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ORIGINS OF THE USAF SPACE PROGRAM - 1945-1956

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ORIGINS OF THE USAF SPACE PROGRAM

1945-1956

by
Robert L. Perry

prepared as
Volume V
(Space Systems Division Supplement)
HISTORY OF DCAS
1961

HOWELL M. ESTES, JR
Lieutenant General, USAF
Deputy Commander (AFSC)
for Aerospace Systems

APPROVED:
Chief, DCAS Historical Office

RALPH LEMES
Colonel, USAF
Assistant for Administration

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Viewpoints on Space Technology:

Before long, someone will start on the construction of a satellite vehicle, whether in the United States or elsewhere. History shows that the human race does not allow physical development to lag very far behind the mental realization that a step can be taken. This is particularly true of progress which has a direct bearing on man's conquest of his environment. . . .

Since the United States is far ahead of any other country in both airplanes and sea power, and since others are abreast of the United States in rocket applications, we can expect strong competition in the latter field as being the quickest shortcut for challenging this country's position. No promising avenues of progress in rockets can be neglected by the United States without great danger of falling behind in the world race for armaments.

J.E. Lipp
RAND Report RA-15032
"Reference Papers Relating to a Satellite Study,"
1 February 1947

The type of pyramidal totalitarian regime that the Communists have centered in Moscow . . . is not adapted for effective performance in pioneering fields, either in basic science or in involved and novel applications . . . Hence it is likely to produce great mistakes and great abortions.

No other nation will have the atomic bomb tomorrow, . . .

It [the ballistic missile] would never stand the test of cost analysis. If we employed it in quantity, we would be economically exhausted long before the enemy.

Vannevar Bush
Modern Arms and Free Men, 1949

FOREWORD

The United States did not have a space program of any sort until 1954, when the Air Force finally secured permission to begin preliminary work on a satellite reconnaissance system. About one year later, in the spring of 1955, the National Security Council's decision to permit development of a relatively simple "scientific satellite" marked the start of another approach to space activity. In both instances, it was 1956 before much in the way of funds was available to support either activity.

The background of American space interest before the 1954-1955 period remains comparatively obscure, even to specialists. During the epidemic of space fever that swept the nation following the Soviet successes of late 1957, the general public became rather hazily aware of such earlier related activities as the experiments of Robert H. Goddard, the development of the German V-2, and the security-shrouded intercontinental ballistic missile program. But perhaps because the years between 1945 and 1957 had seen slight American space enterprise, and perhaps because Americans little like to be told of their failings, the details received no significant attention.

The purpose of this brief study is to gather some of the threads of space enterprise in the 1946-1956 period. For obvious reasons, attention is concentrated on the American scene and, still more narrowly, on the role of the United States Air Force. Nevertheless, an attempt has been made to provide some perspective on other activities related to that general theme.

Available sources are few. H. Lee Bowen's Threshold of Space, 1945-1959 devotes only portions of its first 18 pages to the pre-1957 years. He had completed the draft of a more detailed treatment of Air Force space programs by the middle of 1962, but its publication date remained uncertain. No other Air Force history deals with the period in any depth. Of course, a phalanx of popular writers of variable talent and uncertain knowledge had flooded the market with pseudo science treatises on space flight by 1960, but none of these writers made much use of official documents and most were more concerned with dramatics than with the relatively prosaic background to the Sputnik years.

In the interest of early publication, research for this history was limited largely to sources available within the Space Systems Division (Air Force Systems Command) at the time of writing. Dr. Bowen, in Air Force headquarters, provided both advice and specific information from his own research, while cheerfully acceding to the use of some material he had laboriously gathered for his own work. Bits and pieces of data came from the office of the command historian and from a skimpy lot of documents collected by the author during an earlier assignment to the Aeronautical Systems Division. Advice, guidance, and invaluable information were also provided by several individuals assigned to both the Space Systems Division and its sibling, the Ballistic Systems Division. Major General R. E. Greer, Colonels P. E. Worthman and Ray Soper, and Lieutenant Colonel V. M. Genez were particularly helpful. Individual acknowledgements are provided in citations of the information as it appears in the narrative.

It is to be hoped that additional information bearing on the formative years of the space program will appear as a result of continuing research. Much that is critical to an adequate understanding has been forgotten, or the records have disappeared. Comments on the accuracy and completeness of this account are, therefore, openly solicited, and any contributions individual readers can make either to the fund of facts or to their interpretation will be most welcome. A continuation of the history of Air Force space programs, probably covering the period from 1955 through 1959, is presently in the research stage with publication scheduled, hopefully, for late 1962 or early 1963. Revision of this manuscript to reflect the product of reader commentary and additional research may then be attempted.

RLP
August 1962

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SPACE FLIGHT CHRONOLOGY - 1890-1956

1890	Hermann Ganswindt proposes a reaction-powered space ship
1895-1898	First publication of Konstatin Tsiolkovski articles on the mechanics and theory of space flight
1906-1908	Robert H. Goddard begins experiments with powder rockets
1914	Goddard patents liquid rocket engine
1919 Jan	Publication of Goddard's "A Method of Reaching Extreme Altitudes"
1923	Hermann Oberth publishes his doctoral thesis on space flight
Nov	Goddard successfully static tests the world's first liquid fuel rocket engine
1927 Jul	German Society for Space Flight is formed
1929	Oberth's book, Wege zur Raumschiffahrt, containing engineering details of a satellite rendezvous proposal, is published
1933 Jan	Wehrmacht assumes control of German rocket experimentation; Captain Walter Dornberger is assigned to monitor program for the eventual development of a bombardment rocket
1935 May	Goddard fires a liquid-fuel test rocket to an altitude of 7,000 feet
1938	Formal development of A-4 (V-2) missile begins at Peenemunde
1942 Oct 2	V-2, on third attempt, successfully completes its initial field trial
1944 Sep 8	The first V-2 hits London
1945 Oct 3	U S Navy Bureau of Aeronautics proposes development of an American satellite
1945 Nov	General of the Armies H H Arnold urges that the air service start the development of long range ballistic missiles and space vehicles
1945 Dec	Dr Vannevar Bush [illegible] Arnold recommendations in testimony before S[illegible]

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1946	Mar 7	U S Navy proposes interservice space program
	Apr 9	Aeronautical Board of Research and Development Committee first discusses proposal for American satellite program
	May 12	U S Army Air Forces receive the RAND study proposing early development of an American satellite and attesting to the feasibility of the undertaking
	May 14	Major General C E LeMay presents AAF-RAND study to the Aeronautics Board of the Research and Development Committee; board fails to take any action
1947	Jan	U S Navy asks Research and Development Board for authority over United States satellite development
	Jun	Aeronautical Board requests authority to fund satellite studies
	Sep 18	United States Air Force officially created and activated
	Sep 25	USAF headquarters directed Air Materiel Command Engineering Division to evaluate RAND satellite studies received the previous February
	(Fall)	White Sands Proving Ground designs and proposes Army space flight experiment
	Dec	Navy claims satellite jurisdiction; USAF rocket programs dropped
	Dec 8	Engineering Division completes evaluation of RAND satellite proposals
	Dec 19	Joint Research and Development Board Committee on Guided Missiles acquires Department of Defense responsibility for coordination and control of Earth Satellite Vehicle programs
1948	Jan 15	General H S Vandenberg issues policy statement on primacy of USAF space interest
	Jan 16	Navy withdraws claim for control of satellite development
	Oct	"Grimminger Report" is published, starting United States interest in a scientific satellite
1951		The Artificial Satellite, first published work on scientific space experimentation, appears
1953	May 22	USAF headquarters directs the Air Research and Development Command to investigate the feasibility of starting development of an auxiliary nuclear power source for satellites
	Jun 16	Defense Secretary C E Wilson directs review of all guided missile programs with the objective of eliminating duplicative effort
	Sep 8	RAND recommends that the USAF let a contract for development of a satellite system with a reconnaissance mission
	Dec 3	Weapon System 117L, Advanced Reconnaissance System, is documented by ARDC as first step toward securing approval for a system program

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1954	Mar 1	RAND formally recommends early start on the development of a reconnaissance satellite
	Aug	Congress approves United States participation in the International Geophysical Year program
	Sep 15	Army Ordnance proposes development of a minimum satellite under the name "Project Orbiter"
	Oct	USAF Assistant Secretary Trevor Gardner asks the Scientific Advisory Group to study and report on the interaction of current satellite proposals with the recently accelerated intercontinental ballistic missile program
	Nov 27	System Requirement Number 5 is issued, covering a reconnaissance satellite
	Dec 14	Army representatives approach the other services with proposals for cooperative development of Project Orbiter
1955	Mar 16	General Operational Requirement Number 80 is issued, covering development of a reconnaissance satellite
	May 26	The National Security Council rules that military rockets may not be used in the United States scientific satellite program
	Aug	The Stewart Committee selects the Navy Vanguard proposal as the United States scientific satellite program
	Aug 31	USAF headquarters directs ARDC to establish a scientific satellite auxiliary to the Weapon System 117L program
	Oct 10	Responsibility for Weapon System 117L is transferred from Wright Air Development Center to the Western Development Division of ARDC
	Oct 14	USAF cancels the requirement for a scientific satellite version of Weapon System 117L
	Nov 1	USAF directs re-establishment of scientific satellite program and submission of development plan
1956	Jan 14	Preliminary development plan covering a scientific satellite version of Weapon System 117L is published; Western Development Division emphasizes urgency of support requirements if program is to have any chance of success
	Jan 16	ARDC headquarters approves preliminary development plan
	Feb	Presentation of ARDC plan to Stewart Committee
	Apr 2	Western Development Division publishes full development plan for Weapon System 117L
	Jul 24	USAF approves development plan for Weapon System 117L

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INTRODUCTION

If there is a theme to the following narrative, it is that the United States did not exploit its initial postwar advantage over Soviet technology. There is significant evidence to support the conclusion that American science could have pushed the nation into the space age in advance of the Russians. The key event was the successful launch of a satellite, and here the United States clearly failed to take the initiative.

The enormous advantages of such an undertaking have often been stated in retrospect, hindsight being one of the most highly perfected human characteristics. Enhanced national prestige, a significant lead in the space race, and substantial benefits to national security would certainly have resulted from the launching of a successful American satellite at any time between 1946 and 1956. It is little known that precisely such benefits were foreseen on the occasion of the first serious engineering proposal that the United States sponsor a satellite program. Ten years before Sputnik, in February 1947, a RAND report prepared for the air forces predicted:[1]

> . . . Although trips around the moon and to neighboring planets may seem a long way off, the United States is probably in a better position at present to progress in this direction than any other nation. Since mastery of the elements is a reliable index of material progress, the nation which first makes significant achievements in space travel will be acknowledged as the world leader in both military and scientific techniques. To visualize the impact on the world one can imagine the consternation and admiration that would be felt here if the United States were to discover suddenly that some other nation had already put up a successful satellite.

Rarely has a forecast been so accurate!

By 1946 it was apparent to many that the United States then had sufficient technical competence to embark on a realistic space program with attainable objectives. Contemporary studies and related correspondence clearly show that both technical specialists and Air Force managers had an abundance of vision. In the early years, before 1952, the booster problem in particular would have been troublesome, but the difficulties were probably no more formidable than those overcome in developing and operating the X-1, the first supersonic aircraft. And from the level of the Air Force chief of staff down to project engineers, virtually everyone exposed to the potential of the space proposals became an enthusiast. What happened, then, to delay for a decade the nation's decision to enter the space age?

Lack of real progress between 1945 and 1955 was attributable chiefly to a sequence of circumstances stemming from the extreme conservatism of national goals. Like the "experts" who early denied that aircraft could ever play a useful military role, critics of the embryonic space proposals questioned both the feasibility and the utility of a space program--and sometimes slighted the good sense of its supporters. The dominant attitude paralleled that of Secretary of Defense Charles E. Wilson, who in the late months of 1954 told reporters he had never heard of an American satellite program and when informed that the Soviets might orbit a vehicle earlier than the Americans responded publicly that he "wouldn't care if they did." Most Americans, secure in their transitory nuclear dominance and thinking of national strategy in terms of World War II concepts, probably would have agreed with him.

There were other difficulties and problems in the early space effort. Interservice rivalry certainly was one. Austere budgets, without "frills" like missiles and satellites, constituted another. The space effort certainly was not the sole victim; over the same decade relatively little progress was made in the development of ballistic missiles, nuclear propulsion for both aircraft and submarines remained sludgebound, and experimental aerodynamics was so thoroughly stifled that some operational prototype aircraft of 1958 were superior in performance to contemporary research aircraft.

It should be remembered, nonetheless, that the decade before 1956 was marked by the emergence of the first intercontinental bombers (produced over the violent protests of many who decried the practicality of intercontinental bombardment), the first turbojet aircraft, the first hydrogen bomb, and a host of other major advances. It should also be recalled that notwithstanding national folklore, [redacted]ism has never looked with particular favor on revolutionary military technology--as witness the fate of General Mitchell--and that the results of World War II had reinforced a national faith in rapid mobilization (the "minuteman syndrome") and an unmatched production potential as panaceas for disabilities arising from lack of preparedness. It is an historical cliche that the United States has entered every war superbly prepared to win the previous war. In this context, the struggles of space program advocates to obtain recognition, and their success in advancing basic technology to the point where a 1955 start on a space program could be realistically scheduled, probably deserve more praise than they have been accorded.

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1 "RAND Rpt RA-15032, "Reference Papers Relating to a Satellite Study," 1 Feb 1947, p 48; see also Douglas Airc Co Rpt SM-11827, "Preliminary Design of an Experimental World-Circling Space Ship," 2 May 1946 (commonly cited as a RAND report under that title and date).

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CHAPTER 1

THE BEGINNINGS

In the conception of the United States Air Force, "space" is part of an operationally indivisible medium called "aerospace," a continuum from the surface of the earth through the atmosphere to the limits of the solar system--or the universe. In the years preceding that October 1957 day when the first Sputnik radioed from orbit, and in the furor following that day, a great many specialized definitions of "space" were foisted on a confused public. Such terms as cis-lunar space, trans-lunar space, interplanetary space, near space, deep space, and cosmic space were employed loosely, each defined by its employer. Subsequently there emerged a better understanding of such terminology, and "space" came to mean that near-airless regime above which vehicles could not maneuver by aerodynamic processes. As time passed, that altitude was informally defined as 25 to 50 miles above the earth. A different working formula derived from experience with early satellites, and in that context "space" came to mean the height above which it was possible for an object to remain in orbit for significant periods without catastrophic degradation of performance because of aerodynamic drag. The minimum height for such performance was informally defined as being about 100 miles above the earth's surface. Between, in the altitudes from 50 miles to 100 miles above the surface, there existed insufficient atmosphere to support aerodynamic flight and too much to permit orbital flight.

None of these considerations was of any moment when the first technical discussions of space flight began to appear at the start of the twentieth century.* Such discussions preceded by many years the first consideration of rockets as long-range bombardment devices.

The earliest serious proposal for a space ship emerged from the mind of Hermann Ganswindt, a German dabbler in science and invention, who in 1890 contributed the notion of a reaction-powered vehicle based on reasonably sound theory but impossibly impractical engineering details. Ganswindt apparently preferred to argue the theory rather than improve the details, and apart from stimulating some heated but skeptical discussion in minor technical journals had no lasting influence.

Konstantin Tsiolkovski (also Ziolkovsky) was a Russian, a teacher largely self-educated in physics and mathematics, who first mentioned the possibility of space flight in an 1895 article which, somewhat to his surprise, was accepted and published. By 1898 he had carefully refined his ideas on the subject--which had fascinated him for perhaps 20 years--and had arrived at a workable rocket theory involving liquid fuels based on kerosene, the only then-apparent means of producing the exhaust velocities he knew to be essential. He devoted another 25 years to further studies, with little or no experimentation, before receiving any general recognition. Even then, that recognition came because the Soviet state was interested in demonstrating that a native Russian had been the first to propound mathematical formulae for rocketry.

Tsiolkovski knew nothing of Ganswindt, and neither of the two pioneers who followed Tsiolkovski heard of him before their own work became rather well advanced. The creation of useful interest in rocketry--and in space flight--was the achievement of a German--Hermann Oberth--and an American--Robert H. Goddard--whose work was for practical purposes entirely

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* Consideration of non-technical (fictional) or pseudo-science (fanciful) treatments of space flight has been excluded from this volume for two reasons: apart from stimulating interest in adolescent minds such science-fiction had no influence on later events, and the subject has been exhausted to the point of ennui by any number of students and connoisseurs of the literature of science [redacted]

independent of outside influences. Oberth was a theoretician and Goddard an experimenter. Oberth had space flight in mind from the start; Goddard was interested in rocketry almost as an end in itself. Oberth never succeeded in transforming his entirely sound concepts into a functioning rocket engine; Goddard did virtually no public theorizing until he had proven the validity of his concepts by demonstration. Goddard was a proponent and practitioner of pure research; with Oberth, the object of space flight far overbore considerations of science in the abstract. Goddard published only two significant items, and one of these was a 1919 paper which evoked enough public ridicule (because it gently suggested the theoretical feasibility of hitting the moon with a payload of flash powder) to cause its author deliberately to seek obscurity for 16 years. Oberth was more interested in obtaining support for his ideas than in proving or trying them, and he was entirely willing to employ such unprofessional media as pseudo-science motion pictures in the process. Goddard was the first man to build and successfully test a liquid-fuel rocket (November 1923), and by May 1935 had succeeded in sending a gyroscope-stabilized rocket to an altitude of 7,000 feet. (The best of the pre-Peenemunde rockets created by the German research group that eventually developed the V-2 was much heavier but attained an altitude of only 6,500 feet in about the same time period.) Oberth's efforts resulted in the formation, in July 1927, of a German Society for Space Flight which promptly set about recruiting enthusiasts, seeking publicity, and collecting funds to support experimental work. Goddard carried his objections to publicity so far as to refuse to answer letters from such groups. In 1929 Oberth reworked his 1923 book, which had started the enthusiasm in Germany, and produced as a result the most authoritative of the early treatises on experimental rocketry. Goddard made no effort to circulate the results of his work until 1936, when it was largely complete (at least he carried it little further).

Indirectly, Goddard's work led to the formation of the Aerojet Engineering Company through the Guggenheim Foundation (Jet Propulsion Laboratory of the Guggenheim Aeronautical Laboratory at California Institute of Technology), the interest of Dr. Theodore von Karman, and Army Ordnance

Department desires to use high altitude rockets to prove-out missile designs. Very much the same thing came from Oberth's efforts, which led with similar indirection to German Army sponsorship of the experimental work being conducted by the "Society for Space Flight." The Wehrmacht, of course, was not interested in space flight but was very much interested in long range artillery that did not come under the ban of the Treaty of Versailles. As it happened, that treaty became inconsequential shortly after the German Society for Space Flight did the same; Hitler's seizure of power in January 1933 coincided with the start of Army-funded rocket research, and the indifferently concealed rearmament of Germany thereafter obviated the need for any particular disguise. By that time, however, the well financed experiments had been transferred to Peenemunde, on the Baltic coast, and had produced results which encouraged the Wehrmacht to continue research toward the objective of a long range bombardment rocket. Wernher von Braun, a boyish latecomer to the Society for Space Flight, became the principal civilian manager of the Peenemunde work and converted to his way of thinking--that missiles were a step toward space flight, not an end in themselves--the unlikely figure of the military chief, Captain (later Lieutenant General) Walter Dornberger. With resources that at one time accounted for at least one third of Germany's entire aerodynamic and technological research establishment, they moved with relative rapidity from the primitive rockets of 1933 to the operationally ready V-2 bombardment missiles of 1943. Development of the V-2, or properly the A-4, began during the winter of 1938-1939 as the climax of five years of applied research. The first successful operational prototype, and the third test vehicle in the series, completed a field trial on 2 October 1942; more than 100 production versions were tested in Poland in the early months of 1943. The first combat firing at London came on 8 September 1944, and by March of the following year more than 1,300 V-2's had followed the first to England.

Unfortunately, from the standpoint of the scientist and the space flight enthusiast, concentration of attention on bombardment missiles neatly eliminated serious work on space research. At least four people (Tsiolkovski, Oberth, Goddard, [redacted] of Hamburg) had

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worked out perfectly valid data on exhaust velocities, mass ratios, and trajectories before 1930; the decade of the 30's was spent in carrying rocket technology to the point of practical application, and during the first half of the 40's rocket technology was applied to the art of war. There were some few exceptions--concentrated largely in Germany, where the only propulsion systems with sufficiently high thrust to promise eventual space applications were being perfected. Walter Dornberger recalled several years after the fact that "our aim from the beginning was to reach infinite space, and for this we needed speeds hitherto undreamed of. Range and velocity were the great landmarks that guided our thoughts and actions."* In another context he remarked, "With our big rocket motors and step rockets we could build space ships which would circle the earth like moons . . . Space stations . . . could be put into orbit around the earth. An expedition to the moon was a popular topic too." He also conceded, however, that most German scientists were not interested in anything beyond the atmosphere. [1]

In point of fact, Oberth was the first practicing scientist to have a clear concept of a useful artificial satellite, although his theorizing, carried to the point of detailed formulae, was concentrated about the notion of man-carrying satellites. and space ships. Lacking any appreciation for the probable growth of guidance and control technology to match what he anticipated for rocketry, Oberth largely ignored the possibility of robot vehicles. He saw specific applications

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* Dornberger wrote the quoted words in 1952, seven years after the collapse of Nazi Germany but five years before the first Sputnik. When he put them on paper, he was principally engaged in work on a boost-glide vehicle for military uses--a vehicle of semi-orbital character based on the Sanger-Bredt thesis. It may reasonably be assumed, however, that his memory was precise. It is certain that most military organizations developing large rocket engines contained a noticeable sprinkling of space flight advocates, and in a group built around the core of Oberth disciples the probability was impressively high.

[redacted]

in observation, mapping, and communications--among other fields.* Interestingly enough, he clearly foresaw, in 1924, the probable need for rendezvous satellite stations to carry additional fuel for true extra-terrestrial expeditions.

In the immediate postwar years, only two serious mentions of satellite programs received much public notice. Defense Secretary James V. Forrestal's brief mention of the possibility of military satellite applications in his 1948 report on the state of the National Military Establishment drew slight--and sometimes condescending--attention. The publication of a short article (later called the Grimminger Report) in the October 1948 issue of the Journal of Applied Physics drew notice to the concept of a scientific satellite, but except among devotees of space flight it had little lasting influence. Popularization of the space flight thesis had its start in the early 1950's, with Wernher von Braun's impassioned advocacy of the need for manned space stations for military purposes--an obvious outgrowth of the Oberth thesis--and with a gradual growth of interest in instrumented satellites--an evolution of the Goddard theme--among physical scientists in general. A slim 1951 volume entitled The Artificial Satellite constituted the first public circulation of an entire book devoted to discussion of the subject. Its emphasis was on a "minimum space vehicle," a favorite 1953-1955 project of several prominent British and American scientists. At that point, the "open" aspects of satellite work began to merge again with the military aspects. The "minimum" satellite became the core of a classified Army-Navy project, Project Orbiter, and the whole blended imperceptibly with International Geophysical Year proposals then gaining adherents. Almost inevitably, the feasibility of experimentation with satellites and space vehicles became associated with the only available launch vehicles: the military rockets then under development. Private enterprise had neither the means nor the motivation to support multi-million dollar space research.[2]

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* In a fashion that was reminiscent of Goddard's brief excursion into the feasibility of a moon rocket, Oberth touched in passing on the notion of an orbiting mirror that could focus the sun's rays on an area of the earth--for heat and light. In the circus atmosphere of the immediate postwar world, the pseudo-science publications seized upon his vagrant (and most impractical) thougnt and emerged with conceptions of a deadly space mirror focusing intense heat [redacted] untryside.

NOTES - CHAPTER 1

1. Walter Dornberger, V-2, New York Viking Press, 1958 (copyright 1952 in German edition); Dornberger testimony before Select Committee on Astronautics and Space Exploration, 85th Cong, 2nd Session, 30 Apr 1958, in Hearings Before the Select Committee. . . , on HR 11881.

2. Except where specifically noted, the foregoing summary is based principally on Willy Ley, Rockets, Missiles, and Space Travel (New York, Viking Press, 1957 edition), and Arthur C. Clarke, The Making of a Moon, (New York, Harper and Brothers, 1957). Ley was personally associated with the early German experiments and knew virtually all of the participants. He remained on friendly terms with both von Braun and Dornberger in later years. Clarke is, next to Ley, the most popular and the most proficient of those who write on space flight topics and has the additional qualification of being both a practicing and a preaching space scientist. The literature on early space work is relatively sparse, but there is a considerable fund of related material on early missile and rocket experiments. Robert H. Goddard, A Method of Reaching Extreme Altitudes (Smithsonian Institute, 1919), and Liquid-Propellant Rocket Development (Smithsonian, 1936), are the only original products of America's rocket pioneer, although his wife presented major excerpts from his notebooks in the posthumous Rocket Development (New York, Prentice Hall 1948). E.G. Pendray, The Coming Age of Rocket Power (New York, Harpers, 1945), is the earliest reliable summary of the work of the American Rocket (Interplanetary) Society, but has virtually no emphasis on space flight. Hermann Oberth, Wege zur Raumschiffahrt (Munich, 1929) (Road to Space Travel), lacks adequate translation but is essentially the core of Man Into Space (New York, Whittsley House, 1953), even though the English language version carries heavy evidence of hindsight and popularization. K.W. Gatland, Project Satellite (New York, British Book Centre, 1958) provides almost the only other readily available source on early origins of space research. Anything resembling a definitive history of the subject remains to be written.

CHAPTER 2

THE EVOLUTION OF A POLICY

The jetsam strewn over the face of Europe in the process of dismembering the Third Reich included vast quantities of technical data and a respectable assemblage of practicing rocket scientists. Within reasonable limits, the western allies cooperated with one another in the collection and disposition of such esoteric war booty; the scavengers of the Soviet Union competed hotly with the West for equipment, records, and personnel of the defunct German missile programs. In the scramble, the United States fared rather well, emerging with missiles and rocket engines sufficient for several dozen test shots and with personnel and records sufficient to keep intelligence specialists and scientists busy for months--or years.*

All three services promptly set to work on missiles and rockets based on the German originals as well as a few of the more advanced products of domestic wartime research and development. Something more than academic interest was displayed in the question of whether ballistic missiles constituted an extension of air warfare, a variant of long range artillery, or a possible extension of the technique of a naval strike force.

The concept of long range ballistic missiles was sufficiently foreign to the United States experience to require a considerable revision of established theories there. The exploitation of loosely defined space vehicle research

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* Because of the fact that the ground and air arms of the Army were competing with one another, and both with the Navy, in the "liberation" process, it was impossible to specify with accuracy how much each service accumulated. An indicator may be found, however, in the experience of the Department of State, the only agency officially interested in collecting German diplomatic records. Material transported to the United States for examination and utilization was too bulky to permit page counts; the total of diplomatic correspondence and records came to more than 450 tons.

conducted by the Germans required still more vision than was common to the postwar years. The first prominent American with courage to speak forthrightly about the future of warfare in such a context was General of the Armies H. H. Arnold. In his "War Report," a summary of achievements and an anticipation of needs, he stated the problem baldly:[1]

> . . . we should be ready with a weapon of the general type of the German V-2 rocket, having greatly improved range and precision, and launched from great distances.
>
> * * *
>
> If defenses which can cope even with such a 3,000-mile-per-hour projectile are developed, we must be ready to launch such projectiles nearer the target, to give them a shorter time of flight and make them harder to detect and destroy. We must be ready to launch them from unexpected directions. This can be done from true space ships, capable of operating outside the earth's atmosphere. The design of such a ship is all but practicable today; research will unquestionably bring it into being within the foreseeable future.*

The first identifiable interest in a specific American space program was expressed by a group of Bureau of Aeronautics planners under Commander Harvey Hall. By the fall of 1945 they had sifted through enough of the Peenemunde refuse to acquire enthusiasm for the vague satellite proposals that had emerged from the final years of the German programs. In the course of a 3 October 1945 meeting, Hall and his fellows in the Electronics Division of the bureau suggested the need for a satellite test program to determine the basic feasibility of the concept. With some support from a Navy that was willing to investigate virtually any foreseeable future mission (Bureau of Aeronautics created a Committee for Evaluation of the Feasibility of Space Rocketry), the Hall group opened a series of discussions with the

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* General Arnold's forecast was promptly ridiculed as "more or less fantastic" and as the sort of thing that ". . . is impossible today and will be impossible for man years" in official testimony by the wartime head of American research programs, Vannevar Bush--which may help to explain why only two official statements on space research reached the public in the years betwee[redacted]

Guggenheim Aeronautical Laboratories at California Institute of Technology, with Glenn L. Martin Company, with North American Aviation, Incorporated, and with the Douglas Aircraft Company. By early 1946, all four establishments had made preliminary analyses of requirements for the design of spacecraft and had concluded that a satellite could be placed in orbit in the relatively near future if the attempt were adequately supported.

Initial estimates visualized the expenditure of $5 million to $8 million for the development and construction of a 2,000-pound satellite to be boosted into orbit by a rocket vehicle possessing between 100,000 and 200,000 pounds of thrust. Upon consideration, the Navy decided it was unable to finance such a program unassisted, so on 7 March 1946 Hall and his associates met with Army Air Forces members of the Aeronautical Board (jointly staffed by Bureau of Aeronautics and Army Air Forces representatives) to consider his suggestion that the two services undertake a cooperative space program. (Captain W. P. Cogswell and Hall represented the Navy; Major General H. J. Knerr, Major General H. W. McClellan, and Brigadier General W. L. Richardson were the principal Army attendees.) The results of the meeting were summarized in a memorandum which said, in part, ". . . the general advantages to be derived from pursuing the satellite development appear to be sufficient to justify a major program, in spite of the fact that the obvious military, or purely naval applications, in themselves may not appear at this time to warrant the expenditure. On this basis, the Army representatives agree to investigate the extent of Army interest by discussions with [Major] General [C. E.] LeMay [director of research and development] . . . ."

By 9 April, the satellite proposal had found a place on the agenda of the Aeronautical Board's Research and Development Committee. A formal discussion was scheduled for the 14 May meeting of the committee, at which time an official response to the Navy proposal was to be presented.[2]

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In the interval between the 9 April discussion and the 14 May meeting, the matter came to the attention of the Office of the Commanding General, Army Air Forces.* That office decided that the position of the air forces in any interservice conference would be compromised unless its representatives could produce a paper demonstrating equal competence with the Navy--and equal interest--in space research. Air staff authorities also felt that the Army Air Forces should have primary responsibility for any military satellite vehicles, considering such activity be essentially an extension of strategic air power. Thus was shaped perhaps the first expression of a viewpoint that became a significant issue in interservice rivalries for the next 15 years.

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* Whether General Carl Spaatz, newly succeeded to the post, actually had custody of the affair is uncertain. Some 15 years later he had no memory of the incident, suggesting that General LeMay, his deputy chief of air staff for research and development, probably handled the details. LeMay, although diligent in his efforts to rebuild the air forces into a postwar effective striking arm, was rather less interested in far advanced projects than in more immediate problems. The possibility that Spaatz set the resultant policy can not be eliminated, although it is also possible that LeMay seized the opportunity to assert air force prerogatives in space as an extension of strategic air power. Both LeMay and Spaatz, in any event, were fully conversant with General Arnold's views, and Arnold had taken pains to see that his opinions were circulated. In words that were somewhat bitter and probably aphoristic, one of the "young Turks" wrote a brief memoir of those days. He recalled that, "In 1945, General Arnold called a meeting of 250 of the key officers of the Air Force. . . He told them he was about to retire and he had some advice to give them. He said that if they didn't quit operating and get to thinking, they would find themselves in the Service Forces where they belonged. . . He said he was pretty well convinced that an airplane was not a good device to wage war in, and the boys ('you colonels and little buck-generals,' he said) should quit the throttle bending and learn something else while there was still time. And he recommended that the Air Force employ all the scientific brains they could find, and make their own careers out of thinking up ways of turning the weird and wondrous facts the scientists unearthed into useful channels." In such circumstances, it is probable that one of the "colonels and little buck generals" secured approvals from both Spaatz and LeMay for the actions that followed.[3]

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General LeMay, charged with disposing of the problem, asked the Douglas Aircraft Company to have its Project RAND group undertake a satellite feasibility study for the air forces--on a three-week deadline "to meet a pressing responsibility." Douglas sidetracked other current work and ordered 50 of the company's best scientists and engineers to work on the LeMay assignment. The study was ready, in approved draft, on 2 May; after minor revision it was actually forwarded to the Pentagon on 12 May 1946, barely in time for use during the 14 May meeting.[4]

The RAND report was, in the simplest terms, a rapid but thorough engineering analysis of satellite feasibility. Its conclusions were entirely straightforward: ". . . modern technology has advanced to a point where it now appears feasible to undertake the design of a satellite vehicle." An abstract of the original 321 page study appeared the following month with an equally forthright statement of conclusions:[5]

> The Douglas Aircraft Company, Inc., . . . has undertaken a constructive, realistic, engineering appraisal of the possibilities of building a space ship which will circle the earth as a satellite. Report SM-11827, here abstracted, shows it possible today to build such a vehicle which will take off from the surface of the earth and return thereto without destroying itself--this on the basis of our present state of technological advancement and without dependence on future developments such as atomic energy. The particular space ship studied is one designed to obtain scientific data in the upper reaches of the atmosphere and beyond. Once this objective is reached, the feasibility of designing a missile [satellite?] for direct military use will have been demonstrated and then design can be undertaken with confidence.

The arguments, and indeed the basic calculations, were remarkably similar to those exposed to the American public in the period immediately following the 4 October 1957 circuit of Sputnik I. Although considering the feasibility and need for a military vehicle, the initial reports dealt mostly with the problem of orbiting a 500-pound instrumented packet designed to collect information on "cosmic rays, gravitation, geophysics, terrestial magnetism, astronomy, metorology, and properties of the upper atmosphere."

The vehicle was conceived of as a multi-stage rocket, using either alcohol-oxygen (the propellants of the German V-2) or hydrogen-oxygen.

A four-stage alcohol-oxygen rocket and a two or three-stage hydrogen-oxygen rocket received detailed consideration. The gross weight of the alcohol-oxygen version was computed at 302,055 pounds.

The operating mode proposed in RAND's study was remarkably like that actually adopted when the United States began launching satellites 12 years later--even to the suggestion that the vehicle be permitted to stabilize in an extended elliptic arc immediately before firing of the final stage. Calculations (or estimates) of meteorite frequency and re-entry heating were carefully done, prompting the blunt statement "that the maximum acceleration and internal temperatures can be kept within limits safely withstood by a human being. Since the vehicle is not likely to be damaged by meteorites and can be safely brought back to earth, there is good reason to hope that future satellite vehicles will be built to carry human beings."[6]

Although earlier considerations of a "satellite" had been either admittedly theoretical (that is, generally feasible only in the minds of fanatic space flight devotees) or entirely implausible, the RAND study of mid-1946 was nearly as much concerned with engineering as with basic theory and was based on technology then attainable. However, the importance of the report lay not in the precision of its calculations (both Tsiolkovski and Oberth had provided specifics), but in the methods. The figures used in the report, moreover, represented "a reasonable compromise between the extremes which are possible with the data now in hand." One point seemed vitally important to the authors:". . . a satellite vehicle can be made. . . in the present state of the art." In an editorial aside, as if anticipating the emergence of an anti-missile, anti-satellite faction, they emphasized that "even our more conservative engineers agree that it is definitely possible to undertake design and construction now of a vehicle which would become a satellite of the earth."*

One of the most important viewpoints of the RAND study was contained in a cogent preface on the significance of a satellite:[7]

> Attempting in early 1946 to estimate the values to be derived from a development program aimed at the establishment of a satellite circling the earth above the atmosphere is as difficult as it would have been, some years before the Wright Brothers flew at Kitty Hawk, to visualize the current uses of aviation in war and in peace. Some of the fields in which important results are to be expected are obvious; others, which may include some of the most important, will certainly be overlooked because of the novelty of the undertaking.

The RAND study made one other point that was largely disregarded in subsequent years: ". . . the development of a satellite will be directly applicable to the development of an intercontinental rocket missile."**

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* The viewpoint of Douglas Aircraft Company engineers (not theoretical scientists) and of the Army Air Forces Scientific Advisory Group (which in the December 1945 report prepared at General Arnold's urging noted the feasibility of developing a long-range ballistic missile based on Peenemunde group work) may profitably be contrasted with the December 1945 testimony of Vannevar Bush, then chief of the Office of Scientific Research and Development. Bush, who had been and still was for practical purposes the "czar" of military research and development, told a special Senate Committee on Atomic Energy: ". . . We have plenty to think about that is very definite and very realistic--enough so that we don't need to step out into some of these borderlines which seem to be, to me, more or less fantastic." He added, ". . . there has been a great deal said about a 3,000-mile high-angle rocket. In my opinion, such a thing is impossible today and will be impossible for many years."

** Eight years later, conversatives in the Department of Defense would detour the entire space program by insisting that a satellite program must not be allowed to interfere in any fashion with any missile program. During the post-Sputnik congressional hearings of late 1957 and early 1958, the most outspoken advocate of satellite work, Wernher von Braun (then directing technical effort at the Army Ballistic Missile Agency) noted that satellite experiments certainly could be of as great advantage to the missile program as the missile program could be to satellite research. That viewpoint, first expressed by RAND 12 years earlier, apparently was acceptable only to the von Braun group (Army Ballistic Missile Agency) and to a few Air Force officers. Administration officials rejected it in their 1958 testimony.[8]

More particularly and more immediately, RAND anticipated military requirements for both a satellite to aid in missile guidance and another with a reconnaissance and weather surveillance assignment. Scientific information of immense significance could certainly be obtained, with particular benefits probable in the fields of gravitation research, astronomy, weather forecasting, ionospheric studies, and bio-astronautics. Communications satellites were specifically anticipated; the 25,000-mile orbit "stationary satellite" received detailed consideration. Finally, in what probably lent the final touch of fantasy for conservative readers, the RAND studies briefly touched on the potential of the satellite as a forerunner of true space flight:[9]

> The most fascinating aspect of successfully launching a satellite would be the pulse quickening stimulation it would give to considerations of interplanetary travel. Whose imagination is not fired by the possibility of voyaging out beyond the limits of our earth, traveling to the Moon, to Venus and Mars? But, a man-made satellite, circling our globe beyond the limits of the atmosphere is a first step. The other necessary steps would surely follow in rapid succession. Who would be so bold as to say that this might not come within our time?

Descending to the more prosaic, the engineering study considered in detail the several ingredients of a successful satellite program: dynamics of orbital motion, power plants and fuels, structural weights, design proportions, size and trajectory factors, guidance, orbital problems, descent and landing, general vehicle design, the requirements for a man-carrying vehicle, an estimation of time and cost, and an evaluation of research and development requirements.*

Although the entire concept was startling in its implications, in the opinion of those experts who looked at it 15 years later one of its most important contributions--largely unrecognized at the time--was its penetrating analysis of the advantages of and obstacles to the use of hydrogen as a propellant.[10] Perhaps less significant but certainly of considerable

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* It seems neither necessary to discuss in detail these elements of the RAND studies nor (in view of the bulk of the study) feasible to do so. Copies survived, and with a bit of scrambling could still be located 16 years later.

interest in that it represented the basic technical conservatism of the approach, was the general estimate of research and development cost--$150 millions--and time requirements: "approximately five years time." Except that the eventual payload was appreciably less, both the cost and the time were remarkably close to the actuals of the Vanguard program--which finally succeeded in March 1958. In May of 1946, therefore, the best engineering talent the Army Air Forces could employ had concluded that:[12]

> Technology and experience have now reached the point where it is possible to design and construct craft which can. . . become satellites of the earth. This statement is documented in this report, which is a design study for a satellite vehicle judiciously based on German experience with V-2, and which relies for its success only on sound engineering development which can logically be expected as a consequence of intensive application to this effort. The craft which would result from such an undertaking would almost certainly do the job of becoming a satellite, but it would clearly be bulky, expensive, and inefficient in terms of the spaceship we shall be able to design after twenty years of intensive work in this field. In making the decision as to whether or not to undertake construction of such a craft now, it is not inappropriate to view our present situation as similar to that in airplanes prior to the flight of the Wright Brothers. We can see no more clearly all the utility and implications of spaceships than the Wright brothers could see fleets of B-29's bombing Japan and air transports circling the globe.

Unhappily for the prospect of immediate approval and a venturesome approach to the space flight problem, the obvious expensive nature of the program, its tenuous justification and the lack of either obvious or immediate benefits, and the complete absence of any motivation that seemed salable to the general public combined to keep enthusiasm well within bounds.*

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* It must be remembered that the immediate postwar years were characterized by attitudes peculiar to such periods. Congress, the accepted sounding board for public opinion, was set on reducing taxes, cutting federal expenses, and satisfying pent-up consumer demand. There was no apparent threat to the security of the United States; indeed, with exclusive possession of the atomic bomb it seemed the wildest of fancies to conjecture an attack of any sort, from any quarter. Moreover, to many it seemed fanciful enough to work toward an all-jet Air Force, (Continued)

Although the satellite proposals were discussed during the 14 May 1946 Research and Development Committee meeting, nothing approaching a decision resulted. The committee merely forwarded its summary to the Aeronautical Board with a notation that there was no agreement between the air and navy factions, and the Aeronautical Board characteristically decided to await receipt of a high level definition of responsibilities for the military space mission.[14]

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much less a space force. Finally, the chauvinism characteristic of wartime public opinion in every democracy had convinced all but a few that the United States possessed the world's finest aircraft and a supporting technology second to none. With Germany crushed, Russia trodden to bits by invasion and counterassault, France a shell filled with political unrest, and Britain nearly bankrupt, there seemed no conceivable competitor in the technical fields. The sense of realism, the urgency inherent in the Navy satellite proposal, the Arnold philosophy, and the RAND study was unique.

A much less expensive proposal for space experimentation, one having "no obvious scientific value" but possessing a "propaganda value" rated as "considerable," reached the desk of W. Stuart Symington, then civilian chief of the air arm, the day before the 14 May 1946 Research and Development Board meeting. Symington, who was scarcely timid in his support of advanced developments, suggested to one of the air staff chiefs (Lieutenant General I. C. Eaker) that a proposal to shoot a cloud of luminous particles at the moon might be "sticking our neck out as regards careless use of taxpayers money. . . " One of Eaker's aides, who was convinced that the air forces should make some start on space research, nevertheless cautioned his chief, "The newspapers would have a field day if they learned that we were spending a big sum of money to send a cloud of dust to the moon." The project in question, which would--if successful--have constituted a "scientific first" of enormous influence on public opinion, required little more than one of the many surplus V-2 rockets plus a modified nose cone.[13]

Impatient of the delay, the Navy in January 1947 appealed to the Joint Research and Development Board to create a special ad hoc committee on astronautics to determine which of the services should have cognizance over space programs.[15] Each branch obviously recognized the vital character of such a decision (which was not finally reached until March 1961). No ruling at all was forthcoming immediately, with the result that the Aeronautical Board and its Research and Development Committee undertook to defend its own primacy. Inasmuch as the Aeronautical Board was equally composed of Army Air Force and Navy Bureau of Aeronautics delegates, that was no more than a temporizing solution. The absence of any firm policy on which to base the assignment of actual projects or programs continued to dilute whatever useful results happened to emerge from studies.

In June 1947 the Aeronautical Board asked that its innate authority to coordinate special studies and research projects be confirmed but before agreement and a binding decision could be obtained, new developments had overtaken the old. The Joint Research and Development Board on 19 December 1947 directed that its own Committee on Guided Missiles "assume responsibility for the coordination of the Earth Satellite Vehicle."[16]

By that time the muddled organizational squabble had grown more acrimonious through the separation of the air service from the Army and its appearance as an independent Air Force. In the process of creating the new Department of Defense, the Joint Research and Development Board was transformed from a coordinating body into a policy body with authority derived from its status as part of the defense department. Moreover, continuing indecision and the implications of Aeronautical Board recommendations had combined to make space policy a matter of defense department concern rather than a joint service problem .

There was one further obstacle, defined later by a keen student of the period, which arose from the fact that the board and its various committees were strongly influenced by civilian members who frequently exhibited "the conservative judgement that has often characterized leading academic scientists, and for a long time they dismissed space plans as 'military dreams'."[17]

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During the 1940-1948 period the most highly respected spokesman of American science, the individual who had ultimate wartime authority over virtually all applied science and research used by the armed forces, Vannevar Bush, exposed the American people to his opinions on the future of the military arts. His influence could scarcely be questioned; his patronizing distrust of General Arnold (and military scientists in general) was all too obvious.

> We are . . . decidedly interested [he wrote] in the question of whether there are soon to be high-trajectory guided missiles. . . spanning thousands of miles and precisely hitting chosen targets. The question is particularly pertinent because some eminent military men, exhilarated perhaps by a short immersion in matters scientific, have publicly asserted that there are. We have been regaled by scary articles, complete with maps and diagrams, implying that soon we are thus all to be exterminated, or that we are to employ these devilish devices to exterminate someone else. We even have the exposition of missiles fired so fast that they leave the earth and proceed about it indefinitely as satellites, like the moon, for some vaguely specified military purposes. All sorts of prognostications of doom have been pulled from the Pandora's box of science, often by those whose scientific qualifications are a bit limited, and often in such vague and general terms that they are hard to fasten upon. These have had influence on the resolution and steadiness with which we face a hard future, and they have done much harm, vague as they are. But this one is explicit, and we can treat it.

And treat it he did. In essence, Bush ridiculed notions of ballistic missiles on grounds of "astronomical" costs and impossible inaccuracies complicated by the obvious impossibility of creating an effective warhead.

The man who thus cavalierly dismissed the ballistic missile as entirely impractical and satellites as the vaporings of military incompetents was, during the critical years 1946 through 1948, chairman of the Research and Development Board.[18]

As was probably inevitable in the climate of the times, the Research and Development Board ultimately rejected the satellite proposal as not supported by a military requirement. That did not end the matter, however, the Navy in particular was extremely interested in using a cluster of available rockets to orbit "a small payload." The project was quite feasible in terms of available technology--or at least it seemed so to those who looked back on it several

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years later.[19] But the key decision was that of the Research and Development Board, and its Guided Missile Committee allowed the proposal to die of funds starvation. The reason: no evidence of military utility. A great many promising missile programs also disappeared from the funding schedules in 1947 and 1948, most because they were too theoretical or too far removed from operational utility to satisfy existing requirements during a period of financial retrenchment. There was no ready means of appeal; the position of the Research and Development Board, interposed between the researchers and the upper levels of the defense department, gave that organization something like a final word.[20]

Irretrievably tied to the missile program, and being controlled essentially by the missile program managers, space and satellite proposals could not avoid being affected by far-reaching policy decisions aimed principally at missiles. The progression was principally in financial austerity. In December 1946, the guided missile budget for fiscal year 1947 (then halfway to completion) was reduced from $29 million to about $13 million. In consequence 11 of the 28 surviving missile projects had to be eliminated. The 17 remaining projects decreased to a total of 12 in May 1947--and shortly thereafter to 8 programs. The residuals did not include the Consolidated-Vultee long-range ballistic missile project. Apart from the ill-defined requirement for a rocket-boosted, ramjet-cruise missile (eventually the Navaho), no "big rocket" programs remained in the "funded" category. Nor was this situation transitory; not until 1950 did funds appear to support the resumption of "big rocket" work, and even then the program was restricted to research and general design activity.[21]

Thus proposals for an active development program leading toward a specific satellite launching failed of approval. Indeed, it may safely be said that such proposals did not even receive serious consideration. The advisory committees which controlled the decision process were themselves dominated by individuals who considered ballistic missiles and satellites to be inconceivable for practical use in the decades immediately ahead. The uncertain state of technology obviously was another factor, although engineers and scientists who studied the space program proposals had no doubt of the

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nation's ability to overcome whatever technological obstacles there were. The urgent need of the late 1940's to modernize the military and naval machine that had won the war did much to direct attention toward new but relatively conventional weapons rather than missiles and related devices that seemed far in the future. Moreover, in the financial climate of the late 1940's, before the Soviets had demonstrated their ability to construct a nuclear bomb and before the onset of the Korean affair, an economy move was inevitable. The Department of Defense as a whole suffered cutbacks in operational forces as well as research and development--although in proportion the impact was undoubtedly greater for the latter. In 1947 the Air Force lost its only ballistic missile program (the Navy retained the Viking project and the Army continued working toward the Redstone) and Air Force rocket research barely limped along on a slender thread of financial support derived from booster rocket requirements. Nevertheless, the flavor of subtle irresponsibility that missile and space programs acquired through the actions of the major advisory committees probably was at least as important as any other single factor in halting moves to begin development.

In the meantime, the Army Air Forces, with the approval of the Aeronautical Board (and later of the Joint Research and Development Board) continued to support study efforts in the regime of space operations. On 1 February 1947, RAND forwarded a multi-volume expansion of earlier satellite work which contained detailed analyses of satellites in general and specialized aspects of the space vehicle in particular.

For six months, the new submissions had no discernible effects. Then on 18 September, the United States Air Force offically came into being. Precisely one week later, on 25 September, Air Force headquarters asked the materiel command's Engineering Division to study and evaluate the RAND satellite reports of the previous February from the standpoints of technical and operational feasibility.[22]

The Engineering Division response left Wright Field on 8 December 1947. In the interval between the submission of the RAND studies (February 1947) and the completion of the Engineering Division analysis of those studies, a number of critical events had affected the total situation. Probably most important was the continuing decline in the level of missile program funding and, for that matter, in the total of research and development funds. The fact that a considerable quantity of air staff time was consumed in the process of obtaining approval for an independent Air Force (summer 1947) undoubtedly influenced the handling of sensitive topics like the satellite. Additionally, the control of Congress had passed from the administration to the opposition party, which set about eliminating residual wartime controls, reducing taxes in general, and markedly limiting federal expenditures. The general expectation of spokesmen on the new defense establishment was that "unification" would promptly eliminate redundant projects and programs in the three services with a consequent reduction in the cost of national defense. The new defense department was in itself expected to institute immediate reforms which would promptly lower departmental budget requirements. In total, therefore, the prospects for approval of radically new and probably expensive development programs of unproven military worth were no brighter in December than in February, even though the inhibitions of operation under restrictive policies based on extreme scientific conservatism tended to disappear with the establishment of an autonomous Air Force.

It was in this enviroment that the Engineering Division response to General Spaatz was composed. As a beginning, the division certified the technical feasibility of both development and operation of "a satisfactory satellite vehicle." However, the chief of the division wrote, "Insufficient data is available at this time to determine whether the complexity and cost will in time permit practical utilization of such a vehicle." Conceding that "an appropriate development program" could solve apparent technical difficulties, the Engineering Division nevertheless had serious misgivings about the feasibility of funding the necessary program at an appropriate level. The temporizing solution, then, was to recommend establishment of a satellite project, but to limit its scope to the preparation of specifications and the collection of information on requirements ("time, manpower and money"), function ("what useful purposes could be served by the construction and operation of a satellite vehicle"), and scheduling ("the optimum time to begin actual construction of a complete satellite as opposed to component development"). The key phrases came late in the comment letter: "It is recognized that there is an urgent need of developing guided missiles and allied equipments already called for by military characteristics and that scarce funds and limited component scientific talent must first be used in this field."[23]

The Air Force deputy chief of staff for materiel, Lieutenant General H. A. Craig, decided that although the financial obstacles to full satellite development program were formidable, the time had come to take a stand on the general issue. His conclusion was that "the passage of time, with accompanying technical progress, will gradually bring the cost of such a vehicle within feasible bounds." He therefore advised the vice chief of staff, General H. S. Vandenberg, that the proper course was to incorporate the crux of the Engineering Division recommendations in a formal Air Force policy statement. General Craig said, in so many words, that the satellite could and probably should be built, but that at the moment the Air Force was in no position to finance the undertaking.

If the February 1946 decision to have RAND analyze satellite feasibility was the first turning point in the evolution of an Air Force space program, General Vandenberg's January 1948 policy statement was the second. Signed on 15 January and communicated to the Engineering Division one day later, it unilaterally but nonetheless effectively constituted the first clear statement of space program interest by any service:[24]

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

In forwarding that policy to the Engineering Division, the Air Force director of research and development authorized the Wright Field agency to put it into effect "by action under the RAND contract." General Crawford,* at Wright Field, thereupon instructed RAND to establish a satellite project with the objective of furthering the development of vital components and techniques needed "for the eventual construction and operation of a satellite vehicle." The remainder of his instructions paralleled the Engineering Division recommendation of 8 December. RAND received specific authorization to let research and study sub-contracts, though "subject to the approval of the Air Materiel Command and availability of funds."[25]

One of the most discouraging elements of the correspondence was common both to the original Engineering Division comments of December and to the Crawford letter to RAND, in February. It was contained in the injunction that RAND should advise the Air Force "on request or at appropriate intervals" on the question of "what purpose could be served by the construction and operation of a satellite vehicle." It was obvious, quite apart from the matter of funding competition between long range programs and the immediate needs of the Air Force, that higher echelons had no firm conviction of the military worth of satellite proposals. Incredulity that the space age--or even the missile age--was actually dawning typified reaction to both ballistic missile and satellite proposals. The immediate effect of the Vandenberg dictum, then, was little more than to encourage the continuation of RAND-conducted studies of a future satellite and its prospective uses. For the next three years, the critical problem of the air staff--and of the materiel people at lower echelons--was to shelter a minimum research and development effort from the consequences of fund limitations that threatened not merely the "fantastic" elements of the program, but actually such "bread and butter" projects as were involved in the first generation of turbojet-propelled strategic bombers and interceptors.

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* Chief, Engineering Division, Air Materiel Command, recently promoted to major general.

NOTES - CHAPTER 2

1. The War Reports of General George C. Marshall, General H. H. Arnold, Admiral Ernest J. King (New York, Lipincott, 1947), 452-456.

2. Memo, Ch, BuAer to JRDB, subj: Earth Satellite Vehicles, 24 Jan 1947, cited in H L Bowen's unpublished mss on the evolution of space research policy, in Hq USAF Hist Liaison Ofc files; see also H L Bowen, Threshold of Space, USAF Hist Div monograph, Sep 1960; brief mention is found in the Dec 1954 chronology "Project 1115 Background," apparently based on WADC corresp files, cy in SSD Hist Div files: ARS/WS 117L thru 1955; confirming details, and the quotation from the memo following the 7 Mar 1946 mtg, are contained in D Pearson and J J Anderson articles in Los Angeles Mirror, 28 Apr 1961, and in the Pearson and Anderson book: U. S. A., Second Class Power? Although Pearson's contributions to history frequently manage to warp the facts rather thoroughly, it is apparent that in this instance he had unofficial access to certain Navy Department documents. It goes without saying that the Pearson version has both a hero (BuAer) and villains (LeMay and MajGen L C Craigie). For this narrative, the Pearson account has been accepted to the extent of considering his direct quotations and his citations of names, dates, and specific items to be correct if supported by other reliable sources.

3. The precise source of the quotation is unknown. It was given to the present author in 1954 by a Pentagon returnee who had first removed the signature lines. The section quoted is relatively innocuous; other paragraphs contain rather harsh comments on flight pay, the Navy's carrier program, and Air Force "complacency" concerning missiles. Information on the Spaatz recollections was drawn from ltr, H L Bowen, Hq USAF Hist Liaison Ofc, to W D Putnam, SSD Hist Div, subj: Review of Manuscript, 18 Jun 1962, which notes that A L Goldberg of the Hist Liaison Ofc had asked Spaatz about the incident. Bowen, who has studied the era more intensively than any other researcher, believed that Spaatz made the subsequent decisions, a judgement in which the present author concurrs. In the absence of conclusive evidence, however, the matter must be considered uncertain.

4. Memo, Ch, BuAer to JRDB, 24 Jan 1947; Bowen mss; "Project 1115 Background," Dec 1954; Douglas Airc Co Rpt SM-11827, see note below; ltr, Bowen to Putnam, 18 June 1962.

5. At some point over the later years, most copies of the original report received "Project RAND" covers, although the original was Douglas Airc Co Rpt No SM-11827, "Preliminary Design of an Experimental World-Circling Spaceship," Contract [illegible], 2 May 1946 (in SSD Hist Div Files); the subsequent summary report was Project RAND

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First Quarterly Rpt, App II, "World-Circling Space Ship," RA-15001, Jun 1946. They are hereafter cited by their report numbers. Both reports became rarities of a sort, going out of print in relatively short order. The May report, assembled so hurriedly at Gen LeMay's insistence, was reproduced and circulated in ozlid, so great was the rush and so slight the time for final polishing. It is interesting that in all of the testimony taken following the first two Sputnik successes and the several United States space flight failures, there was not a single public reference to the RAND studies of early 1946.

6. RA-15001, Jun 1946.

7. SM-11827, 2 May 1946, p 9.

8. Hearings Before the Preparedness Investigating Subcommittee of the Committee on Armed Services, United States Senate, 85th Cong, 1st and 2nd Sess (Parts I and II): "Inquiry into Satellite and Missile Programs" (hereafter cited as Johnson Committee hearings); Hearings Before the Select Committee on Astronautics and Space Exploration, 85th Cong, 2nd Sess, on H. R. 11881 (hereafter cited as Stennis hearings); particularly testimony by Undersecy of Def D A Quarles, Johnson Committee hearings, p 305. . .

9. SM-11827, 2 May 1946, pp. 10-16.

10. Bowen mss.

11. Johnson Committee hearings, Dr John Hagan (Dir, Vanguard Proj) testimony, 26 Nov 1957; Stennis hearings, MajGen B A Schriever (Cmdr AFBMD) testimony, 24 Apr 1958; Staff Rpt of the Select Committee on Astronautics and Space Exploration, 85th Cong, 2nd Sess, "The International Geophysical Year and Space Research," 22 Dec 1958.

12. SM 11827, 2 May 1946, p 1.

13. Memo, W S Symington, Asst Secy War for Air, to LtGen I C Eaker, Vice Ch Air Staff, 13 May 1946; memo, Col T A Sims, Air Staff, to LtGen I C Eaker, 14 May 1946; both in History of the Development of Guided Missiles, 1946-1950, AMC Hist Ofc (M R Self), Dec 1951, I, 128; the proposal itself, called "Shooting the Moon," is described in RAND Rpt RA 15000, June 1946, p 8. Designed by Dr Luis Alvarez, a RAND consultant, it was considered "relatively simple and inexpensive. . ."

14. Memo, R/Adm Stevens, Chm R and D Comm, Aero Bd, to Aero Bd, subj: Case No 244 - High Altitude Earth Satellite, 15 May 1946, cited in Bowen mss; Bowen interviews with Pentagon staff.

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15. Memo, Ch BuAer to JRDB, subj: Earth Satellite Vehicle, 24 Jan 1947, with Incl A: Ad Hoc Panel on Astronautics, and Incl B: Preliminary Statement of Problem for Ad Hoc Panel, cited in Bowen mss.

16. Memo, F. H. Richardson, Admin Secy to JRDB, to Exec Dir, GM Comm, subj: Earth Satellite, 7 Feb 1947; memo, LtGen H S Vandenberg, Sr Army Mbr of Aero Bd, to JRDB, subj: Satellite Agency, 13 Jun 1947; Memo, R and D Comm, Aero Bd, to Aero Bd for transmission to JRDB, subj: High Altitude Earth Satellite Test Vehicle, 13 Jun 1947; Memo, JRDB to Aero Bd, subj: Earth Satellite Vehicle, 9 Jan 1948; all cited in Bowen mss.

17. Bowen mss.

18. Vanevar Bush, Modern Arms and Free Men (New York, Simon and Schuster), 1949, pp 84-86. Bush contributed other absurdities in a volume that had enormous circulation through the nation's leading book club and obviously influenced the research and development climate of the Pentagon. In a single volume he demonstrated the perils of prophecy by an ill-informed amateur whose viewpoint proved to be considerably more limited than that of the " parochial military experts" upon whom he heaped scorn. Perhaps the best illustration of his unbelievable lack of foresight was his prediction that "years of effort" lay ahead of any foreign power attempting to develop an atomic bomb. Between the time he wrote that unfortunate paragraph and the time his book was circulated, the Russians had exploded their first nuclear weapon!

19. RAdm J T Hayward, Asst Ch Naval Ops(R and D), testifying before Select Committee on Astronautics and Space Exploration, 85th Cong, 2nd Session, 18 Apr 1958, in Hearings Before the Select Committee. . . , on H. R. 11881; draft article for Naval Institute Proceedings Magazine, prep by Capt C W Steyer Jr. et al, cited in Bowen mss.

20. Remarks by Sen W S Symington, 16 Jan 1958, during Johnson Committee hearings (p 1876).

21. Ltr, LtGen N R Twining, CG, AMC, to CG, AAF, 25 Mar 1947; ltr, MajGen B W Chidlaw, DCG, AMC (Eng), to CG AAF, 6 May 1947; memo BrigGen T S Power, Dep Asst Ch, Air Staff (-3), to CG AAF, 16 Jun 1947; all reproduced as docs in Vol II, History of the Development of Guided Missiles 1946-1950, AMC Hist Ofc (M R Self), Dec 1951; see also Vol I of the Self Hist pp 38-46.

22. Ltr, BrigGen A R Crawford, Ch, Eng Div, AMC, to C/S USAF, subj: Project RAND, Satellite Vehicle, 8 Dec 1947, in SSD Hist Div files: Feedback Project.

23. Ibid.

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24. Ltr, MajGen L C Craigie, Dir/R and D, DCS/Mat, USAF, to BrigGen A R Crawford, Ch, Eng Div, AMC, subj: Satellite Vehicles, 16 Jan 1948, with policy stmt of 15 Jan 1948: "Statement of Policy for a Satellite Vehicle," signed by Gen H S Vandenberg, Vice C/S, USAF, in SSD Hist Div files; Bowen mss.

25. Ltr, Craigie to Crawford, 16 Jan 1948; ltr, MajGen A R Crawford, Ch, Eng Div, AMC, to Douglas Airc Co (RAND), subj: Satellite Project, 17 Feb 1948, in SSD Hist Div files.

CHAPTER 3

THE EVOLUTION OF A PROGRAM

The character of the space effort of the late 1940's, in all the services, was best described by a section in the first annual report of the new defense department, issued at the close of 1948:[1]

> The Earth Satellite Vehicle Program, which was being carried out independently by each military service, was assigned to the Committee on Guided Missiles [of the Research and Development Board] for coordination. To provide an integrated program with resultant elimination of duplication, the committee recommended that current efforts in this field be limited to studies and component designs; well-defined areas of such research have been allocated to each of the three military departments.

The limitation "to studies and component designs" was particularly galling to the Air Force. In December 1947, in the letter which had ultimately led to the Vandenberg policy statement, the Engineering Division had specifically recommended--on the basis of the earlier RAND studies--that a satellite project should be established and a start made on component development. In the minds of Air Force engineers and scientists there was no doubt of the feasibility of the RAND approach and of the satellite itself.[2] The problem was essentially that other and more critical programs were suffering from monetary anemia, and in such an environment there was slight chance of obtaining funding support needed for an active space program. In an era of relative abundance, the Air Force might have been able to overcome the skepticism of the civilian scientists who advised the defense department or the enthusiastic support of a group of recognized scientists might have served to loosen departmental purse strings. But in the absence of one or the other, nothing could be done. The key factor, it was early apparent, was the absence of a clearly recognizable military requirement. In so many words, the skeptics could ask "what can a satellite do that an airplane can not do?" The answer of the time was that the satellite could do many things beyond the capacity of an airplane, but none seemed to serve any demonstrable military purpose.

In point of fact, it was precisely toward a proof of military utility that the Air Force had begun moving in 1947. Although disappointed in the fact that no specific development program had been approved, the Air Force was making reasonably steady progress through the studies to which it was essentially limited. The basic feasibility of satellites, from the standpoint of rocket performance, had been examined and accepted. By virtue of the 1946 and 1947 studies (and the subsequent Engineering Division analysis of their findings), engineers and scientists had gained assurance that a useful rocket vehicle to launch a satellite could be developed with but minor and entirely attainable advances over existing technology. Second, they had decided that the payload would have to be relatively slight--probably less than 2,000 pounds--until better rockets were available. Third, it was apparent that a recoverable vehicle would be a complication of the basic problem.

With this indication that a payload would be restricted to instrumentation and communications equipment, the question became one of what equipment, and with what utility. Between 1947 and 1951, RAND devoted considerable effort to an analysis of military usefulness, particularly to reconnaissance--a field "in which a satellite may well show advantages over other types of vehicles."[3]

In those same years, the Air Force continued its tenuous progress toward acquiring authority to conduct a development program as opposed to a study effort. The subdued controversy between Navy and Air Force interests had flared into an open conflict in December 1947, when the Navy formally submitted to the Research and Development Board a claim for exclusive possession of rights to satellite development. After several weeks of acrimony, the Navy on 16 January 1948 (the day after the Vandenberg "position paper" on Air Force space interests) withdrew its claim, and the two services again set about their separate approaches. For the Air Force, all that could immediately mean was continuation of the RAND work. In February 1948 Air Force headquarters, through the Engineering Division, had asked RAND to undertake further detailed studies, and shortly thereafter obtained the concurrence of Research and Development Board in that approach.[4]

For practical purposes, the Navy discontinued satellite studies at that point. Under contract to the Navy, the Glenn L. Martin Company had been doing work similar to that of RAND since early 1946. The Martin efforts had resulted in a proposal for a 1,450-pound satellite that, said the researchers, could be orbited in the near future. (Much later, in the aftermath of the Sputnik affair, the then-president of the Martin Company told a group of reporters that the Navy-Martin program could have put a satellite into orbit "before the Korean War.")[5]

Army ordnance was in roughly the same situation, a group at White Sands Proving Ground having designed a space flight experiment in the fall of 1947.[6] By virtue of a general agreement with the Research and Development Board, however, the Air Force became the only service authorized to expend defense department funds on studies of satellite vehicles. The Air Force assigned the work to RAND under its regular contract, and the Research and Development Board subsequently (mid-1948) confirmed that RAND was solely responsible for such studies.[7]

In November 1950, RAND submitted definitive recommendations to Air Force headquarters covering extension of research into specific aspects of the reconnaissance mission for satellites. Major General D. L. Putt, Air Force director of research and development, endorsed the proposal and saw that it received necessary support. Its product was a pair of brief reports submitted in April 1951--reports which for the first time categorically and in considerable detail stated the engineering feasibility of a military-purpose satellite.[8]

In the most important of the April 1951 studies, RAND reported that "pioneer reconnaissance (general location and determination of appropriate targets) and weather reconnaissance are suitable with the resolving power presently available to a satellite television system." In the interval between 1947 and 1951, of course, it was precisely that sort of intelligence which had become vitally important to the Air Force; the obvious prospective foe was the Soviet Union, its vast spaces and totalitarian political structure giving it relative security from conventional intelligence approaches. Moreover, in that interval the Soviet Union had demonstrated a largely unsuspected scientific competence by detonating atomic weapons years before experts anticipated that event, the Soviet sphere of influence had extended over the whole of continental China, and for the first time since 1939 the Soviet world had attempted armed assault on a bordering state--the Republic of Korea.

In the case of robot reconnaissance, the researchers considered the basic problems involved in developing, assembling, launching, operating and profiting from the device.* The analysis certainly was more comprehensive than anything previously attempted. And the conclusions were quite encouraging, though not markedly different from those of 1946:[9]

> The various components constituting a satellite vehicle to be utilized for reconnaissance . . . [are] individually feasible to various degrees. To combine these parts into a reliable operating whole will require considerable basic scientific and engineering effort. No radically new developments are indicated, however; rather, a reconstitution of known theory and art in rocketry, electronics, engines, and nuclear physics.

Specifically, the researchers concluded that a two-stage rocket (as opposed to the three- or four-stage vehicle originally considered in 1946) weighing about 74,000 pounds and carrying a 1,000-pound payload could satisfactorily conduct general reconnaissance, resolving objects with a maximum dimension of 200 feet. Reliability--largely a matter of refining electronic components--would generally determine the duration of useful activity. With improvements in television components to a stage then attained under laboratory conditions, it seemed entirely possible to reduce the resolvable dimension requirement to 100 feet while still providing continuous coverage from a single satellite on a basis of every target surveyed every other day. A further improvement (to a resolvable dimension of 40 feet) would theoretically permit virtually all military reconnaissance to be performed by satellite.[10] Obviously, useful weather information could be obtained by even less demanding

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* Specifically, individual consideration was devoted to (1) orbits and ground coverage, (2) the problems of television reconnaissance, (3) attitude control in the orbiting vehicle, (4) requirements of an auxiliary powerplant and (5) an analysis of the anticipated reliability of the system. The basic requirements of the launch vehicle received separate consideration.

techniques; resolution on the order of 500-foot dimensions probably would prove entirely adequate. On the basis of sketchy experience with interpretation of weather trends from photographs taken from probe rockets, weather prediction also seemed feasible.[11]

As was sometimes done for particularly significant or potentially sensitive subjects, RAND both preceded and followed the formal published studies and reports by presenting data to specialized groups, particularly at Wright Field and in the Pentagon. Among a great many experts who had been desperately puzzling with the reconnaissance problem, there resulted considerable enthusiasm for RAND's findings.[12] The Research and Development Board, which had only recently rejected another Navy proposal for a small-package scientific satellite, fully sanctioned further studies. In the wake of the 1951 studies, the Air Force authorized RAND to make specific recommendations for the start of development work in the reconnaissance satellite program--then called Project Feed Back.[13]

Submission and consideration of the April 1951 RAND studies coincided, quite by accident, with the activation of an autonomous Air Research and Development Command and with increased stature for the recently created headquarters Air Force staff agency, the Deputy Chief of Staff, Development. Both organizations were guided by officers who were firmly convinced that far too much emphasis had been placed on procurement and production aspects of the materiel function in postwar years. They proposed to re-emphasize the research and development aspects of the Air Force mission, and they promptly set about their task.*

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* The lower-echelon organizations, principally the Air Materiel Command's Engineering Division, had for the most part been entirely sympathetic to "advanced ideas" but had achieved no notable success in securing their acceptance at higher levels. Competition between proposals for radically new techniques and requirements for improved weapons to employ in the immediate future (the Korean affair was then in full flower) tended to decrease the effectiveness [redacted] Division, nonetheless.

By November 1951, the Air Force had arranged for the Atomic Energy Commission to begin work on small reactors suitable for use as power sources in satellite vehicles. RAND planned to subcontract major portions of the next phase of basic research, starting with the study of an orbital sensing and control subsystem (subcontracted to North American Aviation in March 1952). By June of that year, preliminary results of the reactor analyses were available; all were favorable to the feasibility of the proposal. A contract between RAND and the Radio Corporation of America followed, in mid-June; the electronics firm was to study optical systems, television cameras, radiation, recording devices, presentation techniques, and reliability aspects of a reconnaissance subsystem for a satellite. Concurrently the Communication and Navigation Laboratory at Wright Air Development Center contracted with North American Aviation for a study of a pre-orbital guidance system for a satellite (July 1953).

Most of this work was financed under a special supplement to the existing contract with RAND, effective for fiscal year 1953 and specifically designed to support the satellite research. The Atomic Energy Commission acceded to an Air Force proposal that it fund the study aspects of the reactor work, at least to the point of proving theoretical feasibility.

In the first two years following the establishment of an autonomous Air Research and Development Command, a minor difference of opinion involving RAND and the new organization occurred. The command decided early in its existence that the Air Force rather than the corporation should have management responsibility for the several subcontract studies being monitored by RAND. Nothing came of the proposal initially, and RAND continued to control study efforts ("the research phase") under the philosophy of turning the work over to the Air Force "as soon as development work can be started."

In May 1953, this process went one step farther. Air Force headquarters first directed the research and development command to investigate the feasibility of starting development work on an auxiliary nuclear power plant for the satellite, and then added instructions that the agency was to begin "active direction" of the entire Feed Back program by 1 June. One of the prime motives was the obvious fact that the reconnaissance satellite program had to be carefully integrated with the recently re-activated Atlas ballistic missile effort. Staff planners clearly foresaw that Atlas was the logical boost vehicle for the satellite. (At the time, the Air Force was also specifying reconnaissance versions of its major development systems, including Snark and Matador missiles. The reconnaissance package seemed to offer potential for a similar reconnaissance payload for the Atlas.)[14]

Air Research and Development Command representatives who began arranging a transfer of custody emerged from their initial contact with the RAND group in a state of high enthusiasm. Lieutenant Colonel V. L. Genez returned from his initial visit to the RAND satellite office with the firm conviction that an immediate effort should be made to orbit a satellite, regardless of the availability of the reconnaissance subsystem. He considered the psychological advantages of such a program to far outweigh any disability arising from limited operational utility. One month later, in September 1953, RAND itself flatly recommended letting a system design contract within a year and proceeding to a full system development program "perhaps immediately following the completion of experimental component tests."[15]

Endorsement of the RAND recommendation by the research command headquarters and preliminary steps toward the start of component development marked the closing months of 1953. Although there were objections to the proposed acceleration of work (notably from the command's atomic energy program manager, who felt that at least another nine months of study should be devoted to the auxiliary power source before development began), the threads gradually began to draw together once more.[16]

At that point, the Air Research and Development Command decided to pull together the proliferating aspects of the satellite work into a single project, thus making its unified management more feasible. Tentatively identified as Project 409-40, "Satellite Component Study," the program was also given unofficial possession of a system number (Weapon System 117 L) to cover the ultimate system development effort. On 3 December 1953, the program received new direction; headquarters of the Air Research and Development Command ordered Wright Air Development Center to redocument the effort under newly adopted management procedures (80-4) and to direct activity toward a demonstration of the feasibility of major satellite components. The television-optical reconnaissance subsystem, attitude and guidance control equipment, and the auxiliary power plant were specific goals. By the end of the year, the entire satellite "program" had made a semi-official transition from a planning project to a proposed system. Given a new project number, it was transferred to the custody of the Bombardment Missiles Branch in Wright Air Development Center's systems management organization.[17]

In January 1954, while RAND was in the final stages of preparing a summary report on Project Feed Back, Project 1115 acquired the unclassified title "Advanced Reconnaissance System" and an MX (engineering project) number: MX-2226. Apart from the fact that the new names and codes were rather more prosaic than the "Feed Back" nomenclature earlier used, their adoption served to distinguish the proposed Air Force program from the RAND studies, which were rather well known throughout the services. However, the several items of code numbering, system number, and project number had not yet received confirmation or approval from Air Force headquarters. Although the work was progressing, it still lacked the authorization required for a fully effective program.[18] Such authorization was to come in the trail of the long-awaited summary report from RAND on Project Feed Back.

Refinement of engineering data, intensive investigations of individual aspects of the reconnaissance satellite proposal, and highly detailed analysis of technical, fiscal and political (international) requirements and repercussions were complete by early 1954. Over a period of more than two years, RAND had subcontracted studies to a variety of highly qualified research and industry groups. Several hundred scientists and engineers had a part in the contributory studies and in the final report. In consequence, that report (dated 1 March 1954) contained the validated findings of some of the most highly regarded individuals and organizations in the nation. On the basis of such work, RAND specifically recommended that the Air Force undertake "the earliest possible construction and use of an efficient satellite

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reconnaissance vehicle" as a matter of "vital strategic interest to the United States." Additionally, RAND urged that the satellite project be "considered and planned" at a high policy level and that it be conducted under elaborate secrecy wraps to prevent dangerous international repercussions. On such a basis, it seemed possible to RAND that the development and initial operation of the satellite could be completed in about seven years and at a total cost "on the order of $165 million"--although the researchers cautioned that uncertainties inherent in the prediction of development trends might double or treble that cost. (RAND also remarked, with considerable foresight, that "it may be possible to attain the end goal of the program from one to two years earlier at a considerable increase in cost.")[19]

There was an element of finality to the concluding paragraph of the summary:[20]

> RAND has been working on the satellite vehicle for 8 years. During this period the metamorphosis from a feasibility concept to a useful reconnaissance purpose has occurred. Cognizance is now being turned over to the Air Force with the recommendation that the program be continued on a full-scale basis.

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1. Rpt, National Military Establishment, "First Report of the Secretary of Defense, 1948" (29 Dec), p 129.

2. Ltr, BrigGen A R Crawford, Ch, Eng Div, AMC, to DCS/Mat, USAF, Subj: Project RAND Satellite Vehicle, 8 Dec 1947

3. RAND Rpt R-217, Utility of a Satellite Vehicle for Reconnaissance, Apr 1951,. p 1.

4. Project 1115 Background, Dec 1954.

5. Ibid; Denver Post, 25 Sep 1959.

6. Washington Star interview of Dr. H.A. Zahl, Res Div, Sig Corps US Army, 27 Oct 1960.

7. Memo, C G Habley, Dayton rep, RAND, to J E Lipp, Missiles Div, RAND, subj: Feed Back History, 28 May 1952, cy in SSD His Div File: ARS/WS 117L thru 1955.

8. Ibid; RAND Rpt R-217, Apr 1951; RAND Rpt R-218, Inquiry into the Feasibility of Weather Reconnaissance from a Satellite Vehicle, Apr 1951.

9. RAND Rpt R-217, Apr 1951, p 80.

10. Ibid.

11. RAND Rpt R-218, Apr 1951.

12. The author attended a Project Feed Back briefing at Wright Field early in 1952 and clearly recalled, 10 years later, the general excitement that gripped the audience during much of the presentation. The animated discussion that followed was marked by a complete absence of "it can't be done" sentiment and by free expressions of hope for the success of the RAND program during later presentations at the decision level in Air Force headquarters.

13. Memo, Col J A Dunning, Asst Ch, War Plans Div, Dir/Plans, to Dir/Plans, DCS/Plans and Prog; USAF, subj: USAF Satellite Program, 28 Oct 1957, cited in Bowen mss.

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14. History of the Air Research and Development Command, 1 July-31 December 1955, pp 349-353, including citations of: ltr, F. R. Collbohn, RAND Corp, to MajGen D N Yates, Dir R and D, DCS/D, USAF, 10 Feb 1953; ltr, MajGen D N Yates, Dir R and D, DCS/D, USAF, to CG, ARDC, subj: Project FEEDBACK, 22 May 1953, and 1st Ind, Col J D Kay, Dir/Intel, Dep/Dev, ARDC, to Gen Yates, 12 Jun 1953.

15. Memo "For the Record," prep by LtCol V M Genez, Dir/Intel, Dep/Dev, ARDC, subj: Conference with RAND Corporation re FEEDBACK Program, 13 Aug 1953; ltr, J E Lipp, RAND, to CG ARDC, subj: Interim Recommendations for Project FEEDBACK, 8 Sep 1953, cited in History of ARDC Jul-Dec 1955, p 359g.

16. DF, BrigGen D J Kiern, Asst for ANP, to Asst for Weap Sys, ARDC, subj: Phase II Investigations of Nuclear Auxiliary Power Plant in Feedback Project, 3 Nov 53; Status Rpt, Proj Feedback, prep by LtCol V M Genez, 14 Dec 1953; History of ARDC, Jul-Dec 1955, p 356.

17. Memo, Habley to Lipp, 28 May 1952; "Project 1115 Background," Dec 1954.

18. "Project 1115 Background," Dec 1954; Bowen mss.

19. RAND Rpt R-262, Project Feed Back Summary Report, 1 Mar 1954, pp vii, 3-4, 149-150, 164-166.

20. Ibid, vii; appreciation of the enormous amount of data contained in March 1954 study can only be gained by reading it. (It is well worth the time: RLP)

CHAPTER 4

THE TRANSITION FROM PROGRAM TO SYSTEM

A combination of circumstances had contributed to the new course of space-program activity. One of the key elements certainly was the emergence of a group of scientific advisors who both appreciated the gravity of the Soviet threat and seemed willing to consider "unconventional" approaches to the United States response. Oddly enough, it was a new "economy drive" in the defense department that provided the final impetus. Determined that defense expenditures could and should be reduced, the department created a Guided Missiles Study Group (under its Armed Forces Policy Council) to recommend means for cutting the cost of the missile program. (Secretary of Defense Charles E. Wilson in his 16 June 1953 directive creating the review committee specified that "a continuous effort should be made to standardize on one missile for production and use by all military departments, wherever, within the employment limitations of each type of missile, standardization appears to be practicable.") The original group encountered evidence of a significant change in the status of the long-delayed intercontinental ballistic missile program, created a special subcommittee (Strategic Missile Evaluation Committee) to delve more deeply into the subject, and passed on to other topics. Under the leadership of Professor John von Neumann, the Strategic Missile Evaluation Committee reviewed the status of the rocket missile program and concluded that new warhead developments plus advances in rocket technology made an intercontinental missile immediately feasible. That conclusion, and a series of implementation recommendations, reached Trevor Gardner, Air Force Assistant Secretary for Research and Development, in the first quarter of 1954. Enthused about the potential of the proposal, Gardner and von Neumann secured the active support of the Air Force chief of staff, General N. F. Twining, and Secretary of the Air Force Harold E. Talbott. Together, they succeeded in obtaining funds and directives needed to start work. By July, a field organization had been created, a supporting contractor engaged, and the broad outlines of a massive ballistic missile development program sketched in.

The creation of a substantial ballistic missile program in the Air Force had significance far beyond immediate consequences--though these were important enough. It meant, first, that the eight-year struggle to obtain acknowledgement of the feasibility of long range rockets had been won. The Bush thesis had finally succumbed to the von Neumann thesis. Second, it implied the availability, in the foreseeable future, of rocket vehicles sufficiently powerful to thrust a satellite into orbit. Finally, by confirming that space-age weapons would shortly be operational, it testified to the need for developing a useful military competence in space; to a great many Air Force planners it seemed obvious that only a military space capability could provide an effective counterweight to an intercontinental ballistic missile force.[1]

In May 1954, concurrent with key decisions in the ballistic missile area, Air Force headquarters directed the Air Research and Development Command to assume responsibility for a study of the applications of RAND's Feed Back concept. The research command promptly "documented" Project 1115, obtaining final approval from the Office of the Secretary of Defense (Coordinating Committee on Guided Missiles) in July. In August, Pentagon authorization to proceed with actual work reached the field command, and that command set about issuing more comprehensive directives. The appearance of System Requirement Number 5 on 27 November 1954 signaled approval of a clearly defined effort to develop a reconnaissance satellite system, even though the general operational requirement (GOR No 80) did not emerge from Pentagon channels until 16 March of the following year.[2]

A number of presentations of the Feed Back proposal, largely as defined by RAND, marked the summer and early fall of 1954. Following the Air Research and Development Command's assumption of project responsibility in May, that command began a determined attempt to obtain approval for an expanded industry study effort. Among those who heard and in some degree endorsed the Feed Back approach were the acting chairman of the Scientific Advisory Board, J. A. Doolittle, the Air Force Chief of Staff, General N. F. Twining, and the heads of Strategic Air Command and the Air Research

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and Development Command--Generals LeMay and Power. General LeMay was quite responsive to the presentation, urging preparation of a formal Strategic Air Command requirements document covering the satellite, but other of the command's officials, notably in its operations analysis staff, urged the greater need for improved refueling techniques and manned bombers. General Putt, who immediately preceded Power as research and development command chief, strongly supported the satellite program--as did Power himself.[3]

While such presentations were being made at various levels, work began on a number of additional elements, or proposed elements, of the reconnaissance satellite: attitude guidance and control, a solar-electrical energy converter, intelligence processing methods, the auxiliary power plant, and the effects of nuclear radiation on electronic components.[4]

In October 1954, Trevor Gardner asked the "ICBM Scientific Advisory Group" (which included many of the earlier von Neumann committee) to consider the possible interaction of satellite proposals and other missile proposals of the moment with the intercontinental ballistic missile effort then rapidly unfolding. The committee decided that the review should be undertaken directly by the Air Force; it was ultimately completed by the Western Development Division and recommended, in effect, that because of the necessity for coordinating the several large rocket-vehicle programs the reconnaissance satellite should be assigned to the Western Development Division for management.[5]

In that a system requirement generally called for the submission of data needed to prepare a formal development plan, while a general operational requirement specified objectives and time goals, the 16 March 1955 requirements document issued by Air Force headquarters actually constituted the first full and formal statement of the reconnaissance satellite program. In many respects, as might have been anticipated, it paralleled the earlier RAND studies. It defined as the Air Force objective a means of providing continuous surveillance of "preselected areas of the earth" in order "to determine the status of a potential enemy's warmaking capability." Intended for launch from fixed bases, the reconnaissance satellite was to provide daylight visual coverage in sufficient detail to permit identification of airfield runaways, and intercontinental missile launch stations. Additionally, an alternate ability to collect electronic intelligence and to provide weather forcasting data was also specified. Although the "ultimate" required definition (". . . capability to detect objects no more than 20' on a side. . . ") was somewhat optimistic in terms of RAND's earlier findings, the required operational availability date (1965) seemed basically sound.[6]

Initial management of the project was assigned to Wright Air Development Center, the project officers being Lieutenant Colonel Q. A. Riepe and (after August 1955) Lieutenant Colonel W. G. King, Jr. By November 1955, 14 basic "in house" technical tasks had been defined, approved, and assigned to project officers for control purposes. The Air Force had also contracted with Radio Corporation of America, Glenn L. Martin, and Lockheed Aircraft for design studies intended to establish more specifically the time and technology requirements of the undertaking. Industry investigations were conducted under the nickname "Pied Piper."[7]

As early as January 1955, the von Neumann group had decided that it would be possible--and preferable--to work initially on the satellite vehicle and its contents rather than on a total reconnaissance system which would include the booster elements. In this fashion, contended the committee, there would arise no need for interference with the ballistic missile program. The commander and vice commander of the Air Research and Development Command, Lieutenant General T. S. Power and Major General J. R. Sessums, agreed that this was their understanding of program objectives.[8]

In general terms, it was the wish of the Western Development Division and its commander, General Schriever, to devote their principal attention to the intercontinental ballistic missile. The introduction of non-germane tasks such as tactical-range ballistic missiles and satellites promised to interfere with the main assignment unless additional resources were concurrently provided. Nevertheless, it was early apparent than no serious military satellite program could be undertaken by the United States without imposing additional requirements on the ballistic missile development agency. Of the possible launch vehicles that would be available within the years of satellite development and test, only the Atlas-Thor-Titan family promised fully satisfactory thrust characteristics. While not specifically rejecting the notion that the WS 117L program might be assigned to the Western

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Development Division, those concerned tended to express hope that some alternative could be devised. In one of the early discussions of the reconnaissance satellite during a meeting of the "ICBM Scientific Advisory Committee" in June 1955, the group chiefly considered the topic in a context of "steps which could be taken to prevent the TBM [Tactical Ballistic Missile] and Scientific Satellite programs from interfering with the ICBM [Intercontinental Ballistic Missile] program." After evaluating the question in some detail, the group decided on a course of action:[9]

> . . . The committee unanimously agreed that any Satellite program, Scientific or Reconnaissance, which is dependent on components being developed under the ICBM program, would interfere with the earliest attainment of an ICBM operational capability and requested the Chairman to write a letter to the Secretary of the Air Force advising the Secretary of the Committee's concern in this matter.

There was no question of lack of foresight in such a decision. The group was overwhelmingly concerned with keeping the infant ballistic missile program alive* and satisfying the critical need for an operational ballistic missile. There seemed slight prospect that the materiel and personnel resources then available to the Western Development Division could accommodate a major satellite program without diluting the effectiveness of its missile effort; by the same token, in the climate of June 1955, the prospects for obtaining additional resources commensurate with the expanded requirements were so slight as to be unworthy of notice.

The basic question of who should manage WS 117L was resolved in Gordian-knot fashion on 10 October 1955, when General Power ruled that the entire program would be transferred from the custody of Wright Air Development Center to the Western Development Division. The formal notification did not come for another month, and final details of the transfer were not settled until 1956 had begun. Nevertheless, the broad outlines of the

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* The committee members included, among 13 attending, Professor John von Neuman, Professor G. B. Kistiakowsky, Dr. C. B. Millikan, Professor J. B. Wiesner, and Dr. H. F. York--all concerned in the decision which had resulted, a year earlier, in establishment of an accelerated ballistic missile program.

undertaking, the scope of the task, and the obvious difficulty of the program were made clearly apparent in the revised system requirement which formally assigned the reconnaissance satellite to General Schriever's keeping.[10]

The Scientific Satellite and WS 117L

Although much remained before the WS 117L program could complete the transition from system proposal to system development, the first steps had been taken. Unhappily for the simplicity of program management, however, the years between 1953 and 1956 were also marked by the commingling of military space vehicle programs with "alternative" or "scientific" satellite proposals. The basic requirement originated in United States agreement to participate in the International Geophysical Year activities, became attached to independent satellite proposals originiated in both Army and Navy rocket research establishments, and eventually affected the WS 117L program as it was assigned to the Western Development Division.

Although the original Navy approach of 1945 and the RAND studies of early 1946 both contemplated prototype satellites with more "scientific" than military application, it was not until October 1948 that the general scientific community was exposed to such notions. In that month, the Journal of Applied Physics published the "Grimminger Report," a brief article based on unclassified elements of the earlier RAND studies. Its principal effect was to stir up enthusiasm among the various national rocket societies and those relatively small and isolated groups of specialists whose interests were affected by the prospect of space exploration.

The second major impulse for the creation of a scientific satellite came from the space flight enthusiasts and their allies in astronautics. Both formal and informal discussions of the feasibility of and the need for scientific satellites marked the proceedings of the Second Congress of the International Astronautical Federation, in London, and the First Symposium on Space flight, in New York, during the fall of 1951. Publication of the

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proceedings of the London meeting as The Artificial Satellite gave the British Interplanetary Society the distinction of having prepared and circulated the first published work to be devoted exclusively to space vehicles.

Wernher von Braun was by that time conducting his own campaign for sponsorship of an experimental satellite program but as yet had not secured support from the Army Ballistic Missile Agency. The "MOUSE" (Miniumum Orbital Unmanned Satellite, Earth) proposal originated by Dr. Fred Singer was attracting some attention by 1953. (Singer, Arthur C. Clarke, and A. V. Cleaver of the British Interplanetary Society chose the name and blocked out a public relations program for "MOUSE" during an informal meeting in London.) After being rather extensively discussed during the May 1954 Symposium on Space, in New York, the Singer scheme proceeded to gain considerable support in conventional scientific circles.

Concurrent with the "MOUSE" proposal, von Braun* formally recommended that the Army fabricate and launch "a minimum satellite vehicle based upon components available from missile developments of the Army Ordnance Corps." Specifically, he urged that the Army use a Redstone missile as the first-stage booster for a satellite. Deciding that the participation of all three services would be necessary to acceptance and funding of such a program, the Army invited both the Air Force and the Navy to cooperate. The plan then being considered involved orbiting a five-pound inert "slug" about two feet in diameter, using clusters of solid-fuel Loki rockets as the upper three stages of the four-stage launch vehicle.

The Navy expressed rather more than mild interest, but the Air Force declined participation because of its concern for long range efforts leading to heavier satellites with military utility. The key Army report was issued on 15 September 1954, while the formal approach to the Navy (following preliminary informal inquiries) was embodied in a memorandum of 14 December. Project costs, at that point, were estimated at $17 million. Some $500,000 actually were made available to support initial studies.[11]

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* Then chief of the Guided Missile Development Division, Ordnance Missile Laboratory, at Redstone Arsenal, Huntsville, Alabama.

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Although the Air Force was not particularly attracted by the von Braun approach, continued Air Force interest in the general topic was indicated by the appearance of a February 1954 RAND study dealing with the uses of a scientific satellite. In both the 1954 study and a supplemental report of June 1955, RAND emphasized the need for an instrumented test vehicle to provide useful data for later space research; the concept of an "inert slug" then being considered by the Army and the Navy was quite ignored. As had been true since 1946, Air Force concern for space exploration was much more closely concerned with useful scientific experimentation than with the general prospect of orbiting "something."[12]

Among scientists, the notion of satellite research gained additional impetus from published reports of Soviet interest in "an artificial satellite of the earth" (November 1953) and from the Soviet creation in September 1954 of a special Tsiolkovski gold medal for work in the field of space flight. The Russians announced that such awards would be made starting in 1957. Concurrently, in 1954, several leading Soviet scientists were named to a permanent commission on astronautics.[13]

By August 1954, Congress had sanctioned United States participation in the activities of the International Geophysical Year. Shortly thereafter, a special committee of the geophysical year agency had recommended ". . . that thought be given to the launching of small satellite vehicles" and the House of Representatives had begun consideration of a formal appropriation of $10 million to support American participation in the scientific activities of the international group. (At about the same time, Secretary of Defense Charles E. Wilson told a press conference that he had no knowledge of any American satellite program.)[14]

In the early months of 1955, the Army and the Navy worked out the details of their proposed joint satellite effort--dubbed Project Orbiter. At that point, the National Security Council had to decide what, if any, relationship should prevail between the existing military missile programs and the requirement for a scientific satellite to support the International Geophysical Year. The decision was formally inscribed in a council directive of 26 May 1955--a document which officially expressed the President's doctrine on the "peaceful uses of space" and which decreed that the American satellite for the International Geophysical Year could not employ any missile intended for military purposes.[15]

The selection of a satellite program was entrusted to Donald A. Quarles, then assistant secretary of defense for research and development. Quarles named an "Ad Hoc Advisory Group on Special Capabilities," with Dr. H. J. Stewart as chairman, to make specific recommendations on the scientific satellite.

When the Stewart Committee began its investigations, the possible choices had been reduced to three--and two of these were clearly dependent on the use of vehicles drawn from the missile programs of the services. The Army and the Navy proposed Project Orbiter, using the Redstone missile plus upper stages of Loki rockets. In June, the von Neumann group discussed a rather general proposal to employ an early test-version Atlas (Series A) missile to boost a scientific satellite into orbit. The general reaction was that the required Atlas prototypes could be more usefully employed elsewhere. Nevertheless, the Air Force proposed a combination called "World Series" based on an Atlas carrying as its upper stage the well-proven Aerobee-Hi space probe rocket. The third alternate was the Navy's Project Vanguard, a program hinging on use of modified Viking rocket and available upper stages (four stages in all).

Although the Army concluded, on the basis of such developments, that both the Air Force and the Navy were sponsoring firm alternatives to the Orbiter program, and that interservice rivalry was at the core of the situation, such was not the case. Looking at requirements in the light of the 26 May National Security Council directive, the Navy quite logically concluded that neither Orbiter nor "World Series" could receive Stewart Committee approval. The "Viking proposal," which became Vanguard, made its appearance as a backup to the primary Navy submission (jointly with the Army)--Project Orbiter.[16]

Apart from the discussion of an Atlas-launched satellite in the von Neumann group, relatively little of importance emerged from Air Force quarters during the period when the Stewart Committee was considering a recommendation. The committee visited the Western Development Division and heard briefings on the Atlas program, its applicability to the general area of scientific satellites, and the prospect of interference between the scientific satellite and the ballistic missile program, but Air Force spokesmen were quite reserved in their advocacy of the Atlas approach. Although taking a conciliatory approach, division representatives did not disguise their conviction that the directed creation of a special relationship between Atlas and the scientific satellite could easily cause interference with the military effort. They emphasized that a most careful management effort would be required to overcome the effects of such interference if the Atlas and the scientific satellite were tied together.

Shortly after the departure of the Stewart group, the Los Angeles complex considered Convair's presentation of an Atlas-boosted scientific satellite called ORTV--Orbital Research and Test Vehicle--a 500-pound satellite to be tied to an Atlas C missile for launch. In many respects, it was remarkably similar to the RAND concept of early 1947.[17]

Late in August, the Stewart Committee ruled that Vanguard was more acceptable than Orbiter, principally because the latter would require the use of military "hardware"--Redstone rockets. The chief of Army ordnance research and development promptly protested, pointing out technical shortcomings in the Vanguard approach and emphasizing the danger to United States prestige if the nation failed to be first into space--but the Vanguard decision was reaffirmed. Those responsible both for confirming the original Stewart Committee recommendation and for rejecting subsequent appeals later told Congress that the Vanguard offered "greater promise" than its alternatives. The explanation that under the existing ground rules only Vanguard could be selected was not publicly offered. Indeed, at least one of the services which offered alternatives to the Vanguard approach was not even aware of the prohibition on the use of a military rocket as the boost vehicle; the Air Force presentation team continued to support World Series without the least intimation that it had been vetoed in advance.[18]

Subsequent Air Force participation in the affair of the scientific satellite was not germane to the main course of events there. On 31 August 1955, after the Vanguard decision had been made but apparently before it had become general knowledge, Air Force headquarters directed the Air Research and Development command to establish a separate scientific satellite project to be integrated with the WS 117L program. The directive implied that a prototype reconnaissance satellite vehicle should be used to satisfy requirements of the International Geophysical Year.

One month later, on 31 September, Major General Albert Boyd, the command's deputy commander for weapon systems, advised the Pentagon that substantial increases in fiscal 1956-1958 funding were essential before any progress could be attempted. This response and the impact of the Vanguard ruling prompted Air Force headquarters to issue, on 14 October, further instructions that the Air Research and Development Command should take no additional action on a scientific satellite program until Air Force responsibilities in that area had been clarified.

On 1 November 1955 the "hold order" of mid-October was cancelled and the research and development command received teletyped instructions to submit a plan for the use of WS 117L prototypes in the scientific satellite program. Command headquarters, within two weeks, had assigned responsibility for preparing such a plan to the Western Development Division. That organization, in rather less than two months, produced a detailed development plan covering a scientific satellite derived from the basic WS 117L program.[19]

In retrospect, the real translation point between studies, proposals, reports, and component programs with limited objectives on the one hand, and a system development phase on the other, was publication of the 14 January 1956 development plan for a prototype, scientific-satellite variant of the WS 117L reconnaissance satellite. Although the preliminary development plan obviously was a somewhat hastily composed proposal for satisfying an Air Force headquarters desire to participate in the scientific satellite program then beginning, it nevertheless represented the first positive proposal for orbiting an Air Force space vehicle within a given

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time period. In forwarding the preliminary development plan, General Schriever clearly indicated that his division was principally attempting to satisfy the Pentagon requirement for a demonstration of "orbital capability" using major elements of the Advanced Reconnaissance System--WS 117L. The crux of the January 1956 proposal was feasibility demonstration "within the International Geophysical Year . . ." Thus the initial proposal, deliberately "tentative" in nature, encompassed only that portion of the WS 117L program which could influence plans for the geophysical year activities. In General Schriever's words:[20]

> It appears perfectly feasible to provide an orbiting vehicle of considerable payload capacity within the IGY period, provided implementing action is taken at an early date. This vehicle development can be carried out as a coherent part of the overall Advanced Reconnaissance System Program without significant compromise to the latter. Further, if current schedules can be maintained, no hardware interference with the ICBM program is foreseen. Some interference from a personnel dilution standpoint will necessarily exist. This can be minimized by advanced planning if a consistent program is pursued.

In polite terms, the general was stating that his organization could indeed orbit a scientific satellite <u>if</u> certain conditions were satisfied: adequate financial support, appropriate personnel reinforcements, and resolution to proceed with the program once it had been approved--without frequent halts and starts.

The January 1956 proposal conceived of an initial orbital flight, using an Atlas Series C missile as the boost vehicle, by 19 August 1958. The satellite itself, to weigh about 3,500 pounds, was to contain "a propulsion system, guidance and control equipments, beacons and other items being developed for the ARS [Advanced Reconnaissance System] and essential for these tests."

In many respects the proposed vehicle resembled the Thor-Agena combinations actually used in the Discoverer program more than five years later--with Atlas substituted for Thor. Specific scientific measurements which the planning group felt could be taken by the proposed vehicle included atmosphereic density, frequency and mass of micrometeorites, thermal flux effects in orbit, solar radiation in the ultraviolet and X-ray regions, and effects of the ionosphere and trophosphere on communications. Additional

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data that could be obtained from the proposed satellite, it appeared, could include information on cosmic radiation, the earth's magnetic field, and solar high frequency radio noise.

Success in the effort, the Western Development Division carefully explained, would be dependent on four basic circumstances: maintenance of the ballistic missile program schedules, a prompt decision to proceed with the "preliminary" satellite proposal, early selection of a suitable contractor, and "the provision of adequate funds." Planners anticipated that the results of the satellite experiments would be beneficial to progress in ballistic missile development, but specified that missile contractors should not be called upon to participate in the satellite program if that participation would "detract in any way" from their primary concern: missiles.

Estimated program cost totalled $95.5 million, of which $13 million had to be made available by 1 April 1956 if the proposed schedule was to be maintained.[21]

On 16 January 1956, General Power accepted and forwarded the preliminary plan. Two days later, the Air Force Research and Development Policy Council completed a rapid review of the proposal and sent it to the Stewart Committee. Early in February, a composite team from several Air Research and Development Command centers and divisions supported the written proposal through the medium of a special presentation. The Air Force group did not in all respects stand firm behind the Western Development Division plan, however. On instructions from General Putt, newly named deputy chief of staff, development, in Air Force headquarters, the presentation team refrained from emphasizing the need for total program approval and indicated general willingness to "accept approval of a portion of the program."[22]

As far as the Air Force was concerned, nothing particularly significant came from the January 1956 development plan or the later presentation to the Stewart Committee. Notwithstanding the fact that the committee had been far from unanimous in endorsing the Vanguard approach as the most promising of the several alternatives, [illegible] decision in favor of

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Vanguard was allowed to stand. Putt's decision not to press the issue probably made no difference. A more forceful course presumably would have ended, in time, as did the action of the chief of Army research and development, Lieutenant General J. M. Gavin, who in the spring of 1956, again vigorously argued for approval of a modified Orbiter program as a much more promising approach than Vanguard. On 15 May he received orders "telling me in specific terms [he later testified] that the Army would not prepare to launch a satellite using its Jupiter or Redstone missiles." Whatever the consequences, the May 1955 National Security Council decision to separate the scientific satellite from military programs prevailed. In the instance of both the Army Orbiter and the Air Force WS 117L, the key factor in the decision not to proceed with an alternative or accessory scientific satellite approach was the strong possibility that the close association of such a satellite with a specific military weapon might delay the scheduled delivery of that weapon. General Schriever and his staff had consistently emphasized that the earliest possible operational availability of an intercontinental ballistic missile was the key objective of the Air Force program and that an Atlas-launched satellite effort had to hinge on success in that effort. The Army frankly conceded that acceptance of its plan to launch a Redstone Arsenal satellite by January 1957 would delay the Jupiter missile program by about three months. The delicacy of development, test, and delivery schedules for the Atlas was even more pronounced than was true of Jupiter. Even while proposing a plan for using the Atlas Series C missile to orbit a prototype satellite, the Air Force repeatedly emphasized that no more than a slight slippage in Atlas development would be needed to delay availability of Atlas boosters past the point where they could be used to satisfy International Geophysical Year requirements. Thus the uncertainty of success in meeting geophysical year deadlines and the general prejudice against interfering in any way with the progress of ballistic missile development essentially caused the demise of the 1956 proposal to orbit an Air Force scientific satellite.[23]

Something in the nature of an epilogue to the January-February 1956 episode occured one year later. On 1 February 1957* the development staff in Air Force headquarters, at the request of the Department of Defense, asked General Schriever's group to submit a current estimate of the ability of the Air Force to build a "back-up" scientific satellite that could be launched during the International Geophysical Year. The West Coast agency replied on 8 February, in a message that was forwarded from command headquarters three days later, that no Air Force scientific satellite launchings could be scheduled with any assurance of success before mid-1959, but that if the Atlas program continued to make excellent progress it might be possible to schedule one or two maximum risk launchings during 1958--that is, during the final months of the International Geophysical Year. In either event, some $91 million in additional funds would be needed to support such an effort, exclusive of base operation and maintenance costs.[24]

The Department of Defense, which again was considering variants of the Vanguard and Orbiter proposals as well as a scientific satellite based on the WS 117L, decided again that no justification existed for tying the WS 117L program to International Geophysical Year Programs. The Stewart Committee unanimously endorsed the validity of the current Air Force approach and, by implication, the need for a military satellite. Nevertheless air staff members in the Pentagon remained conscious of the continued presence of anti-satellite sentiment in the defense department. Some officials in the defense establishment openly questioned the feasibility of a reconnaissance satellite, much less the existence of a valid military requirement for such a system.** Perhaps equally troublesome, concern for a variety of other programs which, in the climate of the early 1950's,

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* Precisely ten years earlier, on 2 February 1947, RAND had submitted the first technically detailed scientific satellite proposal to the (then) Army Air Forces.

** The attitude was scarcely unprecedented, one of the most notorious examples being Fleet Admiral William D. Leahy's flat refusal to believe in the feasibility of an atomic bomb until the very day of the Almagordo test in July 1945.

appeared to be far more significant to the Air Force than military satellites, frequently caused even those who were officially supporting the space effort to be somewhat tepid in their support. Thus Air Force planners convinced of the urgency of a space program and working to secure its approval too often found their audiences at higher levels to be either indifferent or actively hostile to their proposals.[25]

Nevertheless, work went doggedly ahead. Even though the "crash effort" to prepare a development plan for a scientific satellite to orbit by the fall of 1958 took precedence, work on a military system with a more realistic deadline continued. Indeed, considerable urgency attached to the preparation of a full development plan. On 10 February 1956, before anything was known about the Stewart Committee's decision on the proposed "prototype" scientific satellite, the project officer for WS 117L (Colonel O. J. Glasser) outlined a schedule calling for the completion of all basic planning by 1 April. The project office met that deadline, forwarding on 2 April a formal development plan that established a May 1959 target date for first orbit. (However, as late as March 1956 Glasser's group still was giving thought to meeting the time requirements of the geophysical year program, and as much as a year later it did not seem entirely impossible to launch some sort of a satellite by the end of the geophysical year.)[26]

The full-scope system development plan for WS 117L received General Schriever's approval on 2 April 1956 and General Power's endorsement three weeks later. Designed to satisfy the requirements of the March and October 1955 operational requirement and system requirement documents, it was almost exclusively concerned with the purely military reconnaissance aspects of the satellite program. In the sense of providing that early flights would have the "additional objective" of collecting "geophysical data of interest to the scientific community in general," it conformed roughly to some of the details of the preliminary plan of 14 January. That was the only significant concession to the scientific satellite, however. The orbital element was essentially a refined reconnaissance satellite tied to an Atlas launch vehicle. The complete system, including vital ground installations for analyzing and disseminating the collected information, was intended to be fully operational by the third quarter of 1963. Exclusive of facilities, the research and development cost was expected to be about $114.7 million.[27]

Air Force headquarters approved the 2 April plan, essentially as submitted, on 24 July 1956. A development directive covering the system appeared on 3 August. It contained only one important qualification--but that was all important: development was authorized within a funding limitation of $3 million for fiscal 1957. The Air Research and Development Command system development directive (actually prepared in the Pentagon) which appeared on 17 August expanded on that qualification by citing "severe limitations on FY 1957 funds available to this command," and conceding that this was "inadequate initial funding."[28]

Nevertheless, almost precisely 10 years after its first appearance in the guise of a RAND study, the military satellite had achieved system status. But whereas conservative estimates of program costs had indicated an initial need of at least $39.1 million through fiscal 1957, the WS 117L program approved in August 1956 was funded at rather less than 10 percent of the requirements level. It was not a particularly auspicious start, but considering the obstacles of funding stringency, skepticism and "policy considerations" that had been overcome in progressing that far, the achievement was not unremarkable.

Yet the obstacles that had appeared as early as 1946 still were troublesome. Through the whole of the period when the supporters of WS 117L were seeking program approval and adequate funding, the general attitude of the Department of Defense remained hostile toward satellites. Although not openly proclaimed, it was departmental opinion that satellite vehicles were not feasible and further, that until Vanguard experiments confirmed feasibility itself the WS 117L program should be funded at the "study level."

Another obstacle to careful and detailed planning effort was a severe restriction on the circulation of information concerning the WS 117L proposals. The obviously critical political implications of a reconnaissance satellite designed to operate in peacetime served to inhibit free discussion of the program itself. The extent to which [illegible] security classification hampered thorough planning and prevented a more effective presentation of WS 117L realities was difficult to assess, but in the opinion of one key participant, it certainly had "an adverse impact."[29]

At the point of initial program approval and funding, in 1956, the Air Force space effort gave every indication of being on a sound technical foundation. Unhappily, adequate funding still was lacking, and perhaps more important, high level understanding of the vital need for a realistic military space effort was scant. There lay the real problem.

NOTES - CHAPTER 4

1. The background of the ballistic missile decision of 1954 is perhaps the best documented event in Air Force history. The "most official" version is probably that summarized in Congressional Record (Appendix), 2 Sep 1960, extension of remarks of Rep L C Arends, pp A6642-6645. Most of the key documents, too numerous to cite, are included in "Basic Documents Collection" in SSD Hist Div files.

2. Memo, MajGen J B Carey, D/Plans, DCS/Plans and Progs, to D/Ops, DCS/Ops, subj: Policy on Earth Satellite, 18 Nov 1957, with incls: Position Paper and Chronology, cited in Bowen mss.

3. Interview, LtCol V M Genez, SAFSP, by R L Perry, SSD Hist Div, 23 Jul 1962. Col Genez later concluded that high SAC officers tended to see more value in a reconnaissance satellite than most ARDC general officers, though Generals Putt, Power, and F B Wood were notable sponsors and supporters of Feed-Back.

4. "Project 1115 Background," Dec 1954; DF, Maj Q A Riepe, Weap Sys Officer, MX-2226, Dir/Weap Sys Ops, WADC, to Security Div, IG, WADC subj: Project Nickname, 14 Dec 1954, and cmt 2, IG to Dir/Weap Sys Ops, 17 Dec 1954.

5. Minutes of ICBM Scientific Advisory Committee Mtg, 15 Oct 1954, prep by LtCol B L Boatman, secy, in SSD Hist Div Basic Docs; memo, BrigGen B A Schriever, Cmdr, WDD, to Col C H Terhune, D/Cmdr Weap Sys, subj: Satellite Development Plan 15 Apr 1955, in SSD Hist Div files, Space-Gen.

6. GOR No 80, 16 Mar 1955: "General Operational Requirement for a Strategic Reconnaissance Satellite Weapon System," in SSD Hist Div file: ARS/WS 117L thru 1955.

7. ARDC S R No 5, 29 Nov 1954 and Amend No 1, 8 Aug 1955, authorized design studies by industry; Hist Rpt, WS 117L, Jan-Dec 1956 (WDD), in SSD Hist Div file; Genez interview, 23 Jul 1962; presn: ARS Presentation, LtCol W G King, Ch, MX-2226 WSPO, to BrigGen B A Schriever, Cmdr WDD, and staff, 7 Nov 1955, cy in SSD WS 117L files, R and D Center.

8. Minutes of the ICBM Scientific Advisory Committee Mtg, 4 Jan 1955, Basic Docs file.

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9. Minutes of the ICBM Scientific Advisory Committee, mtg of 16-17 Jun 1955, prep by LtCol B L Boatman, WDD, in SSD Hist Div files.

10. Ltr, MajGen A Boyd, D/Cmdr Weap Sys, ARDC, to BrigGen B A Schriever, Cmdr WDD, no subj, 7 Nov 1957; Memo of Understanding, MajGen B A Schriever, Cmdr WDD, and BrigGen H M Estes Jr, Dir/Sys Mgt, ARDC (Det 1, W-PAFB), subj; Transfer of Responsibility for ARS Program, 13 Jan 1956; ARDC SR No 5, 17 Nov 1955, in SSD Hist Div ARS/WS 117L file.

11. Testimony of MajGen J B Medaris, Cmdr, ABMA, Johnson Committee hearings, 14 Dec 1957; testimony of LtGen J M Gavin, Ch R and D (DCS), U S Army, Johnson Committee hearings, 13 Dec 1957; Spec Rpt, RP-1, "Project Orbiter," prep by R W Seese, ABMA Dev Ops Div, 14 Sep 1956, cited in D S Akens, Historical Origins of the George C Marshall Space Flight Center, NASA Hist, Dec 1960; ltr, Ch GMDD, Ord Msl Lab, Redstone Arsenal, to Ch. Aeromed Br, (Aeromed Lab.) ARDC (WADC.) 23 Dec 1954, in ABMA Hist Div files, cited in Akens: Origins . . . ; J B Medaris, Countdown for Decision (New York, Putnam, 1960); A C Clarke, The Making of A Moon (New York, Harper, 1957).

12. RAND Rpt RM-1194, Scientific Uses for a Satellite Vehicle (R R Carhart), 12 Feb 1954; RAND Rpt RM-1500, Scientific Uses of an Artifical Satellite (H K Kallmann), 8 Jun 1955.

13. Johnson Committee hearings, I, 606, reprint of portion of special RAND memo; F J Krieger, Behind the Sputniks, A Survey of Soviet Space Science (Washington, Public Affairs Press, 1958), 3-4.

14. Supplemental Appropriation Act, 1955, P L 663, 68 Stat 818; Aeronautics and Astronautics, NASA chronology (E E Emme) (Govt Print Ofc, 1961), pp 76, 77; New York Times, 17 Nov 1954, 22 Dec 1954.

15. NSC Dir 5520, 26 May 1955, cited in Bowen mss. In his 18 Jun 1962 letter to Putnam (SSD), Bowen calls this "the decisive document" in the subsequent progress of the American scientific satellite effort. Although it is difficult to discover what alternatives were considered before the NSC made its ruling, it is abundantly clear that the effect of the ruling was to eliminate from consideration both the ABMA (Redstone-Jupiter) and the WDD (Atlas-Thor) vehicles, although these were the only high-thrust rockets that could conceivably be made available during the course of the geophysical year.

16. Minutes of ICBM Sci Adv Comm Mtg, 16-17 Jun 1955, p 6; Akens: Origins . . . , citing Rpt of the Ad Hoc Adv Gp on Spec Capabilities, Ofc of Asst Secy/Def, Aug 1955, pp A-1, 1-17; ltr, Bowen to Putnam, 18 Jun 1962.

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17. Memo, Col C H Terhune, D/Cmdr Tech Ops, to BrigGen B A Schriever, Cmdr, WDD, subj; Visit of DOD Satellite Committee, 28 June 1955; memo by WDD Histn, subj: Convair Presentation, 29 Aug 1955, 30 Aug 1955, both in SSD Hist Div files, ARS/WS 117L thru 1955.

18. Johnson Committee hearings, testimony of D A Quarles, Secy AF, 27 Nov 1957, pp 284-286, LtGen J M Gavin, DCS/R and D, Army, 13 Dec 1957, pp 505-510, and MajGen J B Medaris, Cmdr, ABMA, 14 Dec 1957, pp 540-547; Genez interview, 23 Jul 1962. Genez, who made the AF presentations to the Stewart Committee and to Quarles, was not aware of the NSC directive at the time and actually did not learn of its details for another six years. As he recalled events, there was no evidence that the Army had any knowledge of the NSC directive, and the fact that both Von Braun and Medaris continued to endorse the use of a Redstone launch vehicle would tend to support such an observation.

19. Memo, Col P E Worthman, Ch, Ballistic Div, Asst D/Cmdr Weap Sys (Missiles and Mil Space Sys), to LtGen S E Anderson, Cmdr, ARDC, subj: Chronology of Scientific Satellite Programs, Sept 1959, cy retained by Col Worthman, Ch, SSD Plans and Progs Ofc, and extracted for SSD Hist Div, June 1962, in SSD Hist Div files; interview of Col P E Worthman, Ch, SSD Plans and Progs Ofc, by R L Perry, SSD Hist Div, 1 June 1962.

20. Rpt, WDD (ARDC) Development Plan, "Weapon System 117L Preliminary Development Plan (Initial Test Phase), Advanced Reconnaissance System," 14 Jan 1956 (probable date, not specifically marked on rpt), p ii, in SSD Hist Div files.

21. Rpt, WDD Dev Plan, WS 117L (Preliminary), 14 Jan 1956.

22. Memo, Col C H Terhune, D/Cmdr Tech Ops, to BrigGen B A Schriever, Cmdr, WDD, subj: ARS, 16 Jan 1956; memo, Col O H Glasser, Asst for Sys Mgt, to Col C H Terhune, D/Cmdr Tech Ops, WDD, subj: Presentation to the Stewart Committee on WS-177L, 7 Feb 1956, both in SSD Hist Div files: ARS/WS 117L 1955-1956; TWX, AFORD-RE-54733, Hq USAF to Cmdr, WDD, 22 Jan 1956; DF, LtCol F C E Oder, Ofc of Asst to Cmdr, ARDC, to Exec WDD, subj: RDGE Diary Items for Week ending 27 January 1956, 31 Jan 1956, in SSD Hist Div files: WAR; memo, Worthman to Anderson, Sept 1959; Worthman interview, 1 June 1962.

23. Worthman interview, 1 June 1962; Memo, to Worthman to Anderson, Sep 1959; Johnson Committee hearings, II, 1474, testimony of LtGen J M Gavin, DCS/R and D, Army, 6 Jan 1958, and I, 509, 13 Dec 1957.

24. Memo, Worthman to Anderson, Sep 1959.

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25. Interview, Col Ray Soper, Ch, Plans and Progs Ofc, BSD, by R L Perry, SSD Hist Div, 29 May 1962; Johnson Committee hearings, I, 1116, testimony of R E Gross, Chm of the Bd, Lockheed Airc Corp, 15 Jan 1958; Worthman interviews, 1 Jun, 25 Jun 1962; ltr (lst ind), R E Soper, Ch, Plans and Progs Ofc, BSD, to SSD Hist Div, subj; Request for Comments on Manuscript, 6 Aug 1962, in SSD Hist Div files.

26. Memo, Col O J Glasser, Asst for WS 117L, to Col C H Terhune, D/Cmdr Tech Ops, WDD, subj: ARS Activities, 10 Feb 1956; ltr, Col C H Terhune, D/Cmdr Tech Ops for BrigGen B A Schriever, Cmdr, WDD, to Cmdr, ARDC, subj: WS 117L Contractor Selection Board, 17 Feb 1956; memo, Cmdr R C Truax, Asst Dep, WS 117L Weapon System Ofc, to BrigGen B A Schriever, Cmdr, WDD, subj: 117L Activities at AFMTC, 30 Mar 1956; all in SSD Hist Div files: Terhune read files, Feb, Mar 1956; rpt, WDD Dev Plan, "WS 117L Advanced Reconnaissance System," 2 Apr 1956.

27. Rpt, WDD, Dev Plan, WS 117L, 2 Apr 1956.

28. USAF Dev Dir No 85, Weapon System 117L Advanced Reconnaissance System, 3 Aug 1956; ARDC Sys Dev Dir No. 117L, 17 Aug 1956.

29. Ltr (1st ind), Soper to SSD Hist Div, 6 Aug 1962.

GLOSSARY OF ABBREVIATIONS

AAF	Army Air Forces
ABMA	Army Ballistic Missile Agency
Admin	Administration
Adv	Advisory
Aero	Aeronautical
Aeromed	Aeromediaal
AF	Air Force
Airc	Aircraft
AMC	Air Materiel Command
ANP	Aircraft Nuclear Propulsion
Asst	Assistant
ARDC	Air Research and Development Command
ARS	Advanced Reconnaissance System
Bd	Board
Br	Branch
BrigGen	Brigadier General
BSD	Ballistic Systems Division
BuAer	Bureau of Aeronautics
Capt	Captain
CG	Commanding General
Ch	Chief
Chm	Chairman
Cmdr	Commander
Co	Company
Col	Colonel
Comm	Communication(s)
Cong	Congress
Cy	Copy
DCG	Deputy Commanding General
DCS	Deputy Chief of Staff
DCS/D	Deputy Chief of Staff, Development
DCS/Mat	Deputy Chief of Staff, Materiel
Def	Defense
Dep	Deputy
Dev	Development
DF	Disposition Form
Dir	Director; Directive
Div	Division
Docs	Documents

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Eng	Engineering
Gen	General
GM	Guided Missile(s)
GMDD	Guided Missile Development Division
GOR	General Operational Requirement
Govt	Government
Hist	History; Historical
Hq	Headquarters
ICBM	Intercontinental Ballistic Missile
IG	Inspector General
Incl	Inclosure
Ind	Indorsement
Incl	Inclosure
Intel	Intelligence
JRDB	Joint Research and Development Board
Lab	Laboratory
LtCol	Lieutenant Colonel
LtGen	Lieutenant General
Ltr	Letter
Maj	Major
MajGen	Major General
Mbr	Member
Memo	Memorandum
Mgt	Management
Msl	Missile
Mss	Manuscript
Mtg	Meeting
NASA	National Aeronautics and Space Administration
No	Number
NSC	National Security Council
Ofc	Office
Ops	Operations
Ord	Ordnance

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Prep	Prepared
Presn	Presentation
Progs	Programs
Proj	Project
R/Adm	Rear Admiral
R and D	Research and Development
Rep	Representative
Res	Research
Rpt	Report
SAFSP	Secretary of the Air Force Special Project
Sci	Science; Scientific
Secy	Secretary
Sen	Senator
Sess	Session
Spec	Special
SR	System Requirement
Sr	Senior
SSD	Space Systems Division
Stat	Statute
Subj	Subject
Sys	System
Tech	Technical; Technology
Undersecy	Undersecretary
USAF	United States Air Force
USN	United States Navy
WADC	Wright Air Development Center
WDD	Western Development Division
Weap	Weapon(s)
WSPO	Weapon System Project Office

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