhart from Lt Gen R.C. Wilson, DSC/D, subj: Air Force Missions in Space, 12 Jan 59; Air Staff Summary Sheet (S), subj: USAF in Space, a Policy Statement, 30 Jan 59; memo (S) for DCS/D from Maj Gen Hewitt Wheless, D/Plans, subj: Air Force Objectives in Space, 5 Feb 59; Hq SAC brochure (S), Strategic Air Command Space Concepts, 13 Aug 59; ltr, Maj Gen R.J. Friedman, D/Budget, Hq USAF to Kelly Campbell, Staff Asst, House Cmte on Appropriations, ns, 9 Oct 59; Johnson statement as cited in n 32.

39. ASSS, 30 Jan 59; as cited in note above; memo (S) for Gerhart from Wheless, subj: Aerospace and National Security 1960-1970, 17 Jan 59; memo (S) for Gerhart from Martin, Dep D/Plans, subj: USAF Responsibilities in Aerospace, 17 Jan 59; ltr (S), Gerhart to Lt Gen Emmett O'Donnell, Jr, DCS/P, ns, 15 Jan 59; memo (S) for D/ARPA from Malcolm A. MacIntyre, U-SAF, subj: Advance Program Areas for Military Space Systems, 14 Apr 59, and 2 incls: Purpose of Requirements and Requirements for Military Space Program; ltr (S), Gen Thomas S. Power, Comdr, SAC to Gen White, ns, 9 Feb 59; ltr (S), Lt Gen B.A. Schriever, Comdr, ARDC to Wilson, ns, 15 May 59; Talking Paper (S) for DCS/P&P, re Gen Power's ltr, 19 Feb 59; ltr (S), Wilson to Schriever, ns, 8 Jun 59.

40. Memo by Col Asa B. Gibbs, subj: Astronautics in the Air Force, nd but evidently written shortly after Sputnik.

41. Memo (C) for VC/S from Col V.Y. Adduci, OLL, ns, 22 Nov 57; memo (S) for Maj Gen Jacob E. Smart, Asst VC/S from Lt Gen Donald L. Putt, DCS/D, subj: Establishment of a Directorate of Astronautics, 10 Dec 57.

42. New York Times, 14 Dec 57; verbal information from office of C/S through Col John L. Martin, D/AT, 27 Jul 60; memo for All Directors et al. from Putt, subj: Cancellation of the Memorandum of 10 Dec 57, dtd 13 Dec 57.

43. Memo (S) for Air Staff from Asst VC/S, subj: Space Projects Involving ICBM/IRBM's, 4 Mar 58; memo (S) for Smart from Maj Gen John Mills, Asst DCS/D, subj: A Directorate of Advanced Weapons, 12 Mar 58.

44. Memo for SAF from Brig Gen Robert H. Warren, Military Asst, Dep SOD, subj: Directorate of Advanced Technology, 22 Jul 58; DAF GO 14, subj: Establishment of Directorate of Advanced Technology (AFDAT), 29 Jul 58.

45. Memo for All Dirs et al. from Wilson, subj: Establishment of AFDAT, 29 Jul 58.

46. Memo (S) for C/S USAF from Boushey, D/AT, subj: Function of AFDAT, 8 Dec 58; memo (S) for Asst VC/S from Maj Gen Charles M. McCorkle, Asst C/S (GM), subj: Function of AFDAT, 13 Jan 59.

47. Memo (S) for Asst C/S (GM) from Boushey, Dep D/R&D, subj: Missile Hearing, 6 Dec 57; memo (S) for C/S USAF from J.H. Doolittle, Chmn, SAB, subj: Space Technology, 9 Dec 57; White, "Air and Space Are Indivisible."

48. Ltr (S), Col Spencer S. Hunn, DCS/D, to Comdr ARDC, subj: Astronautics Program, 5 Feb 1958; Comments by William Weitzen, Dep for Development, Asst SAF (R&D) to H.L. Bowen, 12 Aug 60; telephone conversation with Brig Gen Homer A. Boushey, Comdr, Arnold Engineering Dev Center, by H. L. Bowen, 25 Aug 60.

49. Memo (S), for William Holaday, Defense GM, from Richard E. Horner, Asst SAF (R&D), subj: Air Force Astronautical Development Program, 24 Jan 58; Boushey conversation, 25 Aug 60.

50. Statement by Neil McElroy, SOD, in Hearings Before House Cmte on Appropriations, "The Ballistic Missile Program," 20-21 Nov 57; DOD Directive 5105.15, ARPA, 7 Feb 58; memo (S) for SOD from President Dwight D. Eisenhower, subj: Approval of Advanced Space Projects, 24 Mar 58.

51. Memo for Secys/Army, Navy, and Air Force from Johnson, ns, 27 Mar 58.

52. ARPA Order (AO) 1-58, 2-58, and 3-58, 27 Mar 58; ltr (S), Johnson to the President, ns, 19 Mar 58; ltr (S), President Eisenhower to SOD, ns, 24 Mar 58.

53. Hist, ARDC, 1 Jan-31 Dec 58, Vol I, Sec I, p 18; memo (S) for Gerhart from Boushey, subj: Air Force Mission in Space, 7 Jan 59.

54. Memo (S) for Gen Anderson, ARDC from Boushey, subj: Astronautics Program, 13 Feb 58; memo (S) for SOD from SAF, subj: Requesting OSD Approval of the Air Force Program as Presented 12 Nov 57, dtd 1 Feb 58; memo (S) for SOD from SAF, subj: Request for Approval of Plan to Initiate Five Astronautic Projects, 14 Feb 58; memo (S) for SOD from Asst SAF (R&D), subj: Request that USAF be Made Executive Agent for Some Aspects of ARS, 21 Feb 58; memo (S) for Holaday from

[redacted] CONFIDENTIAL

MacIntyre, subj: Request for Authorization to Proceed with Ablation Nose Cone, 21 Feb 58; memo (S) for SOD from Horner, subj: Request for Approval of WS-117L Plans to Put Series of Unmanned Satellites in Orbit, 21 Feb 58; memo (S) for Holaday from Horner, subj: Explanation of USAF Space Program, 28 Feb 58; memo (S) for SOD from SAF, subj: Program for Defense Against ICBM's, 4 Mar 58; memo (S) for Smart from Boushey, subj: USAF Astronautical Program, 2 Apr 58, and incl: proposed memo for Director, ARPA from Horner, same subj.

55. Memo (S) for Smart from Col L.F. Loesch, Secy/Air Staff, ns, 9 Jun 58.

56. Memo (S) for D/ARPA from Horner, subj: Identification of USAF Research and Development Program—Astronautics, 10 Apr 58; DOD Directive 3200.5, Assignment of Advanced Research Projects to ARPA, 19 May 1958, and subsequent assignment inclosures; AO 4, 28 Apr 58; AO 6, 10 Jun 58, and Tasks 1, 2, and 3 on 16, 19, and 20 Jun respectively; AO 9, 30 Jun 58.

57. Memo (S) for Col Leon Booth, Special Asst, DCS/D from Lt Col Francis J. Dillon, Jr, subj: Air Staff Orientation, 10 Sep 58; memo (S) for Col [?] Evans from Lt Col John R. Ryan, Jr, Asst for Space Systems, ARDC, subj: Air Force Space Programs, 29 Jul 58; AO's 10, 12, 13, 14, 18, and 19, dtd 25 Jul, 25 Jul, 23 Aug, 15 Aug, 27 Aug, 29 Aug 58; AO 17, 4 Sep 58, and Amnd 1, 29 Sep 58.

58. Ltr (S), Gen Curtis E. LeMay, VC/S to Anderson, ARDC, ns, 9 May 58; memo (S) for D/Rqmt from Boushey, subj: Air Force Space Activities, 8 Jan 59.

59. Statement by Dr York, Chief Scientist, ARPA, in Hearings Before Subcmte of House Cmte on Appropriations, 23 Apr 58.

60. Executive Order 10783, 1 Oct 58; AO 28, 29 Sep 58, and Amnd 1, 6 Oct 58.

61. "Next Decade in Space—Special Report on NASA Programs," Aviation Week, 22 Jun 59; AO 2, Amnd 5, 6 Oct 58; AO 12, Amnd 1, 6 Oct 58; AO 10, Amnd 17, 13 Apr 59; AO 17, Amnd 5, 13 Apr 59.

62. Memo for Comdr, AFBMD from Johnson, subj: Redefinition of WS-117L, 10 Sep 58; memo (S) for SAF from Johnson, subj: Policy Relating to the Official Identification of DISCOVERER, SENTRY, and MIDAS, 12 Feb 59; AO's 38, 41, 48, 50, 58, 66, and 83, dtd 5 Nov, 17 Nov, 16 Dec, and 19 Dec 58; 22 Jan, 10 Mar, and 29 Apr 59.

63. Memo (S) for SAF from Brig Gen Robert E. Greer, Asst C/S (GM) subj: Space Programs and Projects, 4 Aug 59; ltr (S), Schriever to Comdr, ARDC, subj: NASA and ARPA Space Program Requirements, 11 Feb 59, and 1st ind, Anderson to C/S USAF, 12 Feb 59.

64. Memo (S) for Deputies et al from Smart, subj: Responsibility for Space Projects, 6 Apr 59; HOI 21-14, subj: Director of Advanced Technology, DCS/D, 13 Apr 59.

65. Ltr, Wilson to All Directors et al; subj: Establishment of the Assistant for Astronautics Systems, DCS/D, 9 Nov 59; DAF GO 4, 14 Jan 60.

66. Memo (S) for JCS from CNO, subj: Single Military Agency to Coordinate Facilities and Functions in the Field of Military Space, 22 Apr 59; Craig Lewis, "Navy Bids to Capture Major Space Role," Aviation Week, 27 Jul 59; memo (S) for JCS from C/S USA, subj: Coordination of Satellite and Outer Space Vehicle Operations, 13 May 59; memo (C) for DCS/P&P from Wheless, D/Plans, subj: Coordination of Satellite and Space Vehicle Operations, 11 May 59; memo (C) for JCS from C/S USAF, subj: Coordination of Satellite and Space Vehicle Operations, 13 May 59.

67. Notes by JCS Secretaries (C), subj: Coordination of Satellite and Space Vehicle Operations, 25 Jun 59.

68. Memo (C) for Dep D/Plans from Col C.J. Butcher, D/Plans, subj: Coordination of Satellite and Space Vehicle Operations, 7 Jul 59; memo (C) for JCS from C/S USAF, subj: Coordination of Satellite Space Vehicle Operations, 10 Jul 59; memo (S) for SOD from SAF, subj: Coordination of Satellite and Space Vehicle Operations, 17 Jul 59.

69. Ltr (S), T. Keith Glennan, Administrator, NASA, to Neil McElroy, SOD, ns, 25 May 59; memo (S) for Maj Gen Ralph P. Swofford, Jr, Asst DCS/D from Boushey, subj: Global Tracking, 1 Jun 59; Col Otto Haney, D/Dev Prog, Comments on Letter of Dr. Glennan to SOD, 25 May 59, dtd 4 Jun 59 (C); ltr (S), MacIntyre to D/ARPA, subj: Proposed Reply to Dr Glennan Concerning DOD Support for Project MERCURY, 9 Jun 59; memo (S) for D/ARPA from Charyk, Asst SAF (R&D), subj: World Wide Tracking Facilities, 23 Jun 59; memo (S) for Asst SAF (R&D) from Johnson, subj: World Wide Tracking Facilities, 24 Jun 59; ltr (S), Thomas S. Gates, Deputy SOD to Glennan, NASA, ns, 30 Jun 59; Memo for Record (S) by Col J. L. Martin, D/AT, subj: Proposed Organization for Support of Project MERCURY, 17 Jul 59; draft DOD directive, subj: Assignment of Responsibility for DOD Support of Project MERCURY, 24 Jul 59; Washington Evening Star, 3 Oct 59.

70. Memo (C) for JCS from McElroy, subj: Coordination of Satellite and Space Vehicle Operations, 18 Sep 59; memo (S) for D/AT from Wheless, D/Plans, subj: Air Force Responsibilities to Other Elements of the Department of Defense for Space Systems, 21 Sep 59; DOD News Release, subj: Space Transfer to Services Planned, 23 Sep 59.

[redacted] CONFIDENTIAL

71. Memo (S) for JCS from Gates, Acting SOD, subj: Responsibility and Organization for Certain Space Activities, 8 Oct 59; draft memo (S) for SOD from JCS, subj: Responsibility and Organization for Certain Space Activities, 19 Oct 59.

72. Memo (S) for Gen Martin, D/Plans, DCS/P&P from Col Robert R. Rowland, Dep D/Policy, subj: Agreement on Super-Boosters, 13 Nov 59.

73. Memo, for Asst Sec DOD (Comptroller) from Gates, Deputy SOD, ns, 1 Dec 59.

74. "Technical Support System Summary," 10 Apr 59; New York Times, 9 Jun 59; DAF White House Information Brief, 12 Aug 60.

75. ARDC R&P Project Card (S), 10 Oct 57; GOR 92, 12 May 55.

76. Memo for Record (S) by Lt Col Benjamin H. Ferrer, DCS/D, subj: Boost-Glide Concept, 4 Nov 57; DCS/D Development Directive 94 (S), sgd by Boushey, subj: Hypersonic Strategic Weapon System, 25 Nov 57; memo (S) for VC/S from Swofford, Asst DCS/D, subj: Accelerate DYNA SOAR Program, 14 Feb 58; memo (S) for C/S USAF from MacIntyre, ns, 5 Jun 58; ltr, Maj Gen W. P. Fisher, Dep D/OLL to Rep. James P. S. Devereux, ns, 16 Jun 58.

77. Ltr (S), Swofford, Actg DCS/D to Comdr, ARDC, subj: Selection of Contractor for WS-464L (DYNA SOAR), 25 Jun 58.

78. Ltr (S), Anderson, Comdr, ARDC to Wilson, DCS/D, ns, 24 Jul 58.

79. Memo for Record (S) by Col Ferrer, D/AT, subj: DYNA SOAR Meeting with Mr. Horner on 2 Oct 58, dtd 6 Oct 58; memo (S) for C/S USAF from Douglas, SAF, ns, 15 Oct 58; memo (S) for All Directors et al. from Col J. R. Finton, Exec, DCS/D, subj: DYNA SOAR, 29 Oct 58; memo (S) for SOD from Johnson, subj: DYNA SOAR, 7 Nov 58.

80. Draft memo (S) by D/AT, 23 Oct 59, to be sent by SAF to SOD, subj: Required Action on DYNA SOAR.

81. Memo for Record by Ferrer, subj: DYNA SOAR Decision, 29 Sep 59; ltr, Col George B. Munroe, Jr, Tech Exec, D/AT, to DCS/D, 18 Nov 59, with 5 atchs and suggestion that DYNA SOAR item be submitted to C/S USAF.

82. DYNA SOAR Chronology, in D/AT files.

83. James Baar, "DYNA SOAR Puts AF Back in Space," Missiles and Rockets, 16 Nov 59.

[redacted] CONFIDENTIAL

84. Statement by Wilson, DCS/D, in Hearings Before House Cmte on Science and Astronautics, 4 Feb 60.

85. Memo (S) for Holaday from Horner, 24 Jan 58, Tab B.

86. Memo (S) for Swofford from Col Martin, D/AT, subj: Presentation for Commanders' Conference, 5 Jan 59.

87. Memo for Record (S) by Boushey, subj: Funding for NASA, 29 Jul 58.

88. Washington Space Letter, 2 Jun 59; NASA, Appropriation Summary FY 1959-1960; ARPA, FY 1961 Budget Program; memo by Maj Gen R. J. Friedman, D/Budget, USAF, subj: Justification of FY 1961 Budget Estimate, 15 Jan 60; The Budget of the United States Government for FY Ending 30 Jun 1960, House Doc 15, Pt I, 86th Cong, 1st Sess; The Budget of the United States Government for FY Ending 30 Jun 1961, House Doc 255, Pt I, 86th Cong, 2d Sess.

89. Testimony by Medaris in Hearings Before House Cmte on Science and Astronautics, 18 Feb 60.

90. Astronautics, Oct 59, pp 20-50; Proceedings of 2d Western National Meeting of the American Astronautical Society, Los Angeles, 4-5 Aug 59; Horace Jacobs, ed, Advances in Astronautical Sciences, Vol 5, Advanced Propulsion and Power (New York, 1960), Pt II.

91. Hanson Baldwin, "Neglected Factor in the Space Race," New York Times Magazine, 17 Jan 60; James Hagerty, Jr, "U.S. Program Has Gone Far in 28 Months," special "Flight" sec in Washington Post, 22 May 60; Clarke Newlon, "We Can Catch the Russians in Space," Missiles and Rockets, 14 Dec 59.

92. Ltr, York to Ducander, House Cmte on Science and Astronautics, 30 Dec 59; George P. Sutton, Chief Scientist, ARPA, "The Military Space Program for 1960," Astronautics, Nov 59; NSC 5918 (S), subj: U.S. Policy on Outer Space, appr by NSC 21 Jan 60 and by the President 26 Jan 60.

93. NASA, International Satellite and Space Probe Summary, 15 Jul 60; NASA, Progress Report (C), 1 Jan-1 Apr 60; NASA, United States and Russian Satellites, Lunar Probes and Space Probes 1957-1958-1959.

94. AFBMD, Summary of Air Force Ballistic Missile Division Activities in Space, Jun 60.

95. Msg 39509, AFBMD to Hq USAF, 7 Jul 60.

96. Sutton, "The Military Space Program for 1960."

G L O S S A R Y

ABMA	Army Ballistic Missile Agency
AEC	Atomic Energy Commission
AFBMD	Air Force Ballistic Missile Division
AFCIN	Assistant Chief of Staff, Intelligence
AFOSR	Air Force Office of Scientific Research
amnd	amendment
AO	ARPA Order
AOMC	Army Ordnance Missile Command
ARPA	Advanced Research Projects Agency
ARS	Advanced Reconnaissance System
atch	attachment
BALWARDS	Ballistic Weapons Research and Supporting System
BMTS	Ballistic Missile Test System
BRATS	Ballistic Research and Test System
chmn	chairman
cmte	committee
CRC	Cambridge Research Center
DMA	Division of Military Applications
DOD	Department of Defense
GOR	General Operational Requirement
HETS	Hypersonic Environment Test System
intcp	interceptor
MIS	Man In Space
mis	missile
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NASC	National Aeronautics and Space Council
nav	navigation
NOTS	Naval Ordnance Test Station
ns	no subject
NSC	National Security Council
nuc	nuclear
OLL	Office of Legislative Liaison
OSD	Office of Secretary of Defense

prpln	propulsion
recon	reconnaissance
SA	Secretary of the Army
SAB	Scientific Advisory Board
SAF	Secretary of the Air Force
sat	satellite
SN	Secretary of the Navy
SOD	Secretary of Defense
SR	Study Requirement
S/State	Secretary of State
U-SAF	Under Secretary of the Air Force
WADC	Wright Air Development Center
WADD	Wright Air Development Division
WDD	Western Development Division

Satellite Launchings*

4 Oct 1957 to 26 Nov 1959

Source	Code Name	Launch Date	Success
USSR	Sputnik I	4 Oct 57	Orbital
USSR	Sputnik II	3 Nov 57	Orbital
Navy	Vanguard (1)	6 Dec 57	Manfunction
Army	Explorer (1) I	31 Jan 58	Orbital†
Navy	Vanguard (2)	5 Feb 58	Malfunction
ARPA-Army	Explorer (2)	5 Mar 58	Malfunction
Navy	Vanguard (3) I	17 Mar 58	Orbital†
ARPA-Army	Explorer (3) II	26 Mar 58	Orbital
Navy	Vanguard (4)	28 Mar 58	Malfunction
USSR	Sputnik III	15 May 58	Orbital†
ARPA-Navy	Vanguard (5)	27 May 58	Malfunction
ARPA-Navy	Vanguard (6)	26 Jun 58	Malfunction
ARPA-Army	Explorer (4) III	26 Jul 58	Orbital
ARPA-USAF	Pioneer (1)	17 Aug 58	Malfunction
ARPA-Army	Explorer (5)	24 Aug 58	Malfunction
ARPA-Navy	Vanguard (7)	26 Sep 58	Malfunction
ARPA-USAF	Pioneer (2) I	11 Oct 58	70,000 miles
ARPA-Army	Beacon (1)	23 Oct 58	Malfunction
ARPA-USAF	Pioneer (3) II	8 Nov 58	Malfunction at 963 miles
ARPA-Army	Pioneer (4) III	7 Dec 58	66,654 miles
ARPA-USAF	Score	18 Dec 58	Orbital
USSR	Lunik I	2 Jan 59	Solar orbit†

(contd)

(contd)

Source	Code Name	Launch Date	Success
NASA-Navy	Vanguard (8) II	17 Feb 59	Orbital†
ARPA-USAF	Discoverer (1)I	28 Feb 59	Orbital
ARPA-Army	Pioneer (5) IV	3 Mar 59	Solar orbit†
ARPA-USAF	Discoverer (2) II	13 Apr 59	Orbital
NASA-Navy	Vanguard (9)	13 Apr 59	Malfunction
ARPA-USAF	Discoverer (3) III	3 Jun 59	Malfunction
NASA-Navy	Vanguard (10)	22 Jun 59	Malfunction
ARPA-USAF	Discoverer (4) IV	25 Jun 59	Malfunction
ARPA-Army	Explorer (6)	16 Jul 59	Destroyed
ARPA-USAF	Explorer (7) IV (Paddlewheel)	7 Aug 59	Orbital†
ARPA-USAF	Discoverer (5) V	13 Aug 59	Orbital†
ARPA-Army	Beacon (2)	14 Aug 59	Malfunction
ARPA-USAF	Discoverer (6) VI	19 Aug 59	Orbital
USSR	Lunik II	12 Sep 59	Impacted Moon
ARPA-Navy	Transit (1)	17 Sep 59	Malfunction
NASA-Navy	Vanguard (11) III	18 Sep 59	Orbital†
USSR	Lunik III	4 Oct 59	Photo of far side of Moon
NASA-USAF	Explorer (8) V	13 Oct 59	Orbital†
USAF	Discoverer (7) VII	7 Nov 59	Orbital
USAF	Discoverer (8) VIII	20 Nov 59	Orbital†
NASA-USAF	Pioneer (6)	26 Nov 59	Malfunction

*Arabic figures represent firings; Roman figures successful results except for Discoverer. The Air Force carries Roman figures regardless of results.

†Still in orbit at the close of 1959.