REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
Aug 1995

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
THE RISE AND FALL OF DYNA-SOAR: A HISTORY OF AIR FORCE HYPERSONIC R&D, 1944-1963

5. FUNDING NUMBERS

6. AUTHOR(S)
Roy Franklin Houchin II, Major

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
AFIT Students Attending:
Auburn University, Auburn Alabama

8. PERFORMING ORGANIZATION REPORT NUMBER
95-016

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
DEPARTMENT OF THE AIR FORCE
AFIT/CI
2950 P STREET, BLDG 125
WRIGHT-PATTERSON AFB OH 45433-7765

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for Public Release IAW AFR 190-1
Distribution Unlimited
BRIAN D. Gauthier, MSgt, USAF
Chief Administration

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Accesion For	
NTIS CRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and / or Special
A-1	

14. SUBJECT TERMS

15. NUMBER OF PAGES
468

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

THE RISE AND FALL OF DYNA-SOAR: A HISTORY OF AIR FORCE HYPERSONIC R&D, 1944-1963

Roy Franklin Houchin II, Major, USAF

A Dissertation

Submitted to

the Graduate Faculty of

Auburn University

in Partial Fulfillment of the

Requirement for the

Degree of

Doctor of Philosophy

Auburn, Alabama

1995

19950912 017

UNABLE TO GET MISSING PAGE 219 BECAUSE WE WERE NOT ABLE TO GET IN TOUCH WITH THE STUDENT AND AUTHOR OF REPORT, PER MARY OGLE (1 800 543-3577) X2021 AT AIR FORCE INSTITUTE OF TECHNOLOGY (AFIT) WRIGHT-PATTERSON AFB OH.

FEBRUARY 26, 1996

DISSERTATION ABSTRACT

THE RISE AND FALL OF DYNA-SOAR: A HISTORY OF

AIR FORCE HYPERSONIC R&D, 1944-1963

Roy Franklin Houchin II

Doctorate of Philosophy, August 30, 1995
(M.A., Western Kentucky University, 1981)
(B.A., Western Kentucky University, 1976)

473 Typed Pages

Directed by James R. Hansen

After 8 years of gestation and 11 years of cultivation, the framework underlying the Johnson administration's decision to cancel Dyna-Soar, America's only hypersonic boost-glide program, in December 1963 illustrates the ebb and flow of an advanced technology program within the administrative and political context of modern American society. The decision to cancel Dyna-Soar had several significant consequences. Most important, it ended, at least temporarily, the Air Force's opportunity to use hypersonic flight for military missions. The Air Force's inability to persuade Secretary of Defense Robert S. McNamara and other Department of Defense officials of the wisdom of continuing to build and fly such an advanced transatmospheric vehicle represented the single most important reason for the program's cancellation, overshadowing 11 years of

evolutionary development. The complex political-economic-administrative relationship between the Eisenhower and Kennedy administrations, the aerospace industry, NASA, and the Air Force in the late 1950s and early 1960s left NASA as the national leader for hypersonic R&D.

Dyna-Soar was not a technological failure. It could have flown. On the other hand, Dyna-Soar's cancellation marked the collapse of the Air Force's political-economic efforts for a hypersonic boost-glider, illustrating the need for a rapid and clear consensus of purpose, single-minded and politically astute leadership, and the near-term attainment of advanced technology. Once Dyna-Soar was canceled, NASA began to acquire an increasing amount of the Air Force's hypersonic research until its Space Shuttle offered the Air Force another chance for a joint venture equal in scope to Dyna-Soar. However, this time NASA would be the lead organization.

THE RISE AND FALL OF DYNA-SOAR: A HISTORY OF AIR FORCE HYPERSONIC R&D, 1944-1963

Roy Franklin Houchin II

Certificate of Approval:

William F. Trimble
Professor
History

James R Hansen, Chair
Professor
History

W. David Lewis
University Professor
History

John Pritchett, Dean
Graduate School

Style manual or journal used Kate L. Turabian, A Manual for Writers of Term Papers, Theses, and Dissertations, fifth ed., (Chicago and London: University of Chicago Press, 1987)

Computer Software Used Word Perfect 6.1 for Windows

THE RISE AND FALL OF DYNA-SOAR: A HISTORY OF AIR FORCE HYPERSONIC R&D, 1944-1963

Roy Franklin Houchin II

A Dissertation

Submitted to

the Graduate Faculty of

Auburn University

in Partial Fulfillment of the

Requirement for the

Degree of

Doctor of Philosophy

Auburn, Alabama

August 30, 1995

VITA

Roy Franklin Houchin II, [redacted] He graduated from Western Kentucky University in 1972 (B.A.) and 1981 (M.A.). Having entered the Air Force as a Second Lieutenant in September 1981, he was promoted to Major in December 1992. Sponsored by the Office of Air Force History for the Doctor of Philosophy degree in the History of Technology/Military History, he entered The Graduate School at Auburn University in June 1992. He married Terry Lee (Cardonell) Houchin, daughter of Leroy and Arlene Cardonell, [redacted]. He has a daughter, Lee Ann, and a son, Roy F., III.

DISSERTATION ABSTRACT

THE RISE AND FALL OF DYNA-SOAR: A HISTORY OF

AIR FORCE HYPERSONIC R&D, 1944-1963

Roy Franklin Houchin II

Doctorate of Philosophy, August 30, 1995

(M.A., Western Kentucky University, 1981)

(B.A., Western Kentucky University, 1976)

473 Typed Pages

Directed by James R. Hansen

After 8 years of gestation and 11 years of cultivation, the framework underlying the Johnson administration's decision to cancel Dyna-Soar, America's only hypersonic boost-glide program, in December 1963 illustrates the ebb and flow of an advanced technology program within the administrative and political context of modern American society. The decision to cancel Dyna-Soar had several significant consequences. Most important, it ended, at least temporarily, the Air Force's opportunity to use hypersonic flight for military missions. The Air Force's inability to persuade Secretary of Defense Robert S. McNamara and other Department of Defense officials of the wisdom of continuing to build and fly such an advanced transatmospheric vehicle represented the

single most important reason for the program's cancellation, overshadowing 11 years of evolutionary development. The complex political-economic-administrative relationship between the Eisenhower and Kennedy administrations, the aerospace industry, NASA, and the Air Force in the late 1950s and early 1960s left NASA as the national leader for hypersonic R&D.

Dyna-Soar was not a technological failure. It could have flown. On the other hand, Dyna-Soar's cancellation marked the collapse of the Air Force's political-economic efforts for a hypersonic boost-glider, illustrating the need for a rapid and clear consensus of purpose, single-minded and politically astute leadership, and the near-term attainment of advanced technology. Once Dyna-Soar was canceled, NASA began to acquire an increasing amount of the Air Force's hypersonic research until its Space Shuttle offered the Air Force another chance for a joint venture equal in scope to Dyna-Soar. However, this time NASA would be the lead organization.

ACKNOWLEDGMENTS

I am grateful for the support and sponsorship of the Office of Air Force History. A very special thanks to Dr. Richard H. Kohn, Dr. Richard P. Hallion, the late Colonel John F. Shiner, Colonel David A. Tretler, and Dr. W. David Lewis, University Professor, Auburn University. The friendship, generosity, and guidance of my dissertation committee, Drs. James R. Hansen, William F. Trimble, and W. David Lewis sustained my efforts. I wish to thank William E. Lamar and Albert H. Crews, Jr., for their contributions to my research. Colonel Phillip Meilinger, Lieutenant Colonel Michael Wolfert, and Major Michael Terry (USAF, Retired), freely shared their expertise. Special thanks to Tom Lubbesmeyer, Boeing Historical Archives; Joe Carver and Micky Russell, Air Force Historical Research Agency, Maxwell AFB, AL; Clarence Geiger, Al Misenko, and Lieutenant Colonel Laura Romesburg, Aeronautical Systems Division, History Office, Wright Patterson AFB, OH; and Roger McCormick, Air Force Space and Missile Museum, Cape Canaveral Air Force Station, FL. Many of my fellow graduate students gave me helpful technical and administrative advice, particularly Kevin Kragenbrink. A special thanks to my father; his Air Force career made this dissertation possible. My wife, Terry, and my two children, Lee Ann and Roy III, continue to give me more love and inspiration than I deserve. I thank God for these friends and family. They deserve all the credit for this dissertation.

TABLE OF CONTENTS

INTRODUCTION

A FLIGHT OF FANCY

In the vast cold star-studded stillness of space a 100 miles above the Atlantic Ocean, a futuristic spaceplane, looking like a black twin-tailed delta-shaped fighter aircraft, fired its retro-rockets and began its final maneuvers for reentry. Within minutes a terrific boom signaled the boost-glider's return into Earth's atmosphere. A military air traffic controller at Andrews AFB, Maryland, radioed a priority clearance to the Dyna-Soar's pilot, 44-year-old Colonel "Al" Crews. While Dyna-Soar may seem like an unusual name for a spaceplane, Air Force engineers gave it the name based on its mode of flight; it "dynamically soars" through the atmosphere using the energy generated from its reentry and the maneuverability offered by its aerodynamic design. Looking up from his desk, the controller glanced at a wall calendar. It was 6 October 1973, a Jewish holiday--Yom Kippur.

Half a world away, a war had just started. In a coordinated assault, the Egyptian and Syrian armies launched a surprise attack on the Israelis at 2:00 p.m. The equivalent of the total forces of NATO in Europe would be flung against Israel's borders. As the attack began, 240 Egyptian aircraft crossed the Suez Canal, striking three airfields in the Sinai, surface-to-air missile batteries, and bombing Israeli command and control centers, artillery positions, and fortified strongpoints.

Simultaneously, 2,000 field artillery pieces and mortars opened up along the entire front. In the first minute of the attack, 10,500 shells fell on Israeli positions at a rate of 175 shells per second. Tanks moved up ramps prepared on sand ramparts, depressed their guns and fired point-blank at preselected Israeli fortifications. Surface-to-surface missiles joined the 3,000 tons of concentrated destruction launched against a handful of fortifications that turned the entire east bank of the Suez Canal into an inferno for 53 minutes. The Syrians performed a similarly devastating attack against Israeli defenses along the Golan Heights. It lasted 50 minutes. For the air traffic controller, it was hard to believe that the pilot with whom he had just spoken had, minutes ago, flown over this tremendous battlefield and was already back with high-resolution photographs showing the precise deployments of the warring armies. Rocketing into space on top of an Air Force Titan IIIC missile, Col. Crews, one of only six Dyna-Soar pilots, had responded shortly after the battle began by overflying the Middle East on a path that took him over Jerusalem. With his mission for the National Reconnaissance Office (NRO) completed, he then maneuvered his hypersonic boost-glider down through the atmosphere to a pinpoint landing at Andrews AFB, Maryland. Officially, of course, he had performed no such mission; rather he had flown his Dyna-Soar on a routine weather reconnaissance flight.

Like the U-2 and SR-71 pilots before the development of Dyna-Soar, Colonel Crews now "publicly" flew for the CIA and the Air Force. However, because Dyna-Soar operated in space--like NRO's unmanned reconnaissance satellites--it flew at the request of the president and his National Security Council (NSC). In this particular case, Col. Crews gained valuable information about the Egyptians' and the Syrians' intentions in their new struggle with the Israelis.

After landing "T-Rex," the code-name for Crews' Dyna-Soar, he immediately took the stored photographic information (other "real-time" information had already been dispatched by downlinks and examined by the NRO), that had been processed as the glider maneuvered for reentry and landing, to debriefing. Shortly afterwards, it would be in the hands of the president. The information showed, respectively, the two forces operating from the Suez Canal and the Golan Heights rapidly pushing the surprised Israelis back. The photographic, radar, and electronic intelligence information Col. Crews gathered with Dyna-Soar's multisensor reconnaissance suite would prove invaluable to the United States and its ally, Israel. Additionally, he had been able to redirect his boost-glider's sensors on an area not originally included in his mission briefing, the Soviet Mediterranean fleet. Had this been an unmanned mission, the fleet would have gone unreconnoitered for several days because no other intelligence information provided a reason for studying the Soviet's actions in this area. Nor would the NRO's surveillance satellite routinely covering this area have seen the fleet's actions because the Soviets planned them with full knowledge of the satellites timing and coverage. The information Col. Crews and his squadron of Dyna-Soar pilots provided in their twenty-four-hour coverage of the crisis turned the tide of war and averted a superpower confrontation. By 15 October, all the warring nations accepted a United Nations Security Council cease-fire resolution.

At least the warring nations could have accepted a cease-fire agreement on 15 October 1973, only 9 days after the Yom Kippur War had started, if anything about this dramatic mission of the Dyna-Soar had been true. But none of it was. There was no Dyna-Soar spaceplane, code-name "T-Rex" or otherwise. Ten years earlier, in December 1963, President Lyndon B. Johnson's Secretary of Defense, Robert S. McNamara, had canceled the program, citing the program's narrowly defined objectives as the reason for its cancellation.[1] He did not want the Air Force solely involved in basic research on hypersonic maneuverable reentry, aerodynamic radiant cooling, and reusable structures technology. If he was going to spend $1 billion, he wanted a weapon system capable of quantitatively and qualitatively outperforming an existing system for a similar mission.

In January 1963, Secretary of the Air Force Eugene M. Zuckert believed if the Air Force was going to have spacecraft with the flexibility required in military systems it must develop the capability to land these craft at points and times of the Air Force's choosing, and to land them in a condition in which they could be readily turned around and reused. The Air Force could not be satisfied with ballistic-type reentry where a spacecraft parachuted into the ocean and was recovered by a salvage-type operation. In fact, the special technology necessary to satisfy the military requirement for routine access to space would not be produced as a fallout of present or planned NASA

---

[1] U.S. Congress, House, Hearings Before a Subcommittee of the Committee on Appropriations, *DOD Appropriations for 1964*, 88th Congress, 1st Session (Washington, D.C.: GPO, 1963).

programs.[2] In a series of interviews conducted for the Kennedy Memorial Library in May through July 1964, Zuckert expressed another very informed opinion about the demise of Dyna-Soar. He believed its termination started with the program's inception. In 1957 the Air Force committed the sin of "overstating" the case for Dyna-Soar and discussing it with a good portion of the scientific community, causing an image problem. Furthermore, Zuckert argued that a major factor in the Dyna-Soar cancellation was that Kennedy got his views on the program from his science advisor Dr. Jerome B. Wiesner, the author of the *Report to the President-Elect of the Ad Hoc Committee on Space* (which highlighted the critical importance of unmanned reconnaissance satellites) and an associate of the NRO director, Under Secretary of the Air Force Dr. Joseph V. Charyk. "Having been over sold," stated Zuckert, "it was passed by the Mercury Program [of NASA]." Additionally, there were too many starts and stops in the program, and too many reviews to determine whether the hypersonic boost-glider, a lifting-body, or a ballistic capsule was the proper approach. Zuckert remembers Charyk saying in 1962 that the Air Force created Dyna-Soar as a suborbital "roller coaster ride." Having been under "development" for four years, it would be reoriented to orbital flight. Zuckert believed his staff reoriented the program to where it made sense--an orbital hypersonic boost-glider to research manned military

---

[2] Office of Information, *Air Force Information Fact Sheet: X-20 Dyna-Soar*, Fact Sheet (Washington. D.C.: Office of the Secretary of the Air Force, 1963).

capabilities in space.[3] Ironically, its 1957 development plan *did* orient it toward researching manned military space operations (Step II) and orbital flight (Step III) after investigating the feasibility of boost-glide hypersonic flight (Step I).[4] Reorientation placed Dyna-Soar in a perilous position. Its mission competed with NASA's Mercury and Gemini programs for the manned space mission and with the NRO's unmanned satellites for the national reconnaissance mission.

Afterwards, suggests Zuckert, Dyna-Soar's survival became a fiscal matter, a question of whether the research information it could yield would be worth its cost. When McNamara went to Seattle in March 1963, the Air Force secretary estimated that the program could still be saved because of the amount of money already invested in the program and the program's relationship to the Titan IIIC booster, which had been selected to lift the craft into space. Dyna-Soar offered the nation an important capability and, once it had the capability, Zuckert felt that the administration would find additional ways of using it. Yet McNamara, in his quest for commonality, felt Dyna-Soar duplicated the capabilities of other DOD programs . With a price tag estimated at $1 billion dollars, it became a high profile cost-cutting target. Once it became a target, Zuckert believed people were taken off the program and placed on

---

[3]E. M. Zuckert, Secretary of the Air Force, ed. Larry McQuade and Ned Trapnell (Washington, D.C., 27 June-11 July, 1964); William E. Burrows, *Deep Black* (New York: Random House, 1986); Jeffery T. Richelson, *America's Secret Eyes in Space* (New York: Harper & Row, Publishers, Inc., 1990).

[4]Directorate of Systems Plans, "Abbreviated Development Plan for Weapon System 464L," First Development Plan for Dyna-Soar (Wright-Patterson AFB, 23 August 1957).

more promising projects. Ultimately, the Air Force secretary felt that Dyna-Soar became a casualty of the mistakes made in its early stages of development and was overcome by the rise of NASA and its manned programs.[5]

The framework underlying McNamara's decision to cancel Dyna-Soar illustrates the ebb and flow of the program within the political and administrative context of modern American society. The decision had several significant consequences. Most importantly, it ended, at least for the time being, the Air Force's opportunity to use hypersonic flight for military missions. The Air Force's inability to persuade McNamara and other Pentagon officials of the wisdom of continuing to build and fly such an advanced transatmospheric vehicle in the early 1960s represented the single most important reason for the program's cancellation, overshadowing 11 years of significant hypersonic development by the Air Force. The complex political-economic-administrative relationship between the Eisenhower and Kennedy administrations, NASA, and the Air Force in the late 1950s and early 1960s left NASA as the pacesetter for hypersonic R&D.

Dyna-Soar was not a technological failure. It could have flown. On the other hand, Dyna-Soar's cancellation marked a political-economic failure, illustrating the need for a rapid and clear consensus of purpose, single-minded and politically astute leadership, and the near-term attainment of advanced technology. Once Dyna-Soar was canceled, NASA began to acquire an increasing amount of the Air Force's hypersonic

---

[5]Zuckert interview, June-July 1964

research until its Space Shuttle offered the Air Force another chance for a joint venture equal in scope to Dyna-Soar. This time NASA would take the lead in developing a new evolutionary technological system.

While Dyna-Soar began in 1957, the roots of Air Force hypersonic R&D go back at least to 1944. In that year Henry H. "Hap" Arnold, the commanding general of the Army Air Forces (AAF), identified the need for advanced airpower weapon systems to meet the anticipated postwar enemy threat.[6] Hoping to capitalize on expanding R&D investments during the war and on public sentiment awakened to the potential dangers of the Soviet Union after the war, Arnold and other advocates of a unified national program of aeronautical development sought to create the means for forecasting airpower weapon systems and organizing new institutions devoted solely to aerospace R&D. Germany's advanced technological capabilities, especially the supersonic flights of the V-2 rocket, illustrated how America might no longer be immune from enemy attack. As the Soviet Union developed nuclear warheads,

---

[6]Donald R. Baucom, "Air Force Images of R&D and Their Reflections in Organizational Structure and Management Policies," Ph.D. Dissertation (Norman Oklahoma: University of Oklahoma, 1976); Capt. Dennis J Stanley and Capt. John J. Weaver, *Air Force Command for R&D, 1949-1976* (Andrews AFB MD: Office of History, Air Force Systems Command, 1976), pp. 1-27; Albert Misenko and Philip H. Pollock, *Engineering History from McCook Field to the Aeronautical Systems Division* (Wright-Patterson AFB OH: Office of History, Aeronautical Systems Division [hereafter cited as OH/ASD], 1978), pp. 1-24; Robert Sigethy, "The Air Force Organization for Basic Research, 1945-1970: A Study in Change," Ph.D. Dissertation (American University, 1980); Walter A. McDougall, *The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, Inc., 1985), pp. 74-80; Michael H. Gorn, *Vulcan's Forge: The Making of an Air Force Command for Weapons Acquisition, 1950-1985* (Andrews AFB MD: Office of History, Air Force Systems Command, 1989), pp. xv-xvii.

intercontinental ballistic missiles (ICBMs), and long-range strategic airpower, the need to maintain the technological superiority of America's airpower assets seemed all the more important in determining the outcome of future wars. Harnessing the ability to push the aeronautical state-of-the-art to ever greater speeds, higher altitudes, and flights over longer distances would this be central to the initiatives of the AAF's Scientific Advisory Group (SAG), created in September 1944 to search the world for the most advanced aeronautical ideas and determine the potential of these ideas for future wartime applications. Taking the SAG's initial forecasts a step farther, a second AAF-created institution--RAND (an acronym for R&D Corporation, a non-profit R&D agency created by Arnold and Douglas Aircraft Corporation president Donald Douglas to study intercontinental warfare)--predicted the importance of orbital satellites.[7] RAND's insight helped foster continued R&D support for ballistic missiles and helped demonstrate the possibilities of supersonic and even hypersonic propulsion systems.

Meanwhile, the Air Force, a separate branch of the military since the 1947 National Defense Act, NACA, and Navy pooled their limited R&D resources and continued to push high-speed and high-altitude technologies with their X-series of manned rocket planes. By October 1951, their joint efforts opened the door to

---

[7]Michael J. Neufeld, *The Rocket and the Reich: Peenemünde and the Coming of the Ballistic Missile Era* (New York: Free Press, 1995); Robert F. Futrell, *Ideas, Concepts, Doctrine: A History of Basic Thinking in the United States Air Force 1907-1964* (Maxwell AFB AL: Air University Press, 1974), pp. 101-06; Bruce L. R. Smith, *The RAND Corporation* (Cambridge MA, 1966), pp. 30-64; Michael H. Gorn, *Harnessing the Genie: Science and Technology Forecasting for the Air Force, 1944-1986* (Washington, D.C.: Office of Air Force History, 1988), pp. 11-15, 30-34.

hypersonic flight, at least at the lower end of the hypersonic regime, between Mach 5 and Mach 7. Studies suggested a rocket-powered aircraft capable of such speeds could be constructed with existing technology and adequate funding.[8] In turn, the technology from a "Round Two" X-15 rocket-plane program could then lead to a "Round Three" program in which an honest-to-goodness "spaceplane" would explore the higher end of the hypersonic regime, beyond Mach 7, and fly into space and back.[9] Despite the initial lack of enthusiasm some Air Force officials showed for space programs during the early 1950s, most officials were 100 percent behind Vice-Chief of Staff General Hoyt S. Vandenberg's 15 January 1948 space policy statement advocating the Air Force's pursuit of missile and satellite technology.[10] In turn, they felt a manned aircraft would eventually carry observers on routine space missions. To mention the quest for space without assuming man's presence was as unthinkable to them as the conquest of the sea without sailors was to the Navy. Although others within the DOD,

---

[8] Research Airplane Committee, "A Report on the Conference on the Progress of the X-15 Project," Compilation of the Papers Presented at the Langley Aeronautical Laboratory (Langley VA, 25-26 October 1956), pp. xv-10.

[9]John V. Becker, "The X-15 Project," *Aeronautics and Astronautics*, February 1964, 52-61; Robert S. Houston, *Development of the X-15 Research Aircraft, 1954-1959*, vol. 3 of *History of Wright Air Development Center, 1958* (Wright-Patterson AFB OH: Office of Information Services, 1959), 1-13, 17-22, 82-128, 182-185; Richard P. Hallion, editor, *The Hypersonic Revolution: Eight Case Studies in the History of Hypersonic Technology*, vol. 1 (Wright-Patterson AFB OH: Aeronautical Systems Division, 1987), pp. I-ii, I-iv.

[10]Lee Bowen, *The Threshold of Space: The Air Force in the National Space Program, 1945-1959* (Washington, D.C.: USAF Historical Division Liaison Office, 1960), p. 16.

Congress, and the public in 1952 were still dismissing man-in-space as a "Buck Rogers stunt," the idea of space as a continuation of atmospheric flight controlled much about Air Force R&D planning in the years before *Sputnik*.[11]

In 1952 the technology for a smooth transition to spaceflight came within reach when Walter Dornberger, the former commander of Nazi Germany's V-2 rocket research at the Peenemünde Research Institute and eventual consultant for Bell Aircraft Corporation, made an unsolicited proposal for a hypersonic boost-glide weapon system to Air Force engineers at Wright Aeronautical Development Center (WADC), Wright-Patterson AFB, Ohio. RAND's forecast regarding the strategic importance of an orbital satellite, coupled with SAG's call for the development of advanced aeronautical technology to counter an enemy threat, laid important groundwork within the Air Force for Bell's hypersonic initiative. As a weapon system based on the projected capabilities of the enemy, this Bell project of 1952, which came to be known as BOMI (Bomber-Missile), represented one of the fruits of Arnold's belief in the benefits of forecasting.

Along with a number of other projects, William E. Lamar, Chief, New Developments Office, Bombardment Aircraft Division, became the first project engineer. Lamar and his assistant, John D. Seaberg, considered BOMI a logical way to combine a high-speed, high- altitude capability with both strategic bombardment and reconnaissance roles. As a general development strategy for new weapon systems, Lamar echoed the sentiments of the SAG and RAND. He too believed that pushing the

---

[11]Lee Bowen, *An Air Force History of Space Activities, 1945-1959* (Washington, D.C.: USAF Historical Division Liaison Office, 1964), pp. 43-44.

technology of advanced flight would increase mission success and force the Soviets into a costly symmetrical response of equal or higher magnitude.[12] BOMI's hypersonic capability would achieve these goals.

Proponents would need to acquire several critical elements before a "Round Three"-style man-in-space program of controlled hypersonic reentry from space could begin. First, they needed to show how a hypersonic boost-glider weapon system could perform an Air Force mission better than an already planned system or show how Soviet R&D might lead to an equivalent boost-glider. Second, they needed to gain the Air Force's total confidence in hypersonic boost-glider technology. Dornberger's proposal showed how the inherent technical difficulties could be overcome, but the Air Force knew it had to acquire significant R&D resources to overcome them in a reasonable amount of time. In peacetime, getting enough money for everything it wanted to do would be difficult. Third, to take advantage of breakthroughs in aerodynamics, thermodynamics, structures and materials, as well as the other related flight technologies, proponents would require a large share of the Air Force's prioritized resources. If an immediate need for a boost-glide program could be demonstrated and a "high priority" status attained, it would be much easier for the Air Force to sustain the support it needed to see the proposed machine fly. If it did not

[12]John D. Seaberg, Letter to John L. Sloop, NASA HQ (Wright-Patterson AFB OH, 25 June 1976); William E. Lamar, Letter to Roger McCormick (Dayton OH, 25 June 1993).

gain this priority status, proponents of hypersonic flight would be in for a long, uphill battle, scrambling just to get incremental support.

Soviet technological achievements, the detonation of an atomic bomb in 1949--four years ahead of American intelligence estimates--the detonation of a thermonuclear device in 1953, and the development of a new long-range bomber comparable to America's most advanced aircraft created a growing anxiety. Dissatisfaction in America's response, stemming from the lengthy development cycle of weapon systems, was rampant. In turn, Air Research and Development Command (ARDC) commander Lieutenant General Thomas S. Power encouraged optimum exploitation of the advancing technology.[13] He called for imaginative, creative, and positive action in applying new configurations. Feasibility studies of BOMI, undertaken since 1951, represented just such a major potential breakthrough, a simultaneous increase in speed, altitude and range. Reorienting technical development to long-term objectives would rationalize technical funding problems within ARDC. In turn, this rationalization would, in the long-term, generate a healthier technical base for advanced weapon systems that could meet the increasing capabilities of the Soviet threat.

Following ten years of policy statements and program development, the *Air Force Manual 1-2* of 1955 integrated Atlas ICBM technology into the traditional roles and missions of air power; however, this manual still considered the manned strategic

---

[13]Major G. D. Colchagoff, Deputy Commander/Weapon Systems, "New Research Systems," Memo to Lieutenant Colonel R. C. Anderson, Commander, Research & Target Division, HQ ARDC (Andrews AFB MD, 16 February 1956).

bomber as the primary deterrent in President Eisenhower's "New Look" policy of massive retaliation. Air Force leaders like Strategic Air Command (SAC) commander Major General Curtis E. LeMay adopted a cautious approach to the "push-button war," seeing ICBMs not as a replacement but as a adjunct to the capabilities of manned strategic bombers.[14] Until 1955, the Air Force promoted the technologically reliable manned bomber as the primary component of strategic air defense.[15] This penchant for a manned bomber hindered ICBM development and made its integration into Air Force doctrine problematic. The majority of Air Force leaders believed ballistic missiles should undergo a gradual development followed by their careful integration into the weapons inventory. This policy meant that the deterrent force of the manned bomber would have to be maintained while ballistic missile technology was being assimilated. Given the budgetary constraints of Eisenhower's New Look policy, however, such an evolutionary process meant that forecasting the requirements of future weapon systems to meet the enemy threat had to be extremely accurate.[16]

---

[14] U.S. Congress, Senate, Hearings Before the Subcommittee on the Air Force of the Committee on Armed Services, *Study of Airpower*, 84th Congress, 2nd Session, Part 2 (Washington, D.C.: GPO, 1956), pp. 107-08.

[15]Major General Bernard A. Schriever, "The USAF Ballistic Missile Program," *Air University Review*, Summer 1957, 1, pp. 19-21.

[16] U.S. Congress, Senate, Hearings Before the Preparedness Investigation Committee on Armed Services, *Inquiry Into Satellite and Missile Programs,* 85th Congress, 1st and 2nd Sessions, Part 1 (Washington, D.C.: GPO, 1958), pp. 839-42; Colonel Richard Klocko, "The Impact of Guided Missile Upon the USAF," Air War College Graduate Study Group Thesis #4 (Maxwell AFB AL, 4 March, 1954), p. 8.

As funding for ICBMs improved in 1955, and the administration's concerns over a means to gather continuous and timely intelligence of the Soviet Union's nuclear capability also increased, Air Force leaders considered ICBMs as no more than a supplemental weapon system. Yet, ICBMs offered the Air Force an opportunity to extend operations into space through satellite reconnaissance and manned boost-glide technology.[17] While Bell's unsolicited 1952 BOMI proposal boosted confidence, the uncertainty of manned space operations made Air Staff planners cautious. Air Force leadership chose to parcel its scarce R&D funds to conservative weapon systems to meet known threats rather than funding radically new weapon systems like the boost-glider. The Soviet Union's curtailment of hypersonic technology in 1953 in favor of ICBM technology meant America would shift its strategic interest similarly.

When new Soviet strategic capabilities threatened the New Look policy, Eisenhower responded with a second New Look, downgrading massive retaliation in favor of deterrence and upgrading conventional, limited-war, capabilities. As the Atlas ICBM budget grew, other ballistic missiles suffered cutbacks; yet the United States maintained its nuclear superiority until November 1955 when the Soviets successfully tested a hydrogen bomb small enough to be used as an ICBM warhead.[18] With two years of focused research behind them, the Soviets were on the verge of demonstrating

---

[17]Futrell, *Ideas, Concepts, Doctrine*, pp. 253, 284.

[18]Charles C. Alexander, *Holding the Line: The Eisenhower Era, 1952-1961* (Bloomington IN, 1975), p. 190; Samuel P. Huntington, *The Common Defense: Programs in National Politics* (New York, 1961), pp. 88-113.

the ability to attack the United States directly from Soviet missile bases. This possibility fostered increased fiscal support of Atlas as a deterrent and an unmanned reconnaissance satellite system, WS 117L, as a means of constantly monitoring the Soviet Union without the potential embarrassing international consequences of losing a military aircraft and its crew on a surveillance mission. Hypersonic boost-glide technology offered a fusion of the best unmanned systems with manned strategic bomber and reconnaissance systems that planners could not ignore. However, with the Air Staff giving the Soviet ICBM threat the highest priority, proponents of hypersonic boost-glide technology had to stake their claim to the precious R&D funds by emphasizing the unique, long-term advantages of the new hypersonic technology.

In late 1957, after five years of scattered hypersonic boost-glide research, the ARDC conducted reconnaissance and bombardment feasibility studies that consolidated the various studies into a single development plan calling for the creation of a dynamic soaring spaceplane--Dyna-Soar. Yet, like it had done with previous hypersonic proposals, the ARDC thought Dyna-Soar too futuristic to be developed directly into a weapon system. But something happened four days into October 1957 that changed ARDC's mind: *Sputnik*.[19]

Without question the spaceflight revolution ushered in by *Sputnik* meant change was imminent. Yet what kind of change would it be? It was a critical time in the

---

[19] Directorate of Systems Plans, "Abbreviated Development Plan"; Brigadier General Homer A. Boushey,"Approval of Abbreviated Development Plan for System 464L," Letter (Washington, D.C., 15 November 1957).

nation's history; the demand for action could not be ignored. Some periodicals called for a designated czar to end the interservice rivalry of the military services and put the nation ahead of the Soviet Union in technology.[20] A contrary viewpoint placed the failure on national policy. America did not have a vigorous space program in 1957 because the administration preferred economy, insisted on space programs to offer returns commensurate with their costs, and seemed determined to keep the military out of space for the sake of foreign relations.[21] Nor did Congress, the armed forces, or much of the population believe appointing anything as "un-American" sounding as "czars" would solve the problem. Adding additional layers of bureaucracy to the existing missile organizations would further slow the process of space development. The question in 1957 became should the czars be overthrown or perpetuated?[22]

In the ensuing conflict between opponents and proponents of military space programs, no one denied the essential need for scientific programs. Too little was known about space. For the same reason many administration officials denied the need for a military space program. While they admitted ignorance regarding the exact nature of space warfare, proponents believed that space, as a medium, would eventually shatter the older military concepts about the land, sea, and air. For this

[20] James R. Hansen, *Spaceflight Revolution*: *NASA Langley Research Center from Sputnik to Apollo* (Washington, D.C.: GPO, 1995); *Newsweek*, 18 November 1957.

[21] Trevor Gardner, "But We Are Still Lagging," *Life*, 4 November 1957.

[22] U.S. Congress, Senate, Hearings Before the Preparedness Investigations Subcommittee on Armed Services, *Inquiry Into Satellite and Missile Programs*, 85th Congress, 1st and 2nd Sessions (Washington, D.C.: GPO, 1957), p. 220.

reason, many in the Air Force believed that it would be a mistake if the United States only sought the scientific exploration of space: America should seek both the civilian-scientific exploration of space and the military control of space.

The Eisenhower administration, resisting the political pressure to make sweeping changes in its space policy, emphasized unmanned satellite reconnaissance. Such reconnaissance capabilities would allow the United States to gain critical information about the "closed" Soviet society. Ike and his advisors would not allow any program to jeopardize this principles.[23] As aspects of Eisenhower's command and control began to materialize in what would become his "freedom for space" or "space-for-peace" policy, Dyna-Soar's part in the Air Force's space policy came under closer political scrutiny.

As the Air Force and its sister services formulated their space policies, Eisenhower established firm civilian control over all military space programs both through legislation and bureaucratic action. This meant that the Air Force would retain control of Dyna-Soar by assuring that Step I of the development plan not involve an orbital capability. But this simply delayed the inevitable decision about whether the nation actually needed the fully capable spaceplane the Air Force envisioned. Additionally, if proponents believed Dyna-Soar was a major first step towards the routine access of space, then an orbital capability was necessary.[24]

---

[23]James Bamford, *The Puzzle Palace* (Boston: Houghton Mifflin, 1982).

[24]Bowen, *Space Activities*, pp. 168, 181-83.

Dr. Herbert F. York, Director of Defense Research and Engineering (DDR&E), Office of the Secretary of Defense (OSD), doubted the utility of a human in space. He believed someone on the ground could remotely perform the same mission better than someone in space. To the extent that human presence was needed in space, it could be done by civilian astronauts; for York, the Eisenhower administration had decided the issue in 1958 by giving the general purpose man-in-space mission to NASA.[25] What York and others within OSD required from the Air Force was proof of the utility of a military man in space. From the Air Force perspective, this could never be proven if OSD refused to allow a single manned military program to fly.

Ironically, Dyna-Soar would offer the administration just such an opportunity. As a space-based reconnaissance system, Dyna-Soar would have yielded near-real-time photographic and ferret (electromagnetic) information of any area in the world, delivering the crucial results safely back to a friendly base just like in the flight of fancy that started this dissertation's introduction. Dyna-Soar's Step II orbital capability, like unmanned reconnaissance satellites, would not have violated international law. With the Soviets' launch of Cosmos 4 on 26 April 1962, a tacit agreement existed between the Soviet Union and the United States for space-based reconnaissance overflights. Dyna-Soar could have been a legal means of gaining a far wider range of photographic and ferret information. Additionally, in its Step III configuration, its increased payload capacity would have brought a greater range of

---

[25]Herbert York, *The Advisors: Oppenheimer, Teller, and the Superbomb* (San Francisco: W. H. Freeman, 1976), pp. 130-31.

reconnaissance resources to bear on each overflight target--more than any single reconnaissance satellite.

Regardless of these possibilities, doubts about the future of Dyna-Soar again began to appear during the summer of 1959. Many Air Force R&D specialists felt the growing prospects of military operations in space seemed more exciting than the Step I boost-glide operations in the atmosphere. Additionally, some Air Force officers--including Major General Bernard A. Schriever, the "father" of the Atlas and commander of ARDC--believed NASA's Mercury program would likely fail, making it necessary for the Air Force to put the first American in orbit. Should Mercury fail, these officers believed Dyna-Soar would be the candidate for the first manned orbital flight. Because of this reasoning, some questioned Dyna-Soar's design methodology. Should it be a sophisticated winged system or a simpler--quicker to develop and perhaps more reliable--ballistic system?[26]

The interagency strife within Air Force Systems Command (formerly ARDC) between the Aeronautical Systems Division (ASD) and the Space Systems Division (SSD) marked an escalating effort inside the Office of the Secretary of Defense (OSD) to maximize cost effectiveness by minimizing duplication, whether real or perceived. McNamara could afford to be selective. By September 1961, the Kennedy administration knew the Soviets were acting out of strategic weakness. Khrushchev had skillfully used the heroic efforts of Soviet space scientists to show the international

---

[26]Hallion, *Hypersonic Revolution*, p. 425.

community how Soviet weapons, technology, and productivity equaled or surpassed anything the Americans possessed. Despite Soviet propaganda to the contrary, the end of the "missile-gap" began in August 1960. After twelve failures, the United States successfully launched and recovered its first spy satellite, publicly called Discoverer 13. In January 1961, the film canisters recovered from the Discoverer flights revealed no missiles, no silos, and no factories at the locations Khrushchev boasted about.[27] By the summer of 1961, additional satellite reconnaissance enabled the NRO to conclude that the Soviets had only a few primitive ICBMs (perhaps four 100-ton SS-6 *Semyorkas*). These ICBMs weighted twice as much as the biggest American ICBM--Atlas. The administration knew these missiles were on a low alert status. It would take the Soviets three hours to fuel each missile, even though all the missiles stood at the same Siberian test site--Plesetsk.[28]

Had Dyna-Soar become militarily operational in the late 1960s as planned, it could have discovered that the probability of the 200 Soviet bombers capable of carrying nuclear weapons to their targets in the United States remained low. It could have shown that the Soviets also had 78 missiles on board submarines and that these ships would need to bring their nuclear weapons within 150 miles of American shores to have any chance of hitting the coastal cities. Ironically, Dyna-Soar could have illustrated that these submarines were rarely at sea. Instead, they stayed in the safe

---

[27]John Ranelagh, *The Agency: The Rise and Decline of the CIA from Wild Bill Donovan to William Casey* (New York: Simon and Schuster, 1986), pp. 323-27.

[28]Ibid.

harbor of Soviet ports. In turn, the Soviets understood the importance of hypersonic flight. By December 1961, the Soviet Air Force would launch a full scale mock-up of its hypersonic boost-glider--Mp-1.[29]

Conversely, the United States would be debating the merits of a new booster and defending various design approaches to hypersonic flight in December 1961. Kennedy needed to make sure Khrushchev was aware that the American president knew the Soviet leader had been bluffing. To accomplish the task, he changed the tone of American defense reporting. Kennedy highlighted the "new" strength of America's strategic military forces.[30] In doing so, the administration decided to restrain the development of hypersonic flight and other means of achieving manned military space operations.

During fiscal year (FY) 1963, SSD, helped by the largest space-oriented budget in its history but hindered by the strictest of OSD-imposed constraints, succeeded in attaining some of its long-term space objectives, particularly with its Titan IIIC booster and interim antisatellite capability. Meanwhile, the NRO's highly-classified first-generation reconnaissance satellites, such as SAMOS, continued to provide critical strategic information to the Kennedy administration, forming the justification for a

---

[29]Anatoliy Kirpil and Olga Okara, "Designer of Space Planes: Vladimir Chelomey Dreamed of Creating a Space Fleet of Rocket Planes," *JPRS-USP-94-006*, 9 August 1994, p. 14.

[30]Richard Reeves, *President Kennedy: Profile of Power* (New York: Simon and Schuster, 1993), pp. 229-30; John Prados, *The Soviet Estimate: U.S. Intelligence Analysis and Russian Military Strength* (New York: Dial Press, 1982).

second generation of more sophisticated, and heavier, reconnaissance satellites. In this competitive domestic environment, the Secretary of Defense continued to set rigid controls on funding. His concerns centered less on the strategic superiority over the Soviet Union and more with obtaining the most efficient and economical use of the nation's space resources. Meanwhile, the administration continued to provide the NRO's "black" unmanned reconnaissance programs the highest priority. Simultaneously, it restricted the flow of information that these national assets yielded. It would, therefore, be difficult for proponents of a publicized program like Dyna-Soar to compete with a program they knew little, if anything, about.

As Air Force Chief of Staff LeMay publicly warned of the inherent threat of the Soviet Union's space capabilities, he emphasized the need to inspect and neutralize Soviet satellites--manned or unmanned. LeMay believed the Soviets would deploy military space systems when they found them feasible and advantageous. Because the Soviets could orbit a nuclear weapon and detonate it in space or deliver it within 50 miles of a target on Earth, the Air Staff believed the Soviets could intercept and damage American satellites.[31] Ready capabilities--not a technology base--would constitute the best means of deterrence. Accordingly, the Air Force must begin to convert its space technology base from research to readiness status at once.[32] The blueprint for those conversions could be found in the service's proposed five-year plan.

---

[31]U.S. Congress, House, *DOD Appropriations for 1964*, Pt. 2pp. 436-37.

[32]Ibid, p. 421.

With McNamara agreeing that such a step be taken, LeMay directed Lieutenant General James Ferguson, Deputy Chief of Staff, R&D, to draft a five-year space plan. Interestingly, while the five-year plan identified practical ways for the Air Force to achieve its space objectives, McNamara subsequently ignored the document he helped to create. Deputy DDR&E John H. Rubel echoed a similarly negative response. He assured the Scientific Advisory Board (formerly SAG), convened to review the five-year plan, that it would receive little support in OSD. As far as OSD was concerned the plan failed to justify the requirements for the programs it outlined. Rubel made it quite clear: an Air Force space program did not exist; only a DOD space program existed. All Air Force space activities were to be conducted within the context of an overall DOD space program. The Air Force, therefore, could not expect to pursue plans on its own.[33] Moreover, OSD did not believe the Soviet threat warranted this particular response from the Air Force. DOD's building-block approach to program development, rather than the Air Force's plans for concurrent R&D leading to a weapon system, would be adequate. As such, OSD limited DOD's space budget to its current level.[34] OSD based its assumptions on information from the "black" world of NRO's spy satellites. Beyond the predictable vision of the spy satellites, the Soviets

---

[33]Gerald T. Cantwell, *The Air Force in Space, Fiscal Year 1963* (USAF Historical Division Liaison Office: GPO, 1966), p. 8.

[34]Futrell, *Ideas, Concepts, Doctrine*, pp. 426, 434-36.

were proceeding nicely with their hypersonic boost-glide research. In March 1963, they launched their second full-scale mock-up of their hypersonic glider.[35]

While final DOD approval of Dyna-Soar's system development plan would still be pending in the middle of 1963, the impact of the December 1961 redirection to orbital flight was significant. OSD still considered the program a means of obtaining research data on maneuverable hypersonic reentry while demonstrating the ability to make a conventional landing at a preselected site.[36] It was to be nothing more. Later, McNamara confirmed his redirection by identifying the purposes of the national military space program. He felt the establishment of a technology and experience base for manned space missions constituted the immediate building-block. The Secretary of Defense placed emphasis on acquiring the ability to rendezvous with uncooperative targets, to maneuver during orbital flight and reentry, to achieve precise recovery, and to insure that the vehicles could be reused with minimum refurbishment. To realize these ends, McNamara offered three programs. The first program, Dyna-Soar, would provide the initial technological and experience base. The second, a cooperative effort with the NASA via its Gemini program, would give experience in manned rendezvous. The third, the development of a manned space laboratory, would be useful for

---

[35]Mikhail Rudenko, "Star Wars: History of the 'Death' of a Unique Spaceplane," *JPRS-USP-93-005*, 5 October 1993, p. 32.

[36] HQ Air Force, "AFSDC-85-081," TWX to HQ AFSC (Washington, D.C., 11 December 1961).

conducting sustained tests of military systems.[37] With this space station, the Air Force would have its means for an operational military system.

In 1963, DOD again questioned the necessity of Dyna-Soar. The scope of it had to be narrowed: direct the program towards achieving its originally planned military goals or terminate it in lieu of another approach to a manned military space system more consistent with national space policy. During the Phase Alpha studies of 1960 and the Manned, Military, Space, Capability Vehicle studies of 1961, the maneuverable reentry approach of the hypersonic glider had been compared with other reentry proposals and systems. In these two studies, both the Air Force and DOD deemed the Dyna-Soar as the most feasible approach, although DOD continued to emphasize its Step I research phase. In the 1963 evaluations, it came under new, and closer, scrutiny.

In January 1963, Secretary McNamara took another significant step in defining the manned military space program. He asked for a comparison between ASD's Dyna-Soar program and NASA's Gemini program to determine the one with the most military value.[38] This request became even more important to the fate of Dyna-Soar when a few days later the DOD completed an agreement with NASA for Air Force participation in Gemini. Following a Dyna-Soar program review in March 1963,

---

[37]Robert S. McNamara, Secretary of Defense, "The Air Force Manned Military Space Program," Memo to Secretary of the Air Force Eugene M. Zuckert (Washington, D.C., 23 February 1962).

[38]Robert S. McNamara, Secretary of Defense, "Gemini and Dyna-Soar," Memo to DDR&E (Washington, D.C., 18 January 1963).

McNamara further clarified this consolidation of manned military space operations involving Gemini and Dyna-Soar. He felt the Air Force placed too much emphasis on controlled reentry to a selected landing site and not enough on the missions Dyna-Soar would perform on orbit. Satellite inspection, reconnaissance, defense of space vehicles, and the introduction of offensive weapons in space were all more significant. But he already believed a space station based on Gemini and serviced by an SSD lifting-body ferry vehicle was the most feasible approach. With HQ Air Force directing AFSC to organize its thoughts about how Dyna-Soar and Gemini objectives could be combined to achieve these four missions, the cancellation of Dyna-Soar could not be far away.[39]

Ironically, only a month earlier, everything looked promising as the Dyna-Soar system program office (SPO) briefed Zuckert on Dyna-Soar's ability to meet all these missions.[40] From its inception in 1952, the Air Force had believed that a hypersonic boost-glider could ultimately perform the strategic reconnaissance and bombardment missions more successfully than any other type of flight vehicle. As this aspiration matured into Dyna-Soar, the Air Force never gave up its belief in the utility of the hypersonic glider. Even when the need for an antisatellite (ASAT) capability replaced the Air Force's concern for a space-based bombardment mission, Dyna-Soar still

---

[39]Brockway McMillan, Assistant Secretary of the Air Force, R&D, "Secretary McNamara's Trip to Seattle," Memo to Secretary of the Air Force (Washington, D.C., 15 March 1963).

[40]William E. Lamar, Deputy Director, "History of Dyna-Soar to Present," Presentation to HQ ARDC (Wright-Patterson AFB OH, 20 February 1963).

seemed to offer the most viable way of getting the job done. Having convinced the Air Staff and the Office of the Secretary of the Air Force of its military value by 1958, the Air Force waged a continuing struggle with OSD from 1958 onward as well as with disgruntled agencies inside the Air Force. As for OSD, it never shared the Air Force's commitment to Dyna-Soar or its approach to hypersonic flight. Nor was it ever convinced of its ultimate military value.

With the cancellation of Dyna-Soar in 1963, however, the Air Force did not lose every aspect of hypersonic. It gained an opportunity to pursue another approach to hypersonic flight, that of lifting-bodies. In addition, it gained another opportunity to examine the role of manned military space operations through its Manned Orbiting Laboratory, or MOL. Dyna-Soar's hypersonic technology, therefore, would be transferred to the various Air Force and NASA lifting-body programs, ultimately forming the foundation of another hypersonic glider, the Space Shuttle, and providing the Air Force with an opportunity to prove the military utility of man-in-space.[41] Some of Dyna-Soar's military objectives would also turn into experiments for MOL.

Ironically, as SSD gained the manned military space mission from ASD through the MOL program, it too would taste the fruits of disappointment when the Nixon

---

[41]Richard P. Hallion, "Saga of the Rocket Ships," *Air Enthusiast*, March-June 1978, 90-91; Richard P. Hallion, *On the Frontier: Flight Research at Dryden, 1946-1981* (Washington, D.C.: NASA, 1984).

administration canceled its program in June 1969 for much the same reasons as McNamara canceled Dyna-Soar.[42]

---

[42]Curtis Peebles, *Guardians: Strategic Reconnaissance Satellites* (Novato CA: Presido Press, 1987).

CHAPTER 1

DEVELOPING TECHNOLOGY TO MEET AN EXPECTED FUTURE: FORECASTING POTENTIAL ENEMY THREATS, 1944-1952

> Except perhaps to review current techniques and trends, I am asking you and your associates to divorce yourselves from the present war in order to investigate all possibilities and desirabilities for post war and future war's development as respects the AAF.
>
> Henry. H. "Hap" Arnold,
> General of the Army Air Forces (AAF),
> 7 November 1944.[43]

In the final months of World War II, General Arnold wondered how the high quality of scientific thought the Army Air Forces benefited from during the war could be sustained in peacetime. Many of the brightest minds in industry and academe had made invaluable contributions to American air power by increasing the speed, range, payload, and accuracy of strategic bombing, as well as multiplying the destructiveness of armament. While their discoveries transformed the nature of aerial warfare by advancing the existing technologies of propulsion, materials, fuels, radar, and explosives, the preeminent state of German technology uncovered in intelligence missions in 1944-1945 illustrated the inherent need for America to continue its

[43]Memo, General H. H. Arnold to Dr. Theodore von Kármán, 7 November 1944 (Andrews AFB MD).

airpower research in peacetime to avoid being caught behind the enemy in any future war. Indeed, Arnold believed the historic lack of a comprehensive forecasting capability for the Army Air Forces before 7 December 1941 contributed to America's unpreparedness for World War II.[44] Still, in the post-World War II world the United States would not be the only country receiving the windfall of technical information provided by Nazi Germany's wind tunnel research, rocketry, jet, and boost-glider concepts. From the ashes of World War II, the United States and the Soviet Union emerged as the two dominant military and industrial powers. As their world interests and ideologies clashed, a Cold War of competing industrial and military capabilities developed, often resulting in some degree of "hot" war between the two nations. Based on his observations, Arnold believed America could not afford to stop its airpower R&D. In fact, it would need to expand its R&D to meet the technological capabilities of an enemy who most likely shared the same technical knowledge coming out of World War II.

---

[44]Donald R. Baucom, "Air Force Images of Research and Development and Their Reflections in Organizational Structure and Management Policies," Ph.D. Dissertation (Norman, Oklahoma: University of Oklahoma, 1976); Capt. Dennis J. Stanley and Capt. John J. Weaver, *Air Force Command for R&D, 1949-1976* (Andrews AFB MD: Office of History, Air Force Systems Command, 1976), pp. 1-27; Albert Misenko and Philip H. Pollock, *Engineering History from McCook Field to the Aeronautical Systems Division* (Wright-Patterson AFB OH: Office of History, Aeronautical Systems Division [hereafter cited as OH/ASD], 1978), pp. 1-24; Robert Sigethy, "The Air Force Organization for Basic Research, 1945-1970: A Study in Change," Ph.D. Dissertation (American University, 1980); Walter A. McDougall, *The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, Inc., 1985), pp. 74-80; Michael H. Gorn, *Vulcan's Forge: The Making of an Air Force Command for Weapons Acquisition, 1950-1985* (Andrews AFB MD: Office of History, Air Force Systems Command, 1989), pp. xv-xvii.

Arnold believed if the enemy obtained the knowledge and technical capability to create a new airpower weapon system, they would certainly develop it. In turn, the Army Air Forces would need to obtain the ability to match or counter this potential threat. Hoping to capitalize on years of expanding R&D expenditures during the war and on public sentiment awakened to the potential dangers of the Soviet Union after the war, Arnold sought to create the means for forecasting the development of airpower weapon systems and to organize new institutions devoted solely to aerospace R&D. Germany's advanced technological capabilities best represented in the supersonic flights of the V-2 rocket illustrated why America would no longer be immune from enemy attack. As enemy nations began to develop the means to attack America directly, the technological superiority of American airpower seemed all the more important in determining the outcome of future wars. Harnessing the ability to fly at ever higher speeds and altitudes would be central to the initiatives of the Army Air Forces' Scientific Advisory Group (SAG), created in September 1944 to search the world for the most advanced aeronautical ideas and determine the potential of these ideas for future wartime applications. Taking the SAG's initial forecast a step farther, a second Army Air Forces created institution--RAND (an acronym for Research and Development Corporation, a non-profit R&D agency created by Arnold and Douglas Aircraft Corporation president Donald Douglas to study intercontinental warfare)--predicted the military and psychological importance of orbital satellites.[45] RAND's

---

[45]Robert F. Futrell, *Ideas, Concepts, Doctrine: A History of Basic Thinking in the United States Air Force 1907-1964* (Maxwell AFB AL: Air University Press, 1974),

insight helped foster continued R&D support for ballistic missiles and helped demonstrate the possibilities of supersonic and even hypersonic propulsion systems. By 1952 the technology came within reach for Bell Aircraft Corporation to propose a hypersonic boost-glide weapon system to the Air Force, a separate branch of the military since the 1947 National Defense Act. RAND's forecast regarding the strategic importance of an orbital satellite coupled with SAG's call for the development of advanced aeronautical technology to counter an enemy threat offered the opportunity for Bell's hypersonic initiative. As a weapon system based on the projected technological capabilities of the enemy, Bell's 1952 Project BOMI (Bomber-Missile), represented one of the fruits of Arnold's belief in the benefits of forecasting.

Forecasting

Shallow roots of the type of forecasting Arnold desired originated in the American Revolution. David Bushnell, albeit belatedly, received an offer for financial support from the Continental Congress to defray his expanses for a new weapon system called the "Turtle"--a submarine and its "torpedo" mine.[46] Following the War of

---

pp. 101-06; Bruce L. R. Smith, *The RAND Corporation* (Cambridge MA, 1966), pp. 30-64; Michael H. Gorn, *Harnessing the Genie: Science and Technology Forecasting for the Air Force, 1944-1986* (Washington, D.C.: Office of Air Force History, 1988), pp. 11-15, 30-34.

[46]Alex Roland, *Underwater Warfare in the Age of Sail* (Bloomington IN: University of Indiana Press, 1978), pp. 68-74; Brook Hindle, *The Pursuit of Science in Revolutionary America, 1735-1789* (Chapel Hill NC: University of North Carolina Press, 1956), pp. 86-89; Frederick Wagner, *Submarine Fighter of the American Revolution* (New York: Dodd, Mead & Company, 1963), pp. 5-10; David Bushnell, "General Principles and Construction of a Submarine Vessel, Communicated by D. Bushnell of Connecticut, the Inventor, in a Letter of October, 1787, to Thomas

1812, the founding fathers realized America needed to improve its ability to manufacture arms for its army. As a result, army and navy arsenals pioneered standardization and interchangeable parts, later recognized as elements of the "American System" of manufactures.[47] While this undertaking constituted an investment in R&D to improve armaments and a desire to keep America from being dependent on foreign manufacture or overly entangled in foreign affairs, it did not constitute a system of forecasting to anticipate the next enemy threat. The Civil War provided further stimulus for the first major experiments in federal patronage of science and technology: the National Academy of Science, chartered in 1863 to mobilize expertise for the Union Army, and the Morrill Act of 1862, created to cede land to the states for agricultural schools. While industry expanded in the following decades, increasing demand for research in the fields of electricity, metallurgy, and chemicals, the federal government did not underwrite the search for new knowledge in these fields nor did it provide a means to forecast long-range needs.[48]

Jefferson Then Minister Plenipotentiary of the United States at Paris," *Transactions of the American Philosophical Society* 4:308-09.

[47]Felicia Johnson Dreyup, *Arms Makers in the Connecticut Valley* (Northampton MA, 1948); Robert J. Woodbury, "The Legend of Eli Whitney and the Interchangeability of Parts," *Technology and Culture* 1:235-51; Merritt Roe Smith, *Harpers Ferry Armory and the New Technology* (Ithaca NY: Cornell University Press, 1977); Paul A. Hanle, *Bringing Aerodynamics to America* (Cambridge MA, 1982), pp. 1-11; McDougall, *Heavens and the Earth,* pp. 74-77.

[48]Hanle, *Bringing Aerodynamics*, pp. 1-11; McDougall, *Heavens and the Earth*, pp.75-79; Robert V. Bruce, *Lincoln and the Tools of War* (Chicago IL: University of Illinois Press, 1989), p. 224.

Instead, an American pattern matured where research became the business of diffuse private entities. Dynamic corporations like those of Thomas Edison, George Eastman, and Alexander Graham Bell, technical schools like MIT (1861), Texas A&M (1876), Georgia Tech (1885), CalTech (1891), the Illinois Institute of Technology (1892), and philanthropic foundations like those of Rockefeller and Carnegie formed the foundation of American R&D. Yet, by 1914, the United States trailed Europe in the nascent processes of R&D technology. Compared to the European belligerents, America made only hesitant feints toward the mobilization of science and technology.[49] In fact, even in meteorology Scandinavian Vilhelm Bjerknes had already begun to revolutionize the science by forecasting detailed, precise, short-term weather conditions for the Western Front.[50]

These shortcomings became painfully evident by World War I. So much so Congress appropriated $5,000 to fund the National Advisory Committee for Aeronautics (NACA) in 1915. A permanent, national body of experts devoted to the advancement of aviation research, the NACA soon had military counterparts: the Army Signal Corps Experimental Laboratory and the Air Service General Laboratory.[51]

---

[49]Hanle, *Bringing Aerodynamics*, pp. 1-11.

[50]Robert Marc Friedman, *Appropriating The Weather* (Ithaca NY: Cornell University Press, 1989), Pt. 3, Chapter 5; James R. Hansen, review of Robert Marc Friedman, *Appropriating the Weather* (Ithaca NY: Cornell University Press, 1989), *Isis* 81, no. 2:382-83.

[51]James R. Hansen, *Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917-1958* (Washington, D.C.: NASA History Office, 1987); Alex Roland, *Model Research: A History of the National Advisory Committee for*

Established in 1917 at McCook Field, Ohio, the Army Signal Corps' laboratory employed over 1,400 scientists and engineers.[52] Concurrently, efforts began to create a Naval Research Laboratory.[53] Yet, the land of the Wright brothers entered the First World War without a single aircraft design ready for production. As a result, American manufacturers adapted British and Italian airplanes to their production facilities.[54]

While government wrestled with several measures to plan technological development for society, the McCook Field and NACA experiences proved to be a few of the bright spots in a dismal history of aviation R&D in the 1920s and early 1930s. From 1925 to 1937, the federal R&D budget hovered between $2-$4 million. Meanwhile, Germany poured much larger amounts of resources into aircraft development. As American engineers talked of jet propulsion and administration officials created a federal office--the Office of Technology Assessment--to forecast

---

Aeronautics, 1915-1958 (Washington, D.C.: NASA History Office, 1985); George C. Gray, *Frontiers of Flight: The Story of NACA Research* (New York, 1948); Frank W. Anderson, Jr, *Orders of Magnitude: A History of NACA and NASA* (2nd ed. Washington, D.C.: NASA History Office, 1981); John Jordan, *Machine Age Ideology* (Chapel Hill NC: University of North Carolina Press, 1994), pp. 68-91, 93-154.

[52]Misenko and Pollock, *McCook Field*, pp. 1-16.

[53]David K. Van Keuren, "Science, Progressivism, and Military Preparedness: The Case for the Naval Research Laboratory, 1915-1923," *Technology and Culture* 33, 4:711-36.

[54]Gorn, *Vulcan's Forge*, pp. vx-xvii; Hansen, *Engineer in Charge*, Chapter 1; Roy F. Houchin, II, "A Unit History of the 94th Pursuit Squadron, 5 March 1917 to 5 May 1918, with Emphasis on the Importance of Technology," M.A. Thesis (Bowling Green KY: Western Kentucky University, 1981).

technological progress for society and evaluate it, German scientists stood at the threshold of the jet age and began to organize society for warfare.[55] Still, under the threat and reality of war, research accelerated. Between 1940 and 1944, Congress allocated six times the funds it had provided in the previous twenty years to NACA. Moreover, during the late 1930s American industry spent almost $100 million each year on aviation research. Universities also contributed in the drive to prepare for war and received 30 major grants from NACA. Additionally, more military personnel enrolled in science courses than ever before.[56]

As America prepared to enter the war, Arnold realized time permitted only the modernization of existing aircraft. He ordered production-line improvements such as auxiliary bomb racks, leak-proof fuel tanks, and de-icing equipment. Ironically, the Battle of Britain in 1940 suggested even this limited effort would need to be curtailed to enable American industry to standardize and mass produce its current aircraft designs. Nevertheless, as Arnold observed, science, engineering and industry would still determine success. Radar and sonar, coupled with renewed emphasis on technical aircraft modifications such as the use of a radically new NACA airfoil that North American Aviation introduced on their P-51 in 1940 and the introduction of the Norden

[55]Jordan, *Machine Age*, pp. 155-254; Hansen, *Engineer in Charge*, Chapter 3; Charles Susskind and Arlene Inouye, "Technological Trends and National Policy, 1937: The First Modern Technology Assessment," *Technology and Culture* 18, 4:593-621.

[56] HQ ARDC, *HQ ARDC Annual History, 23 January 1950-30 June 1951* (Andrews AFB MD: HQ ARDC, 1951), pp. 4-17; Jordan, *Machine Age*, pp. 255-86.

bombsight for America's bombers, resulted in Anglo-American aerial superiority over the Axis powers. Acting in early 1944 on this well publicized advantage, Arnold began to advocate R&D projects for postwar military aviation: guided missiles, jet engines, "super" fuels, computerized gunsights, and improved airplane designs. Wartime levels of R&D appropriations gave him hope for future aeronautical research.[57]

By the summer of 1944, Arnold turned to his close friend, Dr. Robert Millikan of CalTech, to help him select a man with sufficient reputation to bring the best minds in the nation together and to construct the first long-range forecast of airpower technology to guarantee America's continued supremacy in the postwar years.[58] After discussing the matter at some length, Arnold and Millikan agreed on Dr. Theodore von Kármán of CalTech's GALCIT, already a part-time consultant to Arnold and special advisor to the Army Air Forces' Air Material Command (AMC) at Wright Field, Ohio (formally McCook Field).[59]

---

[57]HQ ARDC, *Annual History*, pp. 16-22; Gorn, *Vulcan's Forge*, p. xviii; Roger E. Bilstein, *Flight in America: From the Wrights to the Astronauts* (Baltimore MD: Johns Hopkins University Press, 1984), pp. 125-65; A. Hunter Dupree, "The Great Instauration of 1940: The Organization of Research for War," in *Twentieth Century Sciences*, ed. Gerald Holton (New York, 1972), 445-51; Daniel S. Greenberg, *The Politics of Pure Science* (New York, 1967), pp. 79-86.

[58]Gen. Henry H. Arnold, *Global Mission* (New York: Harper & Brothers, 1949), pp. 532-33.

[59]Michael H. Gorn, *The Universal Man: Theodore von Kármán's Life in Aeronautics* (Washington, D.C.: Smithsonian Institution Press, 1992); Gorn, *Harnessing the Genie*; Misenko and Pollock, *McCook Field*, p. 2; Arnold, *Global Mission*, pp. 534-35.

On 7 November 1944, Arnold established the AAF Long Range Development and Research Program. Soon afterwards, he announced von Kármán as its director. By 1 December, the program acquired the title Scientific Advisory Group with its mission of assembling and evaluating existing data from around the world and preparing a long-range R&D plan for the AAF. In short, Arnold wanted the nation's leading aeronautical scientists to look 20 years into the future and prepare a workable timetable to create the technology the Air Force would need to meet all future threats.[60]

Both von Kármán and Arnold believed the report Arnold wanted would achieve true comprehensiveness only if a SAG team of scientists first traveled to the European war zone and interviewed their counterparts in both the Allied and Axis nations. Early in December 1944, they compiled a list of eleven countries to survey. In late April 1945, they departed for Europe, arriving in London on 28 April.

Creating the Forecast

Von Kármán targeted the national laboratories at NPL Teddington and RAE Farnborough in the United Kingdom, as well as the leading industrial plants. In France and Belgium, von Kármán made plans to see the National Aeronautical Laboratories and the coastal launch sites of the V-1 "robot bombs." The tour of Holland centered on the Philips Corporation, actively engaged in advanced radar research. Germany (Aachen, Metz, Strasbourg, and Göttingen), Switzerland (the Zurich Institute), Sweden, Finland, Poland, and Italy all offered the fruits of German science: either in

---

[60]Arnold, *Global Mission*, p. 533.

German laboratories or in scientists for possible expatriation to the United States. Von Kármán's personal knowledge of the scientists and their equipment proved instrumental in what would become OPERATION PAPERCLIP, the relocation of key German scientists, like Major-General Walter R. Dornberger, Chief of the Peenemünde rocket facilities and Dr. Werhner von Braun, Chief Engineer for the V-2 rocket (referred to as the A-4 by the German scientists), to America. Additionally, it would be very important to see Soviet developments at Moscow's Central Aero-Hydrodynamic Institute (TsAGI).[61] In Paris, von Kármán received an urgent message describing a clandestine, top secret scientific research institute at Braunschweig, northern Germany. On 4 May, they traveled to the site.

Built by von Kármán's former assistant, Adolph Baumker, the facility's 56 buildings had been disguised as farmhouses and camouflaged by trees. While they found the laboratory and its documentation a shambles, even the ruins deeply impressed the SAG scientists. Consequently, von Kármán found the German scientists duplicated 95 percent of their official documentation in their personal files and, gradually, turned it over to the SAG. Between the various sources, he uncovered most of the projects undertaken at the site. Advanced work in ballistics, aerodynamics, high

[61]Thomas A. Sturm, *The USAF Scientific Advisory Board: Its First Twenty Years, 1944-1964* (Washington, D.C.: Office of Air Force History, 1986), pp. 5-6; Gorn, *Harnessing the Genie*, pp. 21-22.

speed human physiology, and jet propulsion topped the list of crucial information gleaned from the Braunschweig location.[62]

Their next stop was Aachen, the seat of the aeronautical institute von Kármán once directed, and Göttingen University, where his mentor, Dr. Ludwig Prandtl, still presided over long-term aeronautical research. Concurrently, a portion of the SAG team traveled south to Munich to meet over 400 engineers and technicians who made their way there after evacuating the Peenemunde rocket facility. Central among them were Dornberger and von Braun. From these engineers and technicians the SAG scientists learned much about the V-1 "robot buzz bomb" and the V-2 long-range rocket. Yet, perhaps the greatest achievement of the Peenemunde scientists, in the minds of von Kármán and the SAG, was their work with the A-4b, a winged version of the A-4, and with their calculations regarding a winged two-stage transcontinental rocket, the A-9/A-10. Indeed, the practicality of the winged transcontinental version had been substantiated, to the SAG's satisfaction, by extensive wind tunnel tests, ballistic calculations, and the experiences of the A-4b.[63]

---

[62]Theodore H. von Kármán, *The Wind and Beyond: Theodore von Kármán, Pioneer in Aviation and Pathfinder in Science* (Toronto, 1967), pp. 272-75; Sturm, *Scientific Advisory Board*, pp. 6-7.

[63]Dr. Theodore H. von Kármán, *Where We Stand: A Report Prepared for the Scientific Advisory Group* (Washington, D.C.: United States Army Air Forces, August, 1945), pp. 9-17; Walter R. Dornberger, *V-2*, 2nd, trans. James Cleugh and Geoffrey Halliday (New York: Viking Press, 1955), pp. 249-51; Frederick I. Ordway and Mitchell R. Sharpe, *The Rocket Team* (New York: Thomas Y. Crowell Publishers, 1979), pp. 53-58.

Alternately, an equally interesting option appeared in the published studies of the Sänger-Bredt boost-glide concept. While the work of Viennese engineer, Eugen Sänger, and his mathematician wife, Irene Bredt, preceded the efforts of Dornberger and von Braun, the Allies did not receive a report before May 1945. Sänger-Bredt proposed launching their hypersonic boost-glider with a rocket-powered sled. After releasing the sled, the laundry-iron-shaped craft would coast upwards until the pilot ignited the "silver bird's" (the nickname of the Sänger-Bredt glider) rocket engine, boosting it into space at Mach 24. The vehicle would then reenter the atmosphere like a stone skipping off the water, until it entered a final supersonic glide just before landing. As a global rocket bomber carrying a one ton warhead--RABO (for Raketenbomber), Sänger-Bredt offered their design to Nazi Germany in 1941. Because of the tremendous thermodynamic loads Sänger expected the vehicle to endure as it skipped through its reentry his ideas earned a cool reception from the Third Reich. While Sänger and Bredt had accomplished wind tunnel testing, their design never attained the hardware stage like Dornberger's A-4b. Embittered, Sänger stopped work on the project. Still, as early as 1945, the report was translated into French, Russian, and English, generating considerable interest for the potential of hypersonic flight in postwar aeronautical communities.[64]

---

[64]Irene Sänger-Bredt, "The Silver Bird Story: A Memoir," in *Essays of the History of Rocketry and Astronautics: Proceedings of the Third Through the Sixth History Symposia of the International Academy of Astronautics*, ed. R. Cargill Hall (Washington, D.C.: NASA, 1977), pp. 195-228; Eugen Sänger and Irene Bredt, *Uber Einen Rakentenantrieb Fur Fernbomber, Deutsche Luftfahrtforschung*, UM 3538, trans. Bureau of Aeronautics Naval Technical Information Branch, United States Navy

To support their R&D during the war, Germany built no less than fourteen supersonic wind tunnels, including Mach 3.3 and 4.4 tunnels at a laboratory at Kochel, Bavaria. At war's end, a Mach 10 hypersonic tunnel with a 1-meter-by-1-meter test section was under construction at the same site. A similar Mach 10 wind tunnel would not emerge in the United States until the Arnold Engineering Development Center (AEDC) placed its fifty inch tunnel "C" into service in 1961. In Switzerland, home of the world's first supersonic wind tunnel (a Mach 2 design located at the *Technishe Hochschule* in Zurich), SAG made arrangements to ship a complete Swiss-made supersonic wind tunnel, originally destined for Germany, back to Wright Field.

Von Kármán spent the last leg of the SAG's fact-finding tour in the Soviet Union where he reviewed a military parade with Josef Stalin. Yet, the trip revealed more about the way the Soviets organized their science than it did about their science. Unlike in wartime Germany, Soviet scientists received both high salaries and top military honors for their service during the war. The extent of the Soviet laboratory system also impressed von Kármán. From the Urals to the eastern Ukraine, he saw laboratories specializing in chemistry and nucleonics. He also visited a cyclotron. However, he did not observe any military equipment or research laboratories of the TsAGI; nor did he find it easy to meet scholars or students informally to discuss their work because most contacts had been arranged in advance.[65]

(Ainring: DFS, 22 September 1944), pp. 209-13.

[65]Von Kármán, *The Wind and Beyond*, pp. 283-89.

Conclusions and Responses to *Where We Stand*

On 22 August 1945, six weeks after his return to the United States, von Kármán submitted a report entitled *Where We Stand* to Arnold, summarizing the existing state of aeronautical knowledge as it related to American air power. While this report constituted an interim report and not the long-term plan Arnold still wanted von Kármán to create, it did crystallize eight fundamental conclusions about where aerial combat was going after the war. Of these, two stand out for their emphasis on supersonic (Mach 1 to Mach 5) and, ultimately, hypersonic Mach 5 and above) research. First, it suggested that aircraft, whether piloted or unpiloted, would fly at speeds far beyond the velocity of sound. Secondly, only aircraft or missiles moving at these extreme speeds could penetrate an enemy's target-seeking missile defense.[66]

To build supersonic aircraft, von Kármán recommended building supersonic wind tunnels of sufficient size to test whole model aircraft. In order to obtain performance and flow mechanics, he proposed flight tests at the speed of sound and beyond in rocket-launched research aircraft.

Despite the enormous contributions of *Where We Stand* toward illuminating the realities of postwar air power, von Kármán felt his investigations of some subjects needed further investigation. As well as expanding his research data base to the Far East, he wanted more information on the German transoceanic rocket, technology that later would become the foundation of American intercontinental ballistic missile

---

[66]Von Kármán, *Where We Stand*, p. iv; von Kármán, *The Wind and Beyond*, p. 289.

(ICBM) technology. Before he embarked on his second investigative trip, the framework for Arnold's long-term study would need to be erected. To streamline the SAG's approach and expedite completion, each member agreed to write a brief monograph related to their specific scientific speciality on subjects of specific interest to the AAF such as missiles, propulsion, or radar.[67] Nor was von Kármán alone in his continued curiosity about German aeronautical technology. The Sänger-Bredt study so impressed Stalin that he sent a team to Western Europe to find the Sängers (who had relocated from Austria to France) and persuade them to work in the Soviet Union. As Irene Sänger-Bredt suggests, if Stalin's men could not persuade them, they had authorization to kidnap them.[68] Stalin's efforts to kidnap them failed, but his quest to obtain a hypersonic boost-glider for the Soviet Union continued until 1953 when Sergei Korolev finished designing an alternative to the Sänger-Bredt intercontinental bomber--the SS-6 ICBM--and development for it began.[69]

As the Soviets continued with their ICBM research, the Truman administration struggled to determine a national strategy to wage a war of conflicting interests and

---

[67]Sturm, *Scientific Advisory Board*, pp. 8-9; von Kármán, *The Wind and Beyond*, pp. 289-90.

[68]Sänger-Bredt, "The Silver Bird," pp. 195-228.

[69]Dennis Newkirk, "Soviet Space Planes," *Spaceflight* 32 (October 1990):350-55; V. M. Petrakov, "Two Projects of V. M. Myasishchev," *Journal of the British Interplanetary Society* 47, 9 (September 1994):345-91.

ideology against the Soviet Union.[70] The communist subversion of Poland and other East European states, disputes over the administration of Germany, apparent Soviet unwillingness to demobilize its military, Soviet-supported destabilization of Greece and Turkey, communist incursions in democratic Czechoslovakia, the Berlin Blockade, the steady build-up of Soviet military technology, and the failure to stop the proliferation of nuclear weapons through cooperative actions within the United Nations combined with American reactions to these events to create a "Cold War" environment between the United States and the Soviet Union. Subsequently, Arnold pushed for increased funding of the AAF's infant R&D programs for missiles and "pilotless aircraft" (or what today would be called "cruise missiles").[71] In turn, the AAF and the aviation industries depended on one another economically and technologically; indeed, American security might hinge on the ability of aviation corporations to expand their production rapidly and perform the R&D required to ensure the highest state of

---

[70]Richard G. Hewlett and Oscar E. Anderson, Jr, *The New World, 1939-1946*, vol. 1 of *A History of the United States Atomic Energy Commission* (University Park PA, 1962), pp. 410-15; R. Cargill Hall, "Earth Satellites: A First Look by the U.S. Navy," in *History of Rocketry and Astronautics*, vol. 7, Part 1 of *AAS History Series* (San Diego CA: American Astronautical Society Publications, 1986), p. 253.

[71]Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force, 1945-1960* (Washington, D.C.: Office of Air Force History, 1990), 7-64; U.S. Congress, Senate, Military Affairs Committee, *Department of Armed Services, Department of Military Security: Hearings*, 79th Congress, 1st Session (Washington, D.C.: Government Printing Office [hereafter cited as GPO], 1945), 291-92; Ernest May, *Lessons of the Past: The Use and Misuse of History in American Foreign Policy* (New York, 1973), Chapter 2.

technology and deterrence.[72] The availability of a hypersonic wind tunnels at NACA's Langley and Ames research laboratories, the AAF's research facility at Tullahoma, Tennessee, and at universities across the nation aided their developments. Yet, as the research demand for speeds greater than Mach 12 increased, the problem of liquefied air, created when high-velocity air passed through the tunnel's nozzles, persisted for the conventional "blowdown" wind tunnels at the NACA's Langley and Ames research laboratories as well as the hypersonic tunnel at MIT's Gas Turbine Laboratory.[73] Possible solutions involved using a medium other than air or a high temperature heater. Antonio Ferri of the Polytechnic Institute of Brooklyn tried air heated by high temperature refractors. R. P. Shreeve of Princeton University's Gas Dynamics Laboratory changed both the medium and the method of heating. Later, working under contracts issued by the Air Force's Office of Aerospace Research, Shreeve and an associate, Seymour M. Bogdonoff, selected nitrogen as a medium and incorporated graphite heating, achieving test section Mach numbers in excess of 20.[74] Hypersonic

---

[72]Charles D. Bright, *The Jet Makers* (Lawrence KS, 1978), pp. 2-14.

[73]Donald D. Baals and William R. Corliss, *Wind Tunnels of NASA* (Washington, D.C.: NASA, 1981), 56-57; Frank L. Wattendorf, *A Chronology of the Background and Early History of the Arnold Engineering Development Center, 1938-1949* (Tullahoma Tennessee: Arnold Engineering Development Center, 1986), 8-9,13-18; Julius Lukasiewicz, *Experimental Methods of Hypersonics* (New York: Marcel Dekker, Inc., 1973), 26-27; Richard P. Hallion, editor, *The Hypersonic Revolution: Eight Case Studies in the History of Hypersonic Technology*, vol. 1 (Wright-Patterson AFB OH: Aeronautical Systems Division, 1987), pp. xxxi-xxxiii.

[74]Baals and Corliss, *Wind Tunnels*, pp. 83, 85-97, 94-95; Lukasiewicz, *Experimental Methods*, pp. 26-27; R. N. Cox, "Experimental Facilities for Hypersonic Research," in *Progress in Aeronautical Sciences*, ed. Antonio Ferri, D. Kuchemann

tunnel nozzle design presented still another problem for conventional tunnel developers. The standard two-dimensional tunnel nozzle created boundary layer limitations. An axisymmetric design could furnish more uniform boundary layer conditions. A team led by Bogdonoff successfully applied an axisymmetric nozzle to a hypersonic helium tunnel at Princeton in 1950. Subsequently, a team directed by Ferri at Brooklyn's Polytechnic Institute incorporated a similar design in 1955.[75]

Hypervelocity gun ranges offered an advantage over the conventional wind tunnel approach; they more closely replicated actual flight conditions. A product of a Navy Bureau of Ordnance contract with Dr. W. D. Crozier and Dr. William Hume of the New Mexico School of Mines, this early effort at creating a light-gas gun sparked considerable interest. The hypersonic range used a high explosive detonation to compress hydrogen gas with a piston. The compressed gas flowed around a model at up to 12,000 ft/sec. Dr. Alex Charters applied the concept to a light-gas gun at NACA's Ames Aeronautical Laboratory to develop a free-flight aeroballistic facility in 1947, resulting in the first light-gas gun built for model use in the United States.[76] Ames engineers developed a small launching gun to fire a model shrouded in a shedding sabot (a boot or shoe surrounding the model), placing this launcher in the

---

and L. H. G. Sterne (New York: Pergamon Press, 1962), pp. 161-63.

[75]Lukasiewicz, *Experimental Methods*, pp. 26-34; Cox, "Experimental Facilities," pp. 150-53.

[76]Lukasiewicz, *Experimental Methods*, pp. 44-51; Cox, "Experimental Facilities," pp. 162-71; Hallion, *Hypersonic Revolution*, pp. xlviii-l.

diffuser section of a small unheated supersonic wind tunnel. By doing so, the velocity of the fired model would be added to the velocity of the wind tunnel (about Mach 3), generating free-flight data at about Mach 10. With a projectile velocity of about 8,000 ft/sec, velocities up to Mach 15 could be achieved. With this device, researchers could measure drag, lift, pitching moments, the amount of travel of the center of pressure, friction of the air on the model's surface, the boundary-layer transition from laminar to turbulent flow, the damping or retarding effects of the wind on the model's ability to roll, and the effectiveness of aileron. The downside to this approach was the size of the model, which needed to be quite small. Still, the technique gained wide acceptance and fostered more elaborate facilities in the mid-1960s.[77] Ultimately, even though the various wind tunnels and free-flight ranges provided vital information, the facilities rarely lived up to the unparalleled advances contemplated by their creators.[78] This necessitated research programs to develop hardware to fly the supersonic and hypersonic flight regimes.

Toward New Horizons and the Establishment of RAND

Realizing the wartime levels of R&D spending would not be sustained as America adjusted to a peacetime economy, Donald Douglas, chairman of the Douglas Aircraft Corporation, and Arnold committed the aviation industry and the AAF to a long-term study of future intercontinental warfare to supplement the SAG's efforts. As

---

[77]Cox, "Experimental Facilities," pp. 165-69; Hallion, *Hypersonic Revolution*, pp. l-lii.

[78]Lukasiewicz, *Experimental Methods,* pp. 246-51.

a result of their September 1945 luncheon agreement, Douglas and Arnold created the Research and Development Corporation (RAND), composed of civilian scientists and engineers.[79] In mid-October 1945, Arnold suffered a serious heart attack. From his bed in Washington, D.C., he called von Kármán and urged him to hasten his draft of the long-range SAG report. They agreed on a 15 December deadline.[80]

Von Kármán's 13-volume survey, *Toward New Horizons*, arrived on 15 December, as promised. In volume one, *Science, the Key to Air Supremacy,* von Kármán called attention to the increasing scientific and technological nature of warfare. In surveying the two world wars, von Kármán believed human endurance decided victory or defeat only in the First World War. Early in the Second World War, Germany's technological superiority secured brilliant successes. On the Western Front, the Allies countered by coupling incremental improvements in air power technology and increased production with a coordinated strategy. Meanwhile, the Soviets mounted an equally undaunting effort with their armor in the East. Ultimately, victory could not have been achieved without technological superiority, due partly to

[79]Gen. Henry H. Arnold, *Third Report of the Commanding General of the AAF to the Secretary of War* (Washington D.C.: War Department, 12 November 1945), 69-74; Smith, *The RAND Corporation*, pp. 30-69.

[80]Sturm, *Scientific Advisory Board*, pp. 8-9; von Kármán, *The Wind and Beyond*, pp. 289-90.

Soviet and partly to American qualitative technological improvements and quantitative production.[81]

Additionally, argued von Kármán, organized science made decisive contributions to weaponry. Large numbers of scientific workers, as never before, united to evaluate and utilize scientific ideas for military purposes. Von Kármán discounted notions about atomic weapons eliminating the need for conventional forces. Indeed, he proposed a large proportion of the AAF's peacetime budget (as much as one third) be invested in a ten-year program of scientific exploration leading to supersonic flight, pilotless aircraft, all-weather flying, perfected navigation and communication, remote controlled/automatic fighter and bomber forces, and airborne transportation of whole armies.

The last section of *Science, the Key to Air Supremacy* summarized the SAG's recommendations on the organization of Air Force research, the extent of cooperation the AAF should pursue with scientific institutions and industry, the facilities the AAF would require, and the scientific training AAF officers would need. Von Kármán insisted person-to-person cooperation between scientists and AAF leadership needed to be strengthened to include research contracts by the AAF to scientific institutions, exchanges of personnel among military officers and civilian laboratories, employment of scientific consultants, and the establishment of laboratories dedicated to research

---

[81]Theodore H. von Kármán, editor, *Science, the Key to Air Supremacy*, vol. 1 of *Toward New Horizons* (Washington D.C.: United States Army Air Force, 1945), pp. 1-2.

facilities in fields related to air power at major universities. Second, industry and the AAF required greater unity of effort. By separating the management of AMC's R&D function from its procurement function, establishing large applied industrial research centers to work large projects on a contract basis, and underwriting industry "pilot" programs with an option for the industry to expand to full production should the product prove useful, von Kármán believed his second objective could be accomplished. Third, he suggested reorienting the AAF's R&D structure to combine complementary technologies in unified research centers devoted to the development of supersonic and pilotless aircraft, operational aircraft, nuclear aircraft, a conventional armament center at Eglin Field, Florida, and a separate site for aerodynamic, propulsion, control, and electronics studies at Tullahoma, Tennessee (later named Arnold Engineering Development Center). Fourth, to infuse scientific ideas and methods into command and staff work, von Kármán suggested permanently establishing the SAG on the Air Staff, creating liaison offices in the HQ AAF R&D hierarchy to coordinate AAF science with other government agencies, integrating new science personnel into intelligence services and keeping already mobilized scientists involved in operational analysis and target studies.

The Air Staff's initial reaction to *Toward New Horizons* could not have been more positive. Arnold praised the report as the first of its kind and a boon to future R&D planning. By February 1946, Arnold had appointed Major General Curtis E. LeMay to the new office of Deputy Chief of Air Staff for R&D. Arnold tasked LeMay to facilitate the creation of a permanent Scientific Advisory Board (SAB) and implement the rest of the SAG recommendations. In ill-health, Arnold retired, naming General Carl Spaatz as his replacement.

A SAG Conclusion and a RAND Forecast

While the duties of the SAG ended in the early months of 1946, LeMay and von Kármán met to work out the details for permanently establishing a SAB to advise the Air Staff. Although LeMay's final plan differed from von Kármán's earlier ideas, a SAB was created to continue the SAG's outstanding effort by reporting on important technological questions and promising scientific research. Von Kármán became its chairman.[82]

By mid-1946, despite making successful appointments to various panels and providing expert advice on the establishment of one of the world's foremost wind tunnel facilities at Tullahoma, von Kármán still believed his first priority was to increase SAB influence by persuading the AAF to give the SAB direct access to Spaatz, rather than report to the Deputy Chief of Air Staff R&D, LeMay. As the Truman administration reduced R&D spending, SAB's situation with the Air Staff worsened. Arnold's successors were concentrating on maintaining the AAF's readiness and force structure at the expense of R&D funding. In addition to reduced appropriations, a key element of the problem involved organization. AMC's responsibilities, as *Toward New Horizons* suggested, constituted a multitude of activities, including logistics, maintenance of existing aircraft, and, thrown in the background, R&D engineering.

---

[82]Sturm, *Scientific Advisory Board*, pp. 13-15; Gorn, *Harnessing the Genie*, pp. 36-42.

Indeed, AMC directed most of its R&D toward improving existing stockpiles of weapons systems, such as the B-50 (upgraded B-29) and P-82 (twin fuselage P-51), rather than developing new ones.[83]

Complicating the situation, interservice rivalry flared in the spring of 1946 as the Navy sought partners for its Earth Satellite Vehicle Program, the Army continued its V-2 activities (achieving hypersonic flight with its Wac Corporal/V-2 two-stage vehicle), and administration officials ridiculed the importance of ICBMs and satellites. Amid the turbulence, the AAF requested a RAND report on the military prospects and value of an Earth satellite.[84] RAND's report, released on 2 May 1946, suggested satellites would prove of great military value; they could become invulnerable observation platforms and function as communications relay stations, or even serve as orbital bombers. Equally important, a United States satellite would have a major politico-psychological effect by inflaming the imagination of humankind, producing

---

[83]Sturm, *Scientific Advisory Board*, pp. 16-36; Futrell, *Ideas, Concepts, Doctrine*, pp. 110-13; von Kármán, *Science*, pp. 3-4; Jacob Neufeld, editor, *Reflections on Research and Development in the United States Air Force: An Interview with General Bernard A. Schriever and Generals Samuel C. Phillips, Robert T. Marsh, James H. Doolittle, and Dr. Ivan A. Getting*, Conducted by Dr. Richard H. Kohn (Washington D.C.: Center for Air Force History, 1993), pp. 1-3.

[84]Hall, *Proceedings*, pp. 256-57; R. Cargill Hall, "Early U.S. Satellite Proposals," in *The History of Rocket Technology*, ed. Eugene M. Emme (Detroit: American Astronautical Society, 1964), pp. 69-93; Vannevar Bush, *Modern Arms and Free Men* (New York: Simon and Schuster, 1949), pp. 84-86; Douglas Aircraft Company, *Preliminary Design of an Experimental World Circling Spaceship*, Report SM-11827 (1946), pp. 1-7.

international repercussions comparable to the first atomic bombs.[85] Such a vehicle would cost some $150 million and take five years to build.

Some AAF leaders saw the military potential of satellites, liked what they read in the RAND report, and argued against the other services for their use. These officers wanted to include satellites as a strategic aviation payload aboard the AAF's MX 774 ICBM, under development by Convair. However, Dr. Vannevar Bush, chairman of the Joint R&D Board for the armed services (and responsible for clarifying the jurisdiction of each service's role and mission), believed the technological problems associated with the weight and kill radius of existing atomic bombs (as well as the development of a booster to carry such an orbital weapon--however lightweight) made ICBMs technologically impractical. In addition, Bush argued for the economic savings of manned bombers, suggesting the expense of a ballistic missile weapon system would bankrupt the American economy before a similar Soviet program exhausted its funds.[86] Bush did not know his Kremlin counterparts disagreed with his strategic philosophy. At the time, Stalin was seeking a Sänger-Bredt boost-glider, a V-2 based ICBM, and an intercontinental jet bomber, weapons capable of carrying Soviets nuclear bombs (then under development) all the way to the United States.[87]

---

[85]Douglas Aircraft Company, *World Circling Spaceship*, pp. 1-7.

[86]Bush, *Modern Arms*, pp. 78, 80-87.

[87]Newkirk, "Soviet Space Planes," pp. 350-55; Petrakov, "Myasishchev," pp. 345-91.

LeMay echoed Bush's sentiments. He felt ICBMs might be more efficient in the future and could replace manned bombers; but, in the near term, manned bombers would be able to counter the existing Soviet threat effectively. Indeed, even when ICBMs became practical, military flexibility would demand manned vehicles to deliver atomic weapons beyond the range of existing ICBMs, conduct secondary operations against remaining targets following an initial ICBM attack, attack targets of opportunity not selected for ICBMs, and provide a recall option during any phase of attack. In essence, while the complexity of future warfare might dictate the need for several weapon systems to answer enemy threats, manned bombers would continue to be the primary delivery platform for atomic weapons.[88]

An Independent Air Force

On 26 July 1947, Congress passed the National Security Act, creating a layer of centralized civilian control over the competing services, separating the Air Force from the Army, and creating the National Military Establishment R&D Board (with Bush as its chairman) to coordinate the R&D programs of all the services.[89] In concert with the National Security Act, one of the Army's R&D laboratories, the Watson Laboratory, split in two. While the Army's portion remained in Newark, New Jersey, the Air Force's portion moved to Rome, New York. Similarly, parts of the Army Radiation

---

[88]Futrell, *Ideas, Concepts, Doctrine*, p. 241.

[89] Department of Defense, *Semi-Annual Report of the Secretary of Defense and the Semiannual Reports of the Secretary of the Army, Secretary of the Navy, Secretary of the Air Force, 1 July to 31 December 1949* (Washington, D.C.: GPO, 1949), pp. 77-78.

Laboratory were assigned to Cambridge Research Laboratory in Bedford, Massachusetts. These facilities began to assess and correct several deficiencies within the Air Force, including the lack of a night fighter, improved airborne intercept equipment, and an air-to-ground communication link.[90] Additionally, the fledgling Air Force immediately recognized the importance of technical education for its officers by sending them to civilian institutions to study electronics and guided missile dynamics. These men formed a vanguard of hundreds of officers inside the Air Force who had studied science and engineering at major universities. As Congress further centralized military operations under a Department of Defense (DOD) and recognized the Air Force's unique role in strategic nuclear bombardment (the cornerstone for its independence from the Army), postwar inflation and reduced budgets began to strap the service's R&D programs. Bush, in response to budgetary reductions made by Bureau of Budget director James E. Webb (the future head of NASA), contemplated limiting the entire DOD budget, beginning in FY 1949, to an arbitrary ceiling of $500 million a year.[91] This meant, while the Soviets were fashioning an intense ICBM program and continued their investigations of a manned hypersonic boost-glider to carry an atomic bomb, the United States failed to sustain its ICBM program because the administration

---

[90]Neufeld, *Reflections*, pp. 3-4.

[91]David A. Rosenberg, "American Atomic Strategy and the Hydrogen Bomb Decision," *Journal of American History* 66 (June 1979):68-69.

failed to perceive the depth of the Soviet's technological capabilities. Subsequently, the administration felt it could offset the Soviet threat by other, less expensive, means.[92]

While the nation searched for a coherent nuclear strategy to cope with the Soviets in a period of fiscal restraint, George Kennan's "X" article appeared in the July 1947 edition of *Foreign Affairs*, focusing American perceptions of the Soviet threat and defining American reaction as "containment."[93] When the president's Air Policy Commission, known as the Finletter Commission because of its chairman, Thomas K. Finletter, published its recommendations in a report entitled *Survival in the Air Age* on New Year's Day 1948, the importance of nuclear deterrence through a strong air force became apparent to the president, Congress, and the public, as did the costs of a national strategy.[94] Simultaneously, Air Force planners signed a policy statement advocating their responsibility for strategic missiles and satellites.[95] At a meeting in Key West, Florida, on 21 April 1948, the Joint Chiefs of Staff (JCS) delegated responsibility for strategic air warfare to the Air Force.[96] Additionally, the JCS responded in May with a new war plan, calling for an offensive stance in Europe, a

---

[92]John Prados, *The Soviet Estimate: U.S. Intelligence Analysis and Russian Military Strength* (New York: Dial Press, 1982), 52-54,57.

[93]George Kennan, "The Sources of Soviet Conduct," *Foreign Affairs* 25 (July 1947):566-82.

[94]Daniel Yergin, *Shattered Peace: The Origins of the Cold War and National Security State* (Boston, 1977), pp. 341-42.

[95]Futrell, *Ideas, Concepts, Doctrine*, p. 99.

[96]Richard I. Wolf, *The United States Air Force: Basic Documents on Roles and Missions* (Washington, D.C.: GPO, 1987), pp. 162-64.

defensive stance in Asia, and a powerful air offensive to exploit the destructive and psychological power of atomic weapons.[97] By June, the Navy, no longer believing it could attain an ICBM role, transferred its satellite funds to more pressing programs, terminating the Earth Satellite Vehicle Project. The service's bid for a satellite program failed as the National Military Establishment R&D Board decided satellites, while feasible, had no military or scientific utility commensurate with the required expenditures.[98] As the prospects for satellite and ICBM programs vanished, a national strategy of containment, enforced through a strong manned bomber force capable of delivering the nation's atomic deterrent, developed. Accordingly, the Air Staff began to realize they must enunciate a clearer strategic military mission for satellites, or any new weapon system, before it could be justified in terms of the national economy or military doctrine.

SAB Rebounds

Concurrent with the Air Force's Key West compromise, the SAB gained increased credibility with Air Force leaders when on 15 April 1948 it became organizationally attached to the Air Force Chief of Staff with Major General Lawrence C. Craige as its military director and von Kármán as the senior civilian scientist. The

---

[97]Ibid.; Rosenberg, "American Atomic Strategy," pp. 71-72.

[98]Department of Defense, *Semi-Annual Report*, pp. 71-72; Hall, *Proceedings*, pp. 259-67; Mary R. Self, *History of the Development of Guided Missiles, 1946-1950* (Wright-Patterson AFB: Air Material Command Historical Study, 1951), pp. 71-74; Ernest G. Schwierbert, *A History of USAF Ballistic Missiles* (New York: Praeger Press, 1965), p. 145.

new SAB would follow the original research guidelines established by LeMay and von Kármán in January 1946. It would meet semi-annually to give the Air Staff Director of R&D suggestions on future air power trends and long-range possibilities.[99] In November 1948, the SAB completed a report on organizational reform and forecasted scientific improvements for the Air Force to meet the potential threat of Soviet weapon systems.

While most Air Force planners concurred with LeMay's opinions about the primacy of manned bombers, others agreed with the reforms proposed by Brigadier General Donald L. Putt, Director R&D, and by the SAB. They believed technological progress in atomic bombs would eventually reduce the weapon's size, increase its yield, and decrease its cost--not to mention the cost of the requisite boosters. Although a minority, this group of Air Force planners fostered accelerated R&D in rockets and a more ambitious military role in the future development of astronautics. They wanted the Air Force to promulgate a space policy and to ensure that an increased share of DOD appropriations went to Air Force missile programs.[100] As a result, they assigned RAND the task of continuing its studies of the potential military utility of reconnaissance satellites and their geopolitical advantages.

---

[99]Gorn, *Harnessing the Genie*, pp. 44-48.

[100]Robert L. Perry, *Origins of the USAF Space Program, 1945-1956* (Wright-Patterson AFB: Office of History, Air Force Systems Command, 1961), pp. 29-33.

The *Ridenour Report* and a Reassessment of the Soviets

When the Soviet Union exploded an atomic device on 3 September 1949, the news shocked administration officials and the JCS; both believed the Soviets incapable of atomic tests before 1952. Despite French reports in 1947 and 1948, as well as a 1948 statement by Soviet deputy foreign minister Andrei Veshinsky regarding the imminent collapse of the American atomic monopoly, administration officials did not foresee such a rapid advance of Soviet atomic technology in their assessments for military R&D funding. Why plan and spend for a Soviet threat in 1949 when it would not exist until 1952?[101]

Also in September 1949, the SAB's *Ridenour Report* (named for University of Illinois Dean Louis N. Ridenour, the chairman of the SAB working group) again advocated sweeping reforms within the Air Force's R&D establishment. It proposed a separate command for R&D, a Deputy Chief of Staff for Development on the Air Staff, and unitary budgeting for USAF R&D outlays. While many of the fiscal policy suggestions of the *Ridenour Report* were not popular among top Air Force leaders in AMC, Vice Chief of Staff Muir S. Fairchild announced implementation of the Ridenour reforms on 2 January 1950, resulting in the creation of a separate Air R&D Command (ARDC) on 23 January with Major Gen. David M. Schlatter as its commander.[102] Not surprisingly, the AMC resisted the reorganization, denying ARDC

---

[101]Prados, *Soviet Estimate*, pp. 16-19.

[102]Sturm, *Scientific Advisory Board*, pp. 41-43; Gorn, *Harnessing the Genie*, pp. 48-50.

the authority to issue procurement warrants and complicating procedural arrangements in converting a project from R&D to procurement.[103]

Soviet possession of an atomic bomb forced a reassessment of American strategy and, after long debates over military and moral issues, led to the administration's decision on 31 January 1950 to develop the hydrogen bomb--a technological breakthrough capable of restoring the types of ICBM and satellite development programs outlined in *Toward New Horizons* and the 1946 RAND report on the potential of Earth orbiting satellites.[104] In addition, innovations in missile technology continued to fuel interservice rivalry as they provided the possibility for all military services to employ these weapons either as intermediate range ballistic missiles (IRBMs) or as ICBMs directly against the Soviet Union. All of this jeopardized the Air Force's strategic bombing mission and by threatening its primary mission challenged the independence of the Air Force as well.

In March 1950, a State Department report recommended a rapid and sustained build-up of multinational free-world strength to counter existing Soviet capabilities. Estimating America's lead in atomic weapons would disappear by 1954, the report argued reductions in the national budget were secondary to the need for effective counter-measures against existing and potential Soviet threats.[105] On 2 June 1950, the

---

[103]Neufeld, *Reflections*, pp. 4-5.

[104]Rosenberg, "American Atomic Strategy," pp. 82-84.

[105]"National Security Council (NSC)-68," *Foreign Relations of the United States* 1 (14 April 1950):234-92.

Communist North Koreans tested the Truman administration's policy of containment when they launched an attack against the South Koreans; by September, the State Department's March report became national policy and America's defense spending tripled.

In July 1950, RAND researchers reported satellites could serve a primary role in maintaining national security through strategic and meteorological reconnaissance. By gathering intelligence information of high military value, unavailable from alternative sources, satellites would provide a novel and unconventional element of reconnaissance while giving the United States the psychological edge in the Cold War. Because of the political implications, what Americans did not say about the flights would be as important as what they *did* say about satellites. Because their launches could not be kept secret, they must be handled shrewdly. Soviet reaction could not be predicted. Additionally, Soviet propaganda made it advisable for the United States to sidestep the military potential of satellites and instead stress the peaceful nature of this new space technology. The legality of space-based reconnaissance hinged on international acceptance of the peaceful right of innocent passage--a concept never adhered to by the Soviets. Indeed, the Soviets might construe orbital overflights as an act of aggression.[106] To secure these objectives, suggested the RAND report, the United States should launch an experimental satellite on an equatorial orbit (to prevent

---

[106]Paul Kecskemeti, *The Satellite Rocket Vehicle: The Political and Psychological Problems*, RM-567 (RAND, 4 October 1950), pp. 1-3; *New York Times,* 10 December 1947; *New York Times,* 7 November 1950.

an overflight of the Soviet Union) to test the issue of freedom of space. While the Soviets could also develop reconnaissance satellites, the ability to gain information readily from America's open society would seem to preempt their development.[107]

Work In Wind Tunnels Continues

Concurrently, another advancing aerospace technology began to change the overall picture. This advantage involved the operation of a new type of wind tunnel known as an impulse tunnel. A generic name for a new class of high-speed aerodynamic test facilities, the impulse tunnel included shock tubes, shock tunnels, and hotshot tunnels. These devices could generate higher, albeit briefer, Mach numbers: speeds as high as 15,000 ft./sec. and stagnation temperatures of 20,000 degrees Fahrenheit for several milliseconds. While primitive shock tubes dated from the nineteenth century, not until the 1950s did aerodynamicists begin using them for hypersonic research. The devices were comprised of a long constant-diameter tube containing high-pressure gas (the driver gas) and low-pressure gas (the worker gas) separated by a diaphragm. Rupturing the diaphragm created a high-energy shockwave, accelerating and compressing the working gas. The generated shockwave then passed over a scale-model placed inside the tube, briefly exposing it to a hypersonic flow.

Expanding the working gas through a hypersonic nozzle, thereby creating a shock wave, generated still higher, but still briefer, hypersonic flow. At Cornell's

[107]Kecskemeti, *Satellite Rocket Vehicle*, pp. 15-22.

Aeronautical Laboratory, a shock tunnel generated flows as high as Mach 18 and temperatures as hot as 6,000 degrees.[108]

The so-called "Hotshot tunnels" first operated at the new Arnold Engineering Development Center in Tullahoma, Tennessee, on 30 June 1956 (Hotshot I).[109] They provided a very hot flow by electrically heating a burst of test gas. The superheated gas then burst through the diaphragm with a pressure as high as 10,000 atmospheres and a temperature near 10,000 degrees, expanding through a nozzle and around a test model at speeds up to Mach 25 for durations up to 100 milliseconds. These durations and temperatures were considerably longer and hotter than shock tunnels. Yet, hotshot tunnels suffered disappointingly from high heat losses, resulting in inconsistent temperatures and unreliable test data.[110]

A Hypersonic Program for the Air Force

As America's wind tunnel facilities refined their ability to duplicate hypersonic speeds, a "hot" war in East Asia seemed to increase the threat from the Soviet Union.

---

[108]Baals and Corliss, *Wind Tunnels*, pp. 83-85; Cox, "Experimental Facilities," pp. 156-60; Lukasiewicz, *Experimental Methods*, pp. 33-38.

[109]Marvin E. Hintz, *Chronology of the Arnold Engineering Development Center* (Tullahoma TN: HQ Arnold Engineering Development Center Historical Office, No Date), p. 53.

[110]Lukasiewicz, *Experimental Methods*, pp. 36-44; Cox, "American Atomic Strategy," pp. 160-63. Lukasiewicz specifically identifies four technical criticisms of hypersonic facilities development. Additionally, he explains why they rarely totally lived up to the expectations of their creators, who believed they would offer unparalleled advances in hypersonic test techniques.; Baals and Corliss, *Wind Tunnels,* pp. 83-85.

The North Korean invasion of South Korea added substance to the specter of Communist aggression and made new nuclear weapons systems more desirable to the public and the politicians. By the spring of 1951, Air Force leaders proposed the development of a new ICBM, the Atlas--Weapon System 107A--to K. T. Keller, the administration's special advisor on missiles.[111] Although the Atlas program's financial problems seemed solved with its acceptance for development, the technical requirements associated with a fission bomb (rather than a fusion--hydrogen--bomb), such as rigorous specifications for accuracy and distance (0.01 degree over 5,000 miles with a 10,000 pound payload), remained; indeed, they would not be resolved until proof of a compact and more powerful hydrogen bomb emerged.[112] In April 1951, a Douglas Aircraft Corporation technical study for Project Feedback, a program dedicated to studying the design of a military reconnaissance satellite, defined the hardware specifications required for an American reconnaissance satellite. Concurrently, Walter Dornberger, now a research employee with Bell Aircraft Company, outlined his plans for a rocket-powered hypersonic boost-glide bomber. Yet, Air Force reconnaissance satellite technology and Bell's rocket-boosted bomber still grew in the shadow of ICBM development. Without a nuclear payload for the Atlas, or any alternative booster program, it would not be developed. Air Force

---

[111]Edmund Beard, *Developing the ICBM: A Study in Bureaucratic Politics* (New York, 1976), 133-35; *Wall Street Journal,* 20 October 1950.

[112]Beard, *Developing the ICBM*, pp. 133-35; Herbert York, *The Advisors: Oppenheimer, Teller, and the Superbomb* (San Francisco, 1976), 82-92.

planners hoped the maturing booster technology could serve as a multi-purpose booster for other payloads as well.[113]

Also in the spring of 1952, Bell officials believed their propulsion experience with the Shrike and Rascal missiles, as well as their rocket-powered experimental aircraft, made feasible a hypersonic rocket-bomber based on Dornberger's A9/A10 concepts. R. J. Sandstrom, vice-president of Bell Engineering, approached the Chief of the Weapon Systems Division at the Wright Air Development Center (WADC) on 17 April 1952 with a proposal for a manned boost-glide bomber, called BOMI (an acronym for Bomber-Missile).[114] BOMI offered the Air Force an opportunity to combine ballistic missile technology with a manned bomber role. Additionally, Dornberger believed other roles, such as various types of reconnaissance missions, might be suitable for BOMI's boost-glide technology. Bell offered a more refined proposal on 26 May. In September, after reviewing Bell's two proposals, WADC personnel prepared feasibility objectives and work requirements for a manned bombing and reconnaissance weapon system traveling at hypersonic speeds up to Mach 12. The vehicle would have a flight radius of 2500 to 5000 miles and a cruising speed of Mach

---

[113]Perry, *Origins of the USAF Space Program*, pp. 34-36, 42-44.

[114]R. J. Sandstrom, Vice President, Engineering, Bell Aircraft Corporation, "Proposed Glide Bomber Study," Letter to HQ WADC (attn: Chief, Weapon System Division), 17 April, 17 April 1952; C. H. Uyehara, "Dyna-Soar Antecedents," Unpublished Manuscript (OH/ASD: Wright-Patterson AFB OH, 1964), pp. 5-7; Erica M. Karr, "Father of Dyna-Soar Awaits Air Force Decision," *Missiles and Rockets*, 4 May 1959, pp. 29-31.

4. The Air Force wanted it ready in 10 years and hoped it could carry a 7000-pound warhead.[115]

Conclusion

By 1952, as the Air Force seemed to stand on the threshold of exoatmospheric hypersonic flight, Air Force leaders believed the history of military aviation showed any nation capable of developing a reconnaissance system would also develop a weapon system to protect its reconnaissance resources. As both the United States and the Soviet Union eventually developed reconnaissance satellites, they would also obtain rocket-boosted antisatellite (ASAT) or satellite inspection capabilities. Because they thought these technologies were inevitable, Air Force leaders, like LeMay, believed a manned weapon system would offer the best solution in the near-term and would allow the greatest flexibility for alternate missions. In turn, such a system would ease the growing concerns of many Air Force officers about the replacement of manned bombers by pilotless cruise missiles or unmanned ICBMs by sustaining a manned strategic role within its doctrine while embracing ballistic missile technology and ensuring the Air Force remained the dominant missile service within the DOD. Air Force leaders understood these issues and believed tight budgets for ICBMs and their payloads would ease if the feasibility of a space-based mission could be proven. In turn, new Soviet aerospace technology would justify these previously forecasted weapon systems, both offensive and defensive. For these Air Force aspirations to

---

[115]Uyehara, "Antecedents," pp. 5-7.

reach fruition, the existing administration had to be willing to promote and secure international acceptance for reconnaissance satellites and be equally willing to win international acceptance of manned military space operations.[116] Arnold had hoped SAB and RAND forecasting would offer Air Force planners the insights and justification they needed to insure the timely development of new technology. Yet, forecasts alone were not enough for Air Force leadership to begin a new development program. Indeed, unless a clear Soviet threat existed, administration officials and even some Air Force leaders would remain reluctant to fund expensive new aerospace R&D.

---

[116]Craig Covault, "USAF Plans Manned Military Exercises on Space Shuttle," *Aviation Week and Space Technology*, 4 January 1988, p. 38.

CHAPTER 2

PUSHING THE STATE-OF-THE-ART: GAINING AIR FORCE CONFIDENCE AND SUPPORT FOR HYPERSONIC RESEARCH, APRIL 1952-MAY 1955

> ...we have invaded space with our rocket and for the first time--mark this well--we have used space as a bridge between two points on Earth....The development of possibilities we cannot yet envisage will be a peacetime task. Then the first thing will be to find a safe means of landing after the journey through space.
>
> Major-General Walter R. Dornberger, Commanding Officer, Peenemünde Rocket Research Institute, Northern Germany, 3 October 1942.[117]

At the end of 1944, as the Allies advanced across Europe and continued to gain greater control of the air war, the operational demand for increased range from the A-4 (V-2) rocket made it necessary for Dornberger to resume work on the winged A-4 variant (A-4b) his team had shelved in 1943 to focus their attention on the ballistic A-4. The Germans named their proposed rocket the A-9. By 24 January 1945, the A-4b successfully reached a peak altitude of 50 miles at a maximum speed of 2700 miles per hour (Mach 4.09). This unmanned remotely-controlled rocket-powered aircraft proved the feasibility of the design. For Dornberger, the problem of designing a boost-glider

[117]Walter R. Dornberger, *V-2*, 2nd ed., trans. James Cleugh and Geoffrey Halliday (New York: Viking Press, 1955), pp. 16-17.

to extend the range of the A-4 ceased to be a problem. Adding a second stage to the rocket would extend the range beyond Europe to America, creating the A-10. By working out the technical details and devoting enough time to development, Dornberger believed he could achieve his goal: landing a rocket aircraft after a flight into airless space.[118] Not only would this enable Nazi Germany to bomb the United States directly, it would give postwar Nazi Germany the capability for routine access to space. The evacuation of Peenemünde in January 1945 marked an end to this experimentation. Instead of witnessing the launch of an intercontinental ballistic missile (ICBM), Dornberger was on trial in England for his war crimes, a charge of which he would later be judged innocent. Released from prison, he flew across the Atlantic and soon acquired a job as a consultant on guided-missiles for the AMC at Wright-Patterson AFB, Dayton OH.

In 1950, Dornberger left the Air Force to become a consultant for Bell Aircraft. Not long after joining Bell, Dornberger asked for a private meeting with Lawrence D. Bell, company president, to discuss a special matter. Before the meeting, one of Dornberger's assistants dragged a footlocker into Bell's office while juggling three briefcases bulging with papers. He distributed the material in front of Bell's desk and left. Shortly afterwards, Dornberger popped in and, grinning broadly, said in his thick German accent, "I didn't show them [the Army] everything."[119] He had a cache of

---

[118]Ibid., pp. 250-52.

[119]William C. Walter, "Project Dyna-Soar: The Roots of Shuttle-A Memoir," IAA-92-0193, 43rd Congress of the International Astronautical Federation (Washington,

hypersonic boost-glide data, select material he had brought with him from Germany covering every aspect of the A-4b and A-9/A-10 programs: technical reports, blueprints, engineering designs, test reports, photographs, and motion picture film. No other American had seen this material, so Dornberger said to the fascinated Bell.

In the stimulating environment of the creators of the first X-series aircraft, the XS-1, the former chief of Peenemünde soon persuaded Bell to begin a hypersonic boost-glide program. By the spring of 1952, they solicited the Air Force for its development. So much had happened to advance aerospace technology in the postwar years (progress with rocket engines, prospects for a smaller thermonuclear or hydrogen bomb, favorable RAND reports on the feasibility of ICBMs and satellites, and the increased range of ballistic missiles) that the Air Force was more ready to reconsider the development of ICBMs as the next step beyond manned bombers. This development gave Bell's boost-glide concept a chance to compete for R&D funding, based on its potential as a manned intercontinental bomber. Potentially far superior in speed, altitude, and range than any existing--or for that matter, superior to any on the drawing boards--intercontinental jet bomber or guided missile, Bell believed his company's project would find an eager sponsor.

If the Air Force needed an enemy threat to justify boost-glider or ICBM development, it did not need to look far. Soviet efforts to develop an intercontinental boost-glide rocket-bomber, an ICBM, and a spacecraft had begun in 1946. By 1949,

---

D.C.: International Astronautical Federation, 28 August-5 September, 1992), pp. 2-3.

Secretary of Defense Louis Johnson knew about Soviet intentions to develop these programs.[120] As early as 1951, several U.S. government top-secret reports highlighted the Soviets' vision of a military space station, an Earth satellite, and a planned lunar landing attempt, all of which were to unfold in the next 10 to 15 years.[121] Yet, the apparent need for a measured American response to the growing Soviet threats would be defined, in part, by the Korean War.

The Korean War focused Air Force concerns on short-term objectives and limited its fiscal ability to fund long-term R&D objectives fully like an ICBM (the Atlas program would be resumed in 1951, after a 4-year delay in funding) or a reconnaissance satellite, much less a boost-glider.[122] Additionally, these long-term programs competed for funding with the Navaho and the Snark guided missile programs. Meanwhile, the Air Force, NACA, and the Navy pooled their limited R&D resources and continued to push the aeronautical state-of-the-art with the X-series of manned rocket planes.

---

[120] U.S. Congress, House, House Committee on Astronautics and Space Exploration, *Astronautics and Its Applications*, Staff Report, 85th Congress, 1st Session (Washington, D.C.: GPO, 1958), pp. 221-23; National Security Council, *U.S. Policy on Outer Space*, NSC 5814/1, Annex A, Soviet Space Systems (Washington, D.C.: GPO, 18 August 1958).

[121] *Washington Evening Star*, 7 September 1951; *New York Times*, 4 October, 1951; *Washington Post*, 12 October 1951.

[122] Lee Bowen, *An Air Force History of Space Activities, 1945-1959* (Washington, D.C.: USAF Historical Division Liaison Office, 1964), pp. 41-42.

By October 1951, these joint efforts had taken them to the verge of hypersonic flight. Studies suggested a hypersonic rocket-powered aircraft (capable of Mach 5-7) could be constructed with existing technology and know-how.[123] In turn, the technology from this intermediate "Round Two" program ("Round One" being the supersonic aircraft) could lead to a winged reentry "Round Three" program to explore the higher end of the hypersonic regime, beyond Mach 7.[124] Indeed, behind the initial lack of enthusiasm some Air Force officials showed for space programs during the early 1950s, most officials believed the space policy issued by Vice Chief of Staff, General Hoyt S. Vandenberg, on 15 January 1948 advocating the pursuit of missile and satellite technology.[125] In turn, the Air Force felt a manned aircraft would someday carry pilots and observers on routine space missions. At this point the quest for space certainly meant a human presence to the Air Force. Rocketing into space without men on board was as unthinkable to the Air Force as conquering the sea without sailors was

---

[123] Research Airplane Committee, "A Report on the Conference on the Progress of the X-15 Project," Compilation of the Papers Presented at the Langley Aeronautical Laboratory (Langley VA, 25-26 October 1956), pp. xv-10.

[124]John V. Becker, "The X-15 Project," *Aeronautics and Astronautics*, February 1964, pp. 52-61; Robert S. Houston, *Development of the X-15 Research Aircraft, 1954-1959*, vol. 3 of *History of Wright Air Development Center, 1958* (Wright-Patterson AFB OH: Office of Information Services, 1959), pp. 1-13, 17-22, 82-128, 182-185; Hallion, *The Hypersonic Revolution,* pp. I-ii-I-iv.

[125]Lee Bowen, *The Threshold of Space: The Air Force in the National Space Program, 1945-1959* (Washington, D.C.: USAF Historical Division Liaison Office, 1960), p. 16.

to the Navy, or the conquest of the continents without soldiers might have been to the Army.

Boost-glide technology offered something else: not the power itself but a sophisticated reusable payload for rocket-power, once it had matured. But this meant that the boost-glider, like the satellite, awaited ballistic missile technology. Ultimately, Air Force leaders would embrace ballistic missiles, as would the other services, in a quest to gain a larger share of decreasing defense appropriations and maintain technological parity with the Soviet Union. After gaining the opportunity to develop the Atlas and a reconnaissance satellite, WS 117L, Air Force leaders appeared the victors. Still, as the Air Force began to gain the lion's share of strategic defense appropriations, boost-glide technology did not receive a proportionate share. Many within the DOD and Congress, not to mention the public at large, were dismissing "man-in-space" discussions as a "Buck Rogers" fantasy in 1952, although the concept would quickly become part of Air Force doctrine in 1957.[126]

Doctrine or not, proponents of military man-in-space knew that several critical elements needed to be achieved before a "Round Three" program of manned controlled hypersonic reentry from space could begin. First, proponents would need to show how a hypersonic boost-glider weapon system could perform an Air Force mission better than other, less futuristic systems, or show how Soviet R&D might lead to a challenging equivalent weapon system. Second, they would need to gain Air Force

---

[126]Bowen, *An Air Force History*, pp. 43-44.

confidence in the technological feasibility of a hypersonic boost-glider. While Dornberger had already demonstrated how the inherent technical difficulties could be overcome, doing so would require resources that the Air Force might not have, or could not commit, without altering priorities. To sustain the necessary technological breakthroughs in aerodynamics, thermodynamics, structures, and materials, enormous resources would in fact have to be committed. If the Air Force could demonstrate an immediate need for a boost-glide program and give it "high priority" status, the requisite technological breakthroughs would come much easier; but that was a big "if." Without "high priority" for the boost-glider, a delicate balance among these three critical elements of success--and the desires of other divisions within ARDC to undermine their efforts--would need to be maintained while they scrambled to sustain step-by-step support. It would not be an easy task.

Bell's Bomber-Missile Proposal

On 17 April and 26 May 1952 Bell made proposals for the development of a manned bomber-missile (BOMI) capable of exceeding the abilities of a medium jet bomber for the same radius of operation: it would go faster (Mach 4+), higher (above 100,000 feet), and farther (as much as a complete trip around the globe) and it could be developed, almost completely, with existing design principles.[127] Additionally, Bell suggested that BOMI would be invulnerable to enemy defenses, including manned

---

[127]R. J. Sandstrom, vice-president, Engineering, Bell Aircraft Corporation, "Proposed Glide Bomber Study," Letter to HQ WADC (attn: Chief, Weapon System Division) (17 April, 17 April 1952).

interceptors and guided missiles. The company believed rocket propulsion would provide large performance gains over bombers powered by air-breathing engines. Of the three propulsion systems available--turbojet, ramjet, and rocket--Bell felt turbojets would eventually be made obsolete by early warning networks and advanced guidance systems. The company suggested hurdling over the ramjet technology of guided missiles to rockets. BOMI would be propelled by a three-stage rocket: two at launch and one for its return trip. First-stage burnout would come at 80,000 feet; second-stage at 120,000 feet at a speed of Mach 12. Over its target, the boost-glider would be flying at four times the speed of sound and 100,000 feet. It would land like a conventional aircraft on a paved runway. After several hours of servicing, the aircraft would be ready for another mission. Bell envisioned the first BOMI would be available by 1962, 10 years after the initiation of their proposed feasibility study.

As far as their preference for a piloted aircraft versus an unpiloted guided-missile, Bell believed no mechanical means could substitute for the human brain. A human being could evaluate defense weapons locations, operate and monitor mapping and photographic equipment, identify targets, guide missiles to their destinations, and provide battle damage assessment of targeted installations. A human crew would be able to execute evasive maneuvers to ensure mission success and provide a recall option should the mission need to be aborted.

While personnel of the New Weapons Systems Office in the Bombardment Aircraft Branch of the WADC supported Bell's proposal, some controversy arose over even considering such an advanced system. Indeed, when Dornberger briefed HQ Air

Force and DOD personnel, the abusive and insulting remarks against the proposal came fast and furious. In the middle of the turmoil, a red-faced Dornberger rose from his chair and boldly declared that his boost-glider would be receiving more respect if he had the opportunity to use it against the United States in World War II.[128] The silence was deafening. Despite the criticism, by September, the Bombardment Aircraft Branch (BAB) had grown optimistic enough to establish program objectives and work requirements for a preliminary feasibility study of BOMI.[129] BAB envisioned development of a hypersonic glider capable of a reconnaissance and a bombardment mission at the speeds, altitudes, and range established in Bell's 17 April and 26 May proposals. The weapon system would carry a 7,000-pound nuclear bomb and be operating as early as 1962.

To facilitate development, the company's engineers would determine--by extrapolating from existing guided-missile and jet data--what tests could be made, what the effects of high temperatures would be on the operating life of the system, what functions the crew would need to perform, and what the reliability of a rocket power plant would be "under hypersonic conditions." Additionally, Bell would conduct

---

[128]Walter, "Project Dyna-Soar," pp. 5-7.

[129] WADC, "Work Requirements for a Preliminary Feasibility Study for an Advanced Long Range Bombing and Reconnaissance Weapon System," Department of Defense (DD) Form 613, Research and Development (R&D) Report Card (Wright-Patterson AFB OH, 26 September 1952).

limited operational analysis for the two military missions.[130] Both WADC and Bell hoped exploring these new avenues might lead to an early manned spaceflight, as general opinion about this advanced system considered "how" the various phases of analysis, design, and experiment should be pursued rather than focusing on "why."

After learning of Bell's proposal to WADC, HQ ARDC reacted favorably, hoping to use it as a means to evaluate boost-gliders and then of advancing the state-of-the-art in manned bombers and reconnaissance vehicles. ARDC recognized, however, that BOMI's mission would overlap with the strategic missions of the Atlas ICBM as well as the reconnaissance satellite program outlined by the RAND study known as Project Feedback. ARDC also acknowledged the fiscal consequences should all three programs prove promising. Unwilling to rule out the long-term capabilities of BOMI over these programs, it authorized a quarter of a million dollars for a limited study.[131]

The Political Potential of Reconnaissance Satellites

On 25 August 1952, four months before the presidential election, Dr. Aristid V. Grosse, a Temple University physicist and Manhattan Project veteran, completed a report on the "satellite problem" for President Truman. Like the previous RAND study, the Grosse report stressed the importance of reconnaissance satellites for their scientific, military, and psychological value. In addition, the physicist suggested, the

---

[130]Major J. D. Seaberg, "Trip Report to Bell Aircraft Company," WCOWB/WADC Trip Report on the November 1952 visit to Bell Aircraft Company (Wright-Patterson AFB OH, 20-21 November 1952).

[131]Lieutenant Colonel Donald H. Heaton, "Rocket Bomber Feasibility Studies," Letter to the Commander ARDC (Washington, D.C., 28 November 1952).

Soviet Union might take the lead in developing and launching a satellite, considering the enormous Cold War potential of a satellite for influencing the minds of citizens in every nation. Should the Soviets accomplish the task, the psychological blow to American prestige would be tremendous.[132]

By the end of 1952, the National Academy of Science (NAS) appointed a national committee for the International Geophysical Year (IGY) to lobby the White House for a civilian satellite program. If the American committee could persuade the Special Committee for the International Geophysical Year (SCIGY) to promote worldwide launchings of Earth satellites for global science, then the basis for international acceptance of overflights by reconnaissance satellites, requested in the RAND and Grosse reports, would be a *fait accompli*.[133]

The election of President Dwight D. Eisenhower on 4 November 1952 followed the detonation of America's first thermonuclear bomb by three days. Secure behind the strength of this potent new weapon and the ability to deliver it against the enemy with manned bombers, the new president approved drastic cuts in defense spending.[134] By December 1952, even before Eisenhower's inauguration, the Air Force SAB had come to the conclusion, based on the successful detonation of a hydrogen bomb, that the

---

[132]A. V. Grosse, "Report on the Present Status of the Satellite Program" (23 August 1953), pp. 118-19.

[133]Constance M. Green and Milton Lomask, *Vanguard: A History* (Washington, D.C.: GPO, 1970), pp. 18-24.

[134]Gorn, *Vulcan's Forge*, p. 36.

accuracy and distance guidelines initially established for ICBM development could be relaxed.[135] The technological limitations Vannevar Bush and Curtis LeMay cited in 1946 as factors for encouraging the continuation of manned bombers while limiting the development of ICBMs were vanishing.

Intent on ending the Korean War, slashing a growing defense budget, and curbing inflation, Eisenhower also wanted nuclear arms control agreements with the Soviets, thereby "cooling off" the Cold War. To accomplish his goals, Eisenhower placed increased reliance on nuclear strength, arms control initiatives, and a lower defense budget; yet, he would not risk falling behind the Soviet Union in nuclear arms. To balance nuclear and conventional defense spending, domestic inflation, and ensure verifiable arms control treaties, Eisenhower needed accurate, reliable, and timely intelligence about Soviet ICBM developments.[136] As a consequence of these objectives several key themes in the administration's missile and space policy were established: eliminating the gap between American and Soviet missile development, the steady development of an American ICBM, maintaining continuous surveillance of the

---

[135]Ethal M. Dehaven, *The Evolution of USAF Weapons Acquisition Policy, 1945-1961* (Washington, D.C.: Air Force Systems Command Historical Study, 1962), 20-21; U.S. Congress, House, *Weapon System Management and Team System Concept in Government Contracting, Hearings Before the Subcommittee for Special Investigations of the Committee on Armed Services*, 86th Congress, 1st Session (Washington, D.C.: GPO, 1959), p. 304.

[136]Alexander, *Holding the Line*, pp. 27-31; Robert Griffith, "Dwight D. Eisenhower and the Corporate Wealth," *American Historical Review* 87 (February 1982): 87-122; E. Bruce Gielhoed, *Charles E. Wilson and Controversy at the Pentagon, 1953-1957* (Detroit, 1979), Chapter 6.

Soviet Union, and easing the nation into the space age through a civilian, rather than military, space program.

The Consequences for BOMI

On 10 April 1953, almost a year after Bell's first BOMI proposal, HQ WADC listed nine primary reasons why they would no longer support BOMI. These are worth noting because they represent HQ WADC's first firm statement about the program:

1. The range of BOMI was too short for intercontinental operations.

2. It was difficult to conceive how the system could be adequately cooled to provide allowable temperatures for the pilot, equipment, and structure.

3. The range or size of the system was sensitive to the lift/drag ratios attainable. The lift/drag ratios assumed were extremely optimistic for the proposed speeds.

4. There was no information available on stability and control or aero-elasticity at the speeds proposed.

5. Considerable uncertainty existed concerning the value of a human pilot on board the aircraft under these extreme conditions.

6. The proposed study, if undertaken, should be paralleled or preceded by an operational analysis of the system to determine its cost and its military worth if proven technically feasible.

7. If this study or a similar study was undertaken, it should be undertaken by several sources simultaneously to provide a broader coverage of this technically advanced type of system.

8. Some doubts existed concerning the capability of the proposed contractor to undertake such a study.

9. Funds available on the suggested line item had been committed on projects expected to provide a greater return on expenditure.[137]

What caused HQ WADC's turnaround? Certainly the Eisenhower administration's fiscal policy did not lend itself to a lot of speculative weapons technology. Long-term "Buck Rogers" objectives had to wait while short-term realities like the Korean War and the Strategic Air Command's (SAC) needed to maintain a credible nuclear deterrent got the primary attention. The Korean War seemed to be on the verge of a truce, but no one could be certain. Within ARDC, WADC's Bombardment Aircraft Branch remained focused on SAC's B-36 and B-47 long- and medium-range manned bombers, still the backbone of U.S. strategic striking power. Additionally, the BAB oversaw the development of the long-range B-52 bomber. Simultaneously, development of the first supersonic manned bomber, the B-58 Hustler, began. The Bombardment Aircraft Branch also supervised the Mach 3, B-70 program, although it was still in its conceptual stages. Until someone placed a higher priority on BOMI, or Air Force R&D funding generally increased, the program remained a "second-string" option.

Outside the purview of the BAB, the Atlas ICBM of the Bombardment Missile Branch received hefty funding because of broad-based belief in its potential. Perhaps

---

[137] HQ WADC, "Reasons for Rejecting the Rocket Bomber," Letter to Commander ARDC (Wright-Patterson AFB OH, 10 April 1953).

surprisingly, the branch's Snark and Navaho guided-missile programs continued to challenge all other missile programs for funding. (Snark received almost 10 times as much funding as Atlas's $26.2 million, while Navaho received over 10 times as much. BOMI received over 50 times less, less than half a million.)[138]

Although BOMI would potentially venture beyond the capabilities of these systems into the fringes of space, such a "step-into-space" label would have further degraded BOMI's chances for survival. Administration officials considered such advanced ideas beyond present technical capability. Indeed, HQ WADC questioned the competence of Bell to develop and produce BOMI. To counter their claim, Dornberger solicited Eugene Sänger and Krafft Ehricke, then Chief of the Gasdynamics Section of the Army Ballistic Missile Agency in Huntsville, to join him at Bell.[139] While Sänger refused to leave France (he worked as a consulting engineer for the *Arsenal de l'Aéronautique)*, Ehricke accepted. Personnel considerations aside, an additionally damaging factor to Bell's reputation involved their practice of underbidding the costs of a program by a substantial margin then creating sizeable cost overruns , often as large as 100 percent. Yet, Bell's successes with their X-series research aircraft, as well as

---

[138]C. H. Uyehara, "Antecedents," pp. 9-11; Jacob Neufeld, *The Development of Ballistic Missiles in the United States Air Force, 1945-1960* (Washington, D.C.: Office of Air Force History, 1990), p. 77.

[139]Curtis Peebles, "Project BOMI," *Spaceflight* 22, 7-8 (July-August 1980): 270-71.

with the Rascal and Shrike missiles, demonstrated their unquestionable ability to obtain tangible results while pushing the state-of-the-art.[140]

As Bell regrouped, the Soviets demonstrated the tangible results of their thermonuclear R&D. In August 1953, the Soviet Union detonated its first hydrogen bomb, demonstrating--once again--that the United States did not hold a monopoly on nuclear bomb technology. Subsequently, Eisenhower approved NSC-162/2, a strategic national security report later to be referred to as his "New Look" policy.[141] Rather than wage a conventional war against a communist offense anywhere and at anytime, America would maintain unmistakable strategic nuclear superiority and assure the Soviets, through diplomatic rhetoric, of its willingness to use it. The United States would rely first on indigenous forces to combat communism, supporting them with tactical air and sea power, including nuclear weapons. Ultimately, the United States would deter aggression through massive retaliatory power. The Air Force, the only service spared from the proposed 30 percent drop in spending and 25 percent cut in personnel, would carry the responsibility for delivering the nuclear weapons with their manned bombers.

---

[140]Uyehara, "Antecedents," pp. 11-12; Irene Sänger-Bredt, "The Silver Bird," pp. 195-228.

[141]Lawrence Freedman, *The Evolution of Nuclear Strategy* (New York: St. Martin's Press, 1981), pp. 76-90.

Another Appeal for BOMI

Concurrently, on 26 August 1953, Bell again urged HQ WADC to initiate development of BOMI, believing that their BOMI studies demonstrated astonishing potential for an investment of less than $300,000. Toward this end, Bell gave a presentation to HQ ARDC on 22 September. While still considering BOMI a radical proposal, HQ ARDC believed it offered some promise. It was not outside the realm of possibility for the United States or the Soviet Union. New solutions to old problems often bear fruit, thus no proposal appearing to have merit should be overlooked. At the meeting, HQ WADC agreed to take another look at BOMI.[142]

In evaluating BOMI, HQ WADC compared it to the Bombardment Missile Branch's Atlas program and RAND's proposed reconnaissance satellite program. Atlas would be available earlier than BOMI and, as an established program, would have a higher probability of success. But BOMI offered a unique capability. As a multi-sensor platform and booster combination, it could supplement the speeds, altitudes, and intercontinental range of the Atlas and Navaho rockets while incorporating more reconnaissance sensors than Rand's proposed reconnaissance satellite. Additionally, BOMI would be useful in studying several hypersonic flight regimes not under investigation by any of the services or by the NACA; it would serve as an introductory means of routinely getting into space and back; it would illuminate some of the inherent problems associated with hypersonic flight and space travel; and it would

---

[142]HQ WADC, "Evaluation and Recommendations for BOMI," Letter to the Commander ARDC (Wright-Patterson AFB OH, 23 December 1953).

under the direction of computer pioneer John von Neumann, the committee confirmed--based on the reports from over 200 German scientists that Stalin had allowed to leave the Soviet Union--that the Soviets were slowing the development of their intercontinental boost-glider program in favor of ICBMs. In fact, while sustaining the continued development of their intercontinental strategic bombers, they were well on their way to developing an operational ICBM. Thus, by forecasting the probable growth of Soviet ICBM technology in combination with their demonstrated thermonuclear capability, the committee placed the Soviet's capacity to develop ICBMs significantly ahead of America's lagging ICBM development.[144]

Still, the committee felt a rapid strengthening of Soviet defenses against SAC's manned strategic bombers would not occur until the last half of the decade. Yet, if the Soviets made rapid progress in the field of hypersonic flight or they made rapid progress in the ICBM field, it would provide a compelling political and psychological reason for the United States to make parallel efforts. Additionally, the committee did not believe any single company had across-the-board technical competence to manage an ICBM program. It proposed creating a special management group by drafting competent individuals from universities, industry, and government. Gardner, feeling

---

[144]Major General Bernard A. Schriever, "The USAF Ballistic Missile Program," *Air University Review*, 2 (Summer 1957), 8; U.S. Congress, House, *DOD Appropriations for 1963, Hearings Before a Subcommittee on Appropriations*, 87th Congress, 2nd Session, Part 5 (Washington, D.C.: GPO, 1963), p. 337.

that the strategic necessity of an ICBM equaled the wartime urgency of the atomic bomb's development, worked diligently to gain top-level support for an ICBM.[145]

Atlas Gains High Priority

From 23 March through 15 August 1954, Air Force leaders acted on the committee's recommendations, creating a Western Development Division of the ARDC (WDD/ARDC) under the command of Brigadier General Bernard A. Schriever. This move finally gave the Atlas missile program the highest priority. WDD would manage all phases of the Atlas' development and operational requirements. Additionally, AMC created a Special Aircraft Project Office to handle all AMC responsibilities for Project Atlas, co-locating it with the WDD.

By September, Schriever contracted with the Ramo-Wooldridge Corporation, a pioneering civilian management team of former Hughes Aircraft Company employees (the future TRW, Inc.), to augment existing Air Force teams with their scientific and technical expertise. Together they formed a new development and management team with a unique style of concurrent development for the major components of the revitalized weapon system. These initiatives rounded out the Air Force's implementation of the committee's suggested response to the growing Soviet threat.[146]

---

[145]Ernest G. Schwiebert, *Air Force Response to the Soviet Threat* (Wright-Patterson AFB: ARDC, 1960), pp. 34-35; U.S. Congress, House, *DOD Appropriations for 1960, Hearings Before the Subcommittee of the Committee of Appropriations, House of Representatives*, 86th Congress, 1st Session, Part 5 (Washington, D.C.: GPO, 1959), pp. 663-64.

[146]Futrell, *Ideas, Concepts, Doctrine*, p. 245.

In creating a specific division for ICBM R&D, Air Force leaders also set the stage for an ongoing appropriations and technology acquisition battle between the Bombardment Aircraft Division (by 7 May 1954 all ARDC branches changed to divisions) and the Western Development Division over which organization should control the largest share of missile funding.

As the nation gave Atlas its highest priority, HQ ARDC made a decision about BOMI. On 1 April 1954, it contracted with Bell for a one-year study to investigate the feasibility of BOMI as a boost-glide bomber-reconnaissance aircraft (after 23 August 1954 the title BOMI would actually be replaced with the project name MX-2276, but this study will continue to use the handy term BOMI). The principal objectives of the feasibility study mirrored those of WADC's earlier studies. However, under the new one-year contract, BOMI was now to consist of a three-stage rocket and boost-glider, a guided missile, involving two pilots plus their navigational, reconnaissance, guidance, and control equipment. The first and third stages would be piloted. The aircraft would reach Mach 22.7, a maximum altitude of 259,000 feet, and glide for 10,600 miles. Although this did not constitute global range, it did constitute a respectable intercontinental range. As a continuing measure of its invulnerability, Bell calculated BOMI would be 140 miles beyond an enemy defense sector before the defenders could react. Flying the same mission, a Mach 2 bomber or Mach 4 ramjet missile would encounter heavy enemy attack.[147]

---

[147]Uyehara, "Antecedents," pp. 15-20.

International Law and SAB's Forecast

On 4 October 1954, against this backdrop of increased concerns about Soviet potential, the SCIGY made a recommendation. It proposed the launching of an Earth satellite in participation of the upcoming International Geophysical Year.[148] While this may have seemed a logical solution to the legal dilemma of satellite overflight, a satellite launch presented a grave problem. Under the guise of such a launch, the Soviets could actually be pushing the development of their ICBM, enabling them to say that their ICBM was simply the booster for their IGY satellite.

Also in October, members of the Aircraft Panel of the SAB submitted their forecast of major technological breakthroughs in aviation over the next ten years. Although they considered the status of research in several technological fields, they devoted their greatest attention to hypersonic flight. In essence, they indicated how and in what form hypersonic research should proceed. In aerodynamics, they believed the most vital subject would be hypersonic flows, in particular, flows with temperatures in the thousands of degrees. In this area the ingenious and clever application of the laws of mechanics would not be adequate. In fact, they believed much of the necessary physical knowledge still remained unknown and would need to be developed.

To accomplish the research, several experimental techniques would be necessary. First, the use of advanced supersonic wind tunnels. Although these tunnels

---

[148]Green and Lomask, *Vanguard*, pp. 19-23.

would be intrinsically limited in their ability to duplicate the temperatures of hypersonic flight, they could still prove useful. Because fairly large supersonic wind tunnels were under construction at NACA and Air Force laboratories, large hypersonic wind tunnels, which would prove very difficult and expensive to build, should wait.

A second experimental technique involved the use of shock tubes and similar devices. Although confident that this kind of facility would receive a lot of attention in the future, the panel felt that the most useful shock-tube devices, in the short-term, would be relatively small-scale and inexpensive. The Air Force, however, should be ready to construct larger ones should techniques be discovered, or invented, to make them more desirable.

Third, the panel thought the Air Force should keep an open mind about other unconventional or exotic means of producing the extremely high Mach numbers and extremely high temperatures of hypersonic flight. Because they knew so little about the field, the panel, like HQ ARDC, felt it would be unwise to discount any new approach.

The fourth experimental technique involved rocket test vehicles. The panel believed two new research vehicles of this type should be investigated: unmanned rockets which offered an inexpensive, though limited, method of hypersonic research, and manned aircraft. This experimental aircraft (eventually known as the X-15) should reach at least Mach 5 and altitudes between 200,000 to 500,000 feet. The panel suggested a joint venture between the Air Force, the Navy, and NACA, similar to the X-series of research aircraft initiated ten years earlier.

While Air Force leaders saw the value of the panel's suggestions, they questioned investing too much of their scarce R&D funds into the unknowns of hypersonic flight. When the Eisenhower administration pressed for the more conservative technology of unmanned satellite reconnaissance, this feeling intensified. The administration believed satellites, like ICBMs, merited high priority, but not manned hypersonic flight in and out of the atmosphere. Understanding this, HQ ARDC issued System Requirement 12 (SR 12) on 4 January 1955, calling for a reconnaissance aircraft or missile with a range of 3,000 miles and an altitude of 100,000 feet. SR 12 stimulated WADC to create a new weapon system designation to fulfil this requirement (WS 118P).

High Priority for a Reconnaissance Satellite

Coinciding with the findings of the Air Force's Strategic Missiles Evaluation Committee (created by Trevor Gardner, Assistant Secretary of Defense for R&D, to examine both the impact of the thermonuclear breakthrough on the development of strategic missiles and the possibility that the Soviets might be ahead of the United States in developing ballistic missiles) and the forecast of SAB's Aircraft Panel, Eisenhower's Technological Capabilities Panel (TCP) brought the best minds in the nation together in an attempt to prevent another technological underestimation like the Soviet hydrogen bomb.[149] The "Killian Report," named for its chairman, MIT

[149] James R. Killian, *Sputnik, Scientists, and Eisenhower: A Memoir of the First Special Assistant to the President for Science and Technology* (Cambridge MA: MIT Press, 1976), pp. 70-80.

president James R. Killian, detailed the panel's findings to the NSC on 14 February 1955. While a variety of options existed--based on various timetables for American and Soviet capabilities--all depended on the early achievement of ICBMs by one opponent or the other. Thus, the TCP recommended the highest priority for Air Force ICBM development, an IRBM suitable for land or shipboard launch, rapid construction of a distant early warning line in the Arctic, a strong and balanced research program to determine the feasibility of ICBM interception and destruction, a greater application of science and technology to fighting limited wars, and, finally, an increase in intelligence gathering capabilities.

As the Killian Report further emphasized the high priority of the WDD's ICBM technology, HQ Air Force and the Central Intelligence Agency (CIA) made their first moves towards the development of a reconnaissance satellite. Issuing General Operations Requirement (GOR) 90 on 16 March 1955, HQ Air Force solicited contractor studies for Weapon System 117L (WS 117L). Three contractors--Martin Company, Lockheed Aircraft Corporation, and RCA--were awarded one-year studies.[150] Like the sensor array envisioned by proponents of boost-glide reconnaissance technology, HQ Air Force planners foresaw a large, sophisticated satellite, integrating the latest technology from dozens of American industries.[151] Although they believed in a working relationship between the first-generation ICBMs

---

[150]Philip J. Klass, *Secret Sentries in Space* (New York: Random House, 1971), pp. 14-15, 82-87.

[151]Perry, *Origins of the USAF Space Program,* pp. 35-36, 42-44.

and the development of space-based military technology (for a variety of defensive and reconnaissance roles), the DOD and the Eisenhower administration did not fully agree on the details. In fact, as the Killian Report recommended top priority for ICBMs and alternative means to increase intelligence gathering capabilities, DOD and administration officials did not believe a satellite should be employed as an offensive atomic weapon system or orbital bomb.[152] Based on this policy, the closer BOMI's speed approached orbital velocity, ironically, the closer it would approach a mission the Eisenhower administration would be less likely to support.

Because of the initial technological successes in the development of the Atlas ICBM, Brigadier General Schriever gained approval, on 28 April 1955, for a second ICBM, the Titan I. The Air Force authorized the Martin Company to design, develop, and test the Titan I, while the WDD and Ramo-Wooldridge Corporation management team again exercised overall responsibility for the program.[153] As the importance of the WDD's missile programs increased within the administration's national defense strategy, so did its share of the Air Force's R&D budget.

Diffusing Development Responsibility

On 12 May 1955 HQ Air Force issued General Operational Requirement 92 GOR 92) for a piloted, high-altitude, reconnaissance system. Because HQ Air Force previously showed an interest in BOMI's reconnaissance capabilities, HQ WADC

---

[152]Killian, *Sputnik, Scientists, and Eisenhower*, pp. 70-80.

[153]Warren E. Greene, *The Development of the SM-68 Titan* (Norton AFB CA: Historical Office Deputy Commander for Aerospace Systems, 1962), pp. 11-18.

initiated Special Reconnaissance System 118P (WS 118P) on the following day to fulfill HQ ARDC's 4 January 1955 SR 12 and HQ Air Force's GOR 92.[154] While the hypersonic speed was not specified, they wanted WS 118P ready by 1959. As a result, R&D programs for five new systems began. Seizing the opportunity to expand their existing guided-missile and aircraft research, North American Aviation and Northrop Aircraft investigated the adaptability of boost-glide rockets to participate in Phase III of HQ ARDC's reconnaissance proposal.

Accordingly, HQ ARDC released an additional $125,000 in June 1955 to extend Bell's existing contract through December and focus it on hypersonic boost-glide reconnaissance. When Bell's original one-year contract ended in May 1955, the company continued research at their own expense. Now, through additional testing, they hoped to validate the assumptions they made during their previous analytical studies while focusing a portion of their hypersonic design data on a boost-glide reconnaissance version of BOMI.[155]

Still, the Air Force planners were dissatisfied, a feeling stemming from the anxiety over the long development cycle of several programs. A high-level meeting among industrial, governmental, and military leaders occurred in June 1955 to break the impasse. Sponsored by Trevor Gardner, Assistant Secretary of the Air Force for

---

[154]Erica M. Karr, "Father of Dyna-Soar," pp. 29-31.

[155] Directorate of Systems Management and Directorate of Systems Management, "Weekly Activity Report" (Wright-Patterson AFB OH, 7 June 1955); Directorate of Systems Management, "Weekly Activity Report" (Wright-Patterson AFB OH, 14 June 1955).

R&D, and attended by Lieutenant General Thomas S. Power, the commander of ARDC, this meeting brought a much closer liaison between the Air Force and industry. In an attempt to cut down the lengthy development cycle, the Air Force agreed to the early release of Technical Program Planning Documents (TPPD) and System Requirements. This action should prevent industry from making wasteful second-guesses about the Air Force's future requirement, something Arnold was after in the SAB and RAND forecasts.

As these weapon system developments unfolded, HQ USAF detached WADC's Directorate of Weapon Systems Operations (of which the Bombardment Aircraft Division was a part) from WADC, making it directly responsible to ARDC. While the new Directorate of Systems Management (Detachment 1) would still be physically co-located with WADC at Wright-Patterson AFB in Ohio, all ARDC weapon system development was now the purview of Detachment 1.[156] Additionally, this reorganization created a Directorate of Systems Plans under the Deputy Commander, Weapon Systems, who was also Commander of Detachment 1. The long-term planning function of the Directorate of Systems Management would be the responsibility of the new Directorate of Systems Plans. Instead of being physically separated from HQ ARDC, the Directorate of Systems Plans would be co-located with HQ ARDC at Andrews AFB, near Washington, D.C. In essence, this new arrangement, though successful, require a detailed planning function not normally associated with a

---

[156] HQ ARDC, *HQ ARDC Semi-Annual History, 1 January -30 June* (Andrews AFB MD: HQ ARDC, 1958).

headquarters planning directorate. Proving unwieldy, the Directorate of Systems Plans would be rejoined with the Directorate of Systems Management in late 1957.[157]

The Directorate of Systems Plans was composed of several divisions, three of which directly influenced hypersonic flight: Strategic Systems, Reconnaissance and Intelligence, and Research and Target Systems. In early 1956, these three divisions took over the management of hypersonic boost-glide follow-on studies. Before the reorganization, WADC treated BOMI as a whole weapon system. Under the new arrangement, an artificial compartmentalization by mission occurred to parallel each new division: bombardment, reconnaissance, and research, respectively. Even though a single weapon system might be under contract to perform any one or several of these missions, a separate division would now consider each mission without any coordination between the divisions. While the responsibility of coordinating the study programs within these divisions would belong to HQ ARDC, this compartmentalization forced the New Developments Weapon Systems Office of the Bombardment Aircraft Division to become the unofficial coordinator of all the hypersonic studies.[158]

Even with the organizational complication, the Directorate of Systems Management felt confident about Bell's efforts to apply hypersonic boost-glide technology to a reconnaissance mission. In fact, the Directorate did not believe it

---

[157] Ibid., pp. 53-58, 142-52; HQ ARDC, *HQ ARDC Semi-Annual History, 1 July-31 December* (Andrews AFB MD: HQ ARDC, 1956), pp. 157-85, 528-52.

[158] William Lamar, Chief, Dyna-Soar Engineering Office, DSE, WADD, ed. C. H. Uyehara (Wright-Patterson AFB, 2 May 1960).

would be necessary to invite other contractors to participate in the early studies of hypersonic boost-glide vehicles. Bell's satisfactory progress meant the next step would be to emphasize tests rather than various study efforts parceled out to the aviation industry. No advantages would accrue to the Air Force through such diffusion.[159] But other organizations within HQ ARDC believed otherwise. The Directorate of Systems Plans felt the industrial base for hypersonic studies should be broadened to make it competitive and assure that the Air Force received the best solution to the problem. This group felt Bell's solutions were not conclusive. It advocated additional feasibility studies to determine the requirements for a hypersonic-glide vehicle, even though HQ Air Force previously established a requirement (GOR 92) and Bell's previous feasibility studies for both a bomber and a reconnaissance boost-glide vehicle were available.

On 1 July 1955, the Directorate of Systems Management received a letter from HQ ARDC. It directed them to give Douglas Aircraft Company a contract for a feasibility study of a manned hypersonic boost-glide weapon system similar to Bell's BOMI project, allowing $300,000 for the work. The Directorate felt Douglas's effort would not necessarily contribute to the advancement of hypersonic boost-glide technology and noted that HQ ARDC's verbal instructions already transferred the proposed Douglas study to the Strategic Systems Division, Directorate of Systems Plans, HQ ARDC. Additionally, the Directorate of Systems Management maintained it

---

[159]Ibid.

would be inconsistent to duplicate Bell's studies without first providing support to the bombardment portion of their BOMI study. It urged HQ ARDC to reconsider its original request and show more confidence in the research capabilities of Bell. Because of this exchange, the responsibility of pre-GOR studies for hypersonic boost-glide vehicles shifted from the Directorate of Systems Management to the Directorate of Systems Plans, and the HQ ARDC contract was expanded to include more companies besides Douglas.[160]

In line with HQ ARDC's decision to broaden the base of boost-glide technology, the Strategic Systems Division, sent another request for a strategic bombardment boost-glide system to ten companies: Boeing, Republic, General Dynamics (Convair Division), Northrop, Chance Vought, Lockheed, McDonnell, Douglas, North American, and Martin.[161] Only Boeing, Republic, Convair, McDonnell, Douglas, and North American responded to the Air Force request. Afterwards, Systems Plans asked these companies to submit a proposal for a strategic bombardment and reconnaissance system before 29 February 1956.

Space Policy and Unmanned Reconnaissance Satellites

Considering the high altitude U-2 spyplane a stop-gap and risky measure, the Eisenhower administration realized it must secure international acceptance of reconnaissance satellites to assure continuous surveillance of Soviet installations and

---

[160]Uyehara, "Antecedents," pp. 33-34.

[161]Captain David M. Fleming, "Request for Proposal," HQ ARDC letter to aircraft companies (Andrews AFB MD, 19 December 1955).

exact targeting of Soviet bases. This position on satellite programs became formalized on 20 May 1955 in NSC-5520.[162] Once again underlining the prestige and psychological benefits for the first nation to launch a satellite, the report asked for a small scientific satellite program to be launched in 1958 under the auspices of the IGY to demonstrate peaceful purposes and test the principle of "Freedom of Space." The IGY program should not, however, jeopardize any other satellite programs. Thus, the NSC-5520 also gave unquestionable primacy to the protection of the Air Force's WS117L reconnaissance program at the same time it approved an IGY satellite. On 28 July, the peaceful, scientific-civilian character of the administration's policy was reported to the press and became public knowledge.

As Eisenhower officials debated the merits of the Army's Project Orbiter over the Navy's Project Vanguard for the IGY satellite, and selected the latter, they continued to give the Air Force's Atlas ICBM program top priority. The DOD and the Air Force remained totally committed to insuring R&D funds for the perfection of this valuable weapon system. In turn, Eisenhower continued to press for an international arms control agreement with the Soviets.[163]

---

[162] National Security Council, *Satellite Program*, NSC-5520, As quoted in Walter A. McDougall, *The Heavens and the Earth* (New York: Basic Books, Inc., 1970), pp. 120-121.

[163]Thomas K. Finletter, *Power and Policy, US Foreign Policy and Military Power in the Hydrogen Age* (New York: Harcourt, Brace, & Company, 1954), pp. 373-75.

Conclusion

From the initial forecasts highlighting the hypersonic boost-glide technology of Major-General Dornberger's A4b and A-9/A10 in *Toward New Horizons* through the Eisenhower administration's "Freedom of Space"declaration in NSC-5520, Air Force leaders believed advances in aerospace technology would insure their continued independence from the other services while providing the best possible means for strategic national defense. Yet, contrary to Dornberger's belief in 1945, technological solutions to boost-glide weapon systems did not crystallize quickly or appear to be within easy reach. Even ballistic missile technology seemed elusive in the 1950s when problems relating to accuracy and thrust could not be quickly resolved. With the development of the hydrogen bomb, the need for accuracy and the problems of weight seemed to be solved. The increasing threat of Soviet ICBM capabilities highlighted the need for timely and accurate reconnaissance information. The Eisenhower administration responded by seeking new technological means to obtain information about the closed Soviet society. Initially, the U-2 filled the void. Yet, even its high altitude capabilities could not keep it out of harm's way indefinitely. A follow-on would someday be necessary. While satellite reconnaissance would yield the necessary information, it needed powerful ballistic missile technology. In addition to the ability to gather information, boost-glide technology offered something else: a sophisticated reusable payload. But like a satellite it too awaited the maturation of ballistic missile technology.

Had proponents of controlled reentry been able to demonstrate the three critical elements they needed to begin a "Round Three" man-in-space program by May 1955? First, regarding the Soviet threat, boost-glide technology offered several advantages over the Air Force's reliance on ICBMs, WS 117L, manned bombers, or combinations of these weapon systems.[164] It yielded a simultaneous breakthrough in speed, altitude, and range. Because it would use rocket propulsion, it could fly the entire Mach spectrum to orbital velocity, allowing it to use the Earth's centrifugal force to improve its lift to drag (L/D) efficiency and range. A boost-glider would fly in the upper altitudes of atmospheric flight or space. While it would experience aerodynamic heating upon reentry, using an equilibrium glide path (a gradual decent through the atmosphere rather than the skip-glide decent suggested by Sänger's studies) would reduce these adverse effects. Because it would not carry the added weight of fuel and an engine, a boost-glider's wing loading would remain low, also contributing to its increased range and reduced aerodynamic heating.

Since the development of the B-17 before World War II, two primary reasons for replacing a weapon system had existed: first, the need to increase range, and second, the need to decrease vulnerability by increasing speed or altitude. As missile systems become available, two other factors come into consideration: the yield-accuracy combination of the weapon system and the total system cost of performing the

[164] Directorate of Systems Plans, "Abbreviated Development Plan for Weapon System 464L," First Development Plan for Dyna-Soar (Wright-Patterson AFB, 23 August, 1957), attachment 3.

mission. To evaluate these factors against a boost-glide weapon system, the New Development Weapons System Office made several assumptions. First, the B-52 would remain in the inventory until at least 1970. The supersonic B-58 would be in the inventory by 1962. Third, the Snark guided missile would be phased in by 1959. The Atlas ICBM would be operational by 1962. The chemically-powered nuclear bomber would be phased in beginning in 1965. Finally, the nuclear powered bomber would not be operational until 1970, if at all.

Given these assumptions regarding future weapons systems, could the strategic bombardment mission be performed with the existing manned weapon systems or ICBMs? If ICBMs capable of striking within 500 feet of the center of the target (circular error probability or CEP) could be operational by 1970, there would not be a need for a boost-glide bomber, but this could not be assumed. The problems of previously unlocated targets, hardened targets, expected CEPs, warhead yields, and lack of reliability made an all-ICBM force after 1970 equally unlikely.

Preliminary investigations by RAND suggested that, by 1965, bombers capable of Mach 2 or 3 speeds would have considerable difficulty penetrating the Soviet Union without decoys or other countermeasure technologies. By 1972, all the manned bomber systems would have difficulty penetrating enemy defenses. Equally worrisome, ICBMs would have difficulty destroying hardened, dispersed, or inaccurately mapped targets. By pushing the state-of-the-art, a manned hypersonic boost-glider would offer a practical alternative. In addition to requiring no refueling, it promised global range, multiple-attack trajectories, a 3000-foot CEP, recall capability, and the speed to reduce detection warning time from 15 minutes (an ICBM's warning time) to 3 minutes.

Equally vital would be the boost-glider's strategic reconnaissance capability. Its high- resolution photographic camera, ferret, radar and infrared sensors, plus its capacity to detect and identify ancillary targets with its human crew, offered a tremendous yield of information. The vehicle would also provide an immediate reaction capability; almost immediately after hostilities began, a wide range of reconnaissance data would be available. While WS 117L and its follow-on technology might meet some of these requirements, it would achieve different objectives. WS 117L would be continuously collecting routine surveillance data. A hypersonic boost-glider would collect detailed tactical information of any area on demand. Its recoverability added an additional element of security. Rightfully so, HQ ARDC did not view the two systems as competitive but as serving two separate missions.

Regardless of the potential advantages, proponents of the hypersonic boost-glider found it difficult to gain any edge for their system over the competition. Questions about its ability to perform any bombardment or reconnaissance mission kept boost-glide technology low on the priority list. The concept seemed too radical. Air Force planners felt such radical technology would not be ready to meet the near-term realities of the Soviet threat.

CHAPTER 3

CONTINUING TO PUSH THE STATE-OF-THE-ART: FOCUSING HYPERSONIC RESEARCH ON DYNA-SOAR, MAY 1955-OCTOBER 1957

> Since the general objectives of these programs represent milestones towards which aeronautical technology is obviously proceeding, attainment of the necessary state-of-the-art is a matter of time, the amount being determined principally by the strength and effectiveness of the attack on the associated general technical problems.
>
> Major George D. Colchagoff,
> Deputy Commander/Weapon Systems,
> Research & Target Systems Division, HQ ARDC
> 16 February 1956.[165]

Major Colchagoff's memo came on the heels of ARDC Commander, Lieutenant General T. S. Power's 15 February 1956 presentation on "radical" technology. A growing anxiety lingered because of Soviet technological achievements: the detonation of an atomic bomb in 1949 (four years ahead of American intelligence estimates), the detonation of a thermonuclear device in 1953, and the development of a new long-range bomber. Dissatisfaction, stemming from concern about long development cycles, was rampant within the DOD. American weapons systems needed to be

[165]Major G. D. Colchagoff, Deputy Commander/Weapon Systems, "New Research Systems," Memo to Lieutenant Colonel R. C. Anderson, Commander, Research & Target Division, HQ ARDC (Andrews AFB MD, 16 February 1956).

developed quicker if they were to match or exceed similar Soviet achievements. In turn, General Power encouraged optimum exploitation of the rapidly advancing technological state-of-the-art. He called for imaginative, creative, and positive action in applying novel ideas to existing or new weapons systems.

Major Colchagoff felt two research programs offered the greatest promise for quick development and superior capabilities: the manned glide rocket research system (MGRR) and the manned ballistic rocket research system (MBRR). MGRR would be a purely research system based on the speed and initial altitude of BOMI but without the military subsystems. Feasibility studies of BOMI, extensively studied since 1951 by Bell Aircraft Corporation, underwent formal evaluation in the fall of 1955 by NACA, WADC laboratories, and the Directorate of Systems Management. Because this concept represented a major breakthrough (simultaneous increase in speed, altitude, and range) in weapon systems development, Colchagoff felt a solution to the technical problems associated with hypersonic boost-gliders needed to be found as quickly as money and research would permit. The Research and Target Systems Division, Directorate of Systems Plans, continued to work on these problems under its Hypersonic Weapons Research and Development System (HYWARDS) studies.

Colchagoff's second proposal, MBRR, would be a manned, powered, controllable final stage to an ICBM, providing General Power the kind of research data and experience required for the military transport and cargo system he proposed. It could also be used to provide data for manned spaceflight. A follow-on model of the same basic system could then be used as a transition vehicle for manned orbital flight.

These objectives would eventually be incorporated into Dyna-Soar's abbreviated development plan in October 1957.[166] Colchagoff believed sound long-range programs, like MGRR and MBRR, would enable a general acceleration of the aeronautical state-of-the-art. Aligning technical development with long-range objectives would also facilitate the existing R&D funding problem. In turn, more funding would lead to a healthier technical base to develop more advanced weapon systems to meet the increasing capabilities of the Soviet threat.

Following ten years of policy statements and technological breakthroughs, the Air Force's 1955 doctrinal manual (*Air Force Manual 1-2*) integrated Atlas ICBM technology into the traditional roles and missions of air power; but it continued to consider a manned strategic bomber force as the primary component of Eisenhower's "New Look" massive retaliation force. Such Air Force leaders as Major General Curtis E. LeMay, SAC commander, adopted a cautious approach to the "push-button war," favoring ICBMs as a compliment rather than as a replacement for manned strategic bombers.[167] Until 1955, the Air Force stutter-stepped economically and doctrinally in their attempts to bring ICBMs into development. Through this period Air Force leaders, skeptical about missile capabilities, promoted the technologically reliable manned bomber over missiles as the primary component of strategic air

---

[166] Directorate of Systems Plans, "Abbreviated Development Plan."

[167] U.S. Congress, Senate, Hearings Before the Subcommittee on the Air Force of the Committee on Armed Services, *Study of Airpower*, 84th Congress, 2nd Session, Part 2 (Washington, D.C.: GPO, 1956), pp. 107-08.

defense.[168] The Air Force's institutional penchant for insisting on a manned bomber to fulfill its primary mission of strategic bombardment hindered the incorporation of ICBM technology. The majority of Air Force leaders believed ballistic missiles should undergo an evolutionary development followed by operational integration into the weapons inventory. This process would require maintaining the deterrence of a manned bomber force while simultaneously assimilating ballistic missile technology and determining the requirements of future weapon systems, all within the budgetary constraints of Eisenhower's "New Look" policy.[169]

As funding for ICBMs improved in 1955, and administration concerns over a means to gather continuous and timely intelligence of the Soviet Union's nuclear capability increased, Air Force leaders favorably considered ICBMs as a supplemental weapon system. ICBMs offered Air Force leaders an opportunity to extend operations into space through satellite reconnaissance and manned boost-glide technology.[170] While Bell's unsolicited 1952 BOMI proposal fostered confidence and support, the uncertainties of manned space operations kept Air Staff planners cautious. Air Force leaders preserved their scarce R&D funds for conservative weapon systems to assure

---

[168]Major General Bernard A. Schriever, "The USAF Ballistic Missile Program," *Air University Review*, Summer 1957, pp. 1, 19-21.

[169] U.S. Congress, Senate, Hearings Before the Preparedness Investigation Committee on Armed Services, *Inquiry Into Satellite and Missile Programs,* 85th Congress, 1st and 2nd Sessions, Part 1 (Washington, D.C.: GPO, 1958), pp. 839-42; Colonel Richard Klocko, "The Impact of Guided Missile Upon the USAF," Air War College Graduate Study Group Thesis #4 (Maxwell AFB AL, 4 March, 1954), p. 8.

[170]Futrell, *Ideas, Concepts, Doctrine*, pp. 253, 284.

responses to known Soviet threats rather than expanding their technological horizons by funding radical, beyond the state-of-the-art, weapon systems. The Soviet curtailment of hypersonic technology in 1953 in favor of ICBM technology meant America would make a similar technological shift in its strategic emphasis to counter the new Soviet threat.

As administration officials attempted to balance military requirements with domestic initiatives according to Eisenhower's "Great Equation" of spending priorities, they also sought international agreements to limit the arms race. In addition, they preferred to bring America into the missile age without public panic and, subsequently, without destabilizing the president's concept of economic balance. For FY 1955, Eisenhower cut defense spending 20 percent, despite talk of rolling back the power of the Soviet Union. Meanwhile, the services chafed under the funding ceilings imposed by the administration.[171] When new Soviet strategic capabilities threatened the New Look policy, Eisenhower responded with a second New Look, downgrading massive retaliation in favor of deterrence and the upgrading of conventional, limited war, capabilities. As the Atlas ICBM budget grew, other ballistic missiles suffered under the cutbacks; yet, the United States, as suggested earlier by the Killian report, maintained its nuclear superiority until November 1955 when the Soviets successfully tested a hydrogen bomb small enough to be used as an ICBM warhead. With two years of focused research behind them, the Soviets were on the verge of demonstrating the

---

[171]Alexander, *Holding the Line*, p. 190; Samuel P. Huntington, *The Common Defense: Programs in National Politics* (New York, 1961), pp. 88-113.

capability of attacking the United States from Soviet missile bases. Such a possibility would foster increased fiscal support of Atlas as a deterrent and of WS 117L as a means of constantly monitoring the Soviet Union. A second benefit of WS117L would be the opportunity for a plausible denial should one be lost over Soviet territory. Losing an unmanned reconnaissance satellite would not be the same as losing a military aircraft and its crew. Hypersonic boost-glide technology promised to fuse the best characteristics of both these unmanned strategic weapon systems with the best qualities of the manned strategic bomber and reconnaissance systems. The Air Staff, however, gave the short-term objective of meeting the Soviet ICBM threat the highest priority. Proponents of hypersonic boost-glide technology would need to maintain a delicate long-term balance among the three critical elements of mission, technical feasibility, and funding priority by sustaining a step-by-step approach to R&D.

Hypersonic Boost-Glide Technology

Also in November, at the request of Trevor Gardner, personnel from the Bombardment Aircraft Division, Directorate of Systems Management, Det. 1, and Bell Aircraft gave several presentations to HQ ARDC and HQ USAF on the BOMI concept. Everyone present agreed that BOMI hypersonic boost-glide technology promised a major breakthrough in weapon system capabilities. Its speed, altitude, and range, for both strategic bombing and reconnaissance missions, could be unsurpassed. Until now, it had appeared that two of these three factors would always be compromised to achieve the third. While the reviewers believed Bell's proposed solutions to the problems, on a theoretical basis, seemed sound, everyone admitted additional tests would be needed.

Bell's three-step approach--a 5,000 mile range, a 10,000 mile range and a global system--appeared to be the best way to investigate the hypersonic flight regime.[172]

Bell believed design tests would help verify their hypersonic aerodynamic theories, particularly regarding stability and control. Accordingly, they believed a double-wall structure appeared the most promising. Bell considered an equilibrium reentry flight path would yield maximum temperatures at the start of reentry. However, as flight time lengthened, temperatures would gradually taper off as the altitude decreased. Because aerodynamic heating would be the governing factor in determining the aircraft's structural design and weight, Bell believed a double-walled structure would serve both as heat insulation system and as a cooling system. It would consist of a light outside skin structure, made of 11-inch-square panels insulated by a layer of fibrous material. While outside skin temperature could be expected to reach as high as 5,000 degrees Fahrenheit, by using a special cooling system between the layers, in addition to the insulation, outside temperatures could be reduced to 1750 degrees. In turn, inside structural temperatures without critical components could be kept to 300 degrees.

Bell reported a hypersonic boost-glide aircraft would be more practical than a conventional aircraft for the same development time. Additionally, the speed of the Earth's rotation would increase the boost-glider's overall range beyond a conventional

---

[172]Brigadier General H. M. Estes, Jr., "Evaluation of Project BOMI," Letter to Deputy Commander, Weapon Systems, HQ ARDC (Andrews AFB MD, 21 December 1955).

aircraft. Because the increased speed from the last stage would push the boost-glide aircraft to near orbital velocity, the centrifugal force generated by the aircraft could be used to obtain additional lift, allowing drag to be appreciably reduced, and range increased. With a little additional energy, orbital velocity could be reached. Such a global BOMI would eliminate the need for foreign bases. Additionally, a descent could be made at the maximum lift coefficient rather than the maximum lift/drag ratio. In addition to increasing its range, this would also help reduce the aircraft's aerodynamic heating.

Bell felt the existing state-of-the-art in propulsion systems allowed a revision from their original 1.2 million-pound-thrust requirement for stages I and II of their three-stage system. By developing a fluorine-based engine, higher performance could be expected from all three booster stages, making the first two stages expendable. Eliminating the piloted recovery option for the first stage and incorporating the fluorine engines reduced the original initial weight of 851,000 pounds by half.

Bell spent considerable time evaluating the role of a human crew in BOMI. They believed, as before, that a manned system increased mission reliability. The ability to accomplish precision bombing, recover detailed reconnaissance information, and reuse the aircraft made a manned system attractive. Also, a human crew would provide mission flexibility. They could select alternate targets; the necessity for elaborate automated equipment (which could not predict, or be designed, for all contingencies) would not be needed; and the pilot could report on enemy tactics, assess bombing accuracy, and land the aircraft in preparation for another mission. To aid in navigating the return trip, Bell recommended an all-inertial navigational system. With this system the exact knowledge of a target's latitude and longitude would not be required before take-off. Although the bomb would be controlled by a self-contained radar-monitored inertial navigation system, provisions for its post-launch command correction from the aircraft would be incorporated.[173]

Meanwhile, officials from the WADC laboratories, the NACA laboratories, and the Directorate of Weapons Systems, HQ ARDC also evaluated Bell's results and drew several conclusions. They, too, considered Bell's concept practical and promising. In turn, BOMI should be continued to determine the feasibility of a hypersonic boost-glide weapon system; however, emphasis should be placed on Bell's three-phase test program to validate the analysis. The NACA specifically recommended further work on BOMI because of the scarcity of information available on the Mach numbers BOMI would achieve. NACA believed the X-15 program would focus attention on other areas by solving the areas problems of hypersonic flight through Mach 7. Additionally, information from the NACA's ballistic missile research would help solve the difficulties related to BOMI's aerodynamic heating problems.[174] Because boosters would be so critical to the ultimate success of a hypersonic aircraft like BOMI, the Directorate of Systems Management established a liaison with HQ ARDC's

---

[173] Bell Aircraft Company, "Advanced Strategic Weapon System-Final Summary Report," Report D143-945-018 (Wright-Patterson AFB OH, 29 April 1955).

[174] NACA Committee for Aeronautics, "Requested Comments on Project MX-2276[BOMI]," Letter from to Commander, WADC (Wright-Patterson AFB OH, 30 September 1955).

WDD to discuss technical problems common to Project Atlas and BOMI. This should reduce the amount of duplicated tasks. After waiting several hours in the lobby of one of the WDD offices, a major in civilian clothes entered the waiting area from an inner door. Walking to the center of the room, he declared, "We wouldn't give you a wooden nickel for your damned winged, boost-glide bomber concept. The Intercontinental Ballistic Missile is the ultimate weapon!" Furthermore, the major informed the Directorate that the nature and priority of their mission precluded support of *any* kind to other Air Force programs such as BOMI. All information except data obtained for WDD by the WADC Material Laboratory would become available for Air Force contractor use only after being placed in the public domain by WDD. Specifically, contact with the Ramo-Wooldridge Corporation by the Directorate was discouraged and prohibited to Bell.[175] This lack of corporation between WDD (and its successor BMD) and the Directorate (and the Dyna-Soar program Office) would continue through the life of the Air Force's attempts to field a hypersonic boost-glide vehicle.

Despite WDD's lack of cooperation, the Assistant Secretary of the Air Force approved Bell's summary report. While pushing the state-of-the-art, BOMI would give the Air Force an opportunity to investigate the high-end of the hypersonic flight regime systematically and evaluate the potential of a boost-glide weapon system.

---

[175] Directorate of Systems Management, "Weekly Activities Report" (Wright-Patterson AFB OH, 17 November 1955); Walter, "Project Dyna-Soar," pp. 12-13.

BRASS BELL

By 1 December 1955, Bell completed its final engineering report for its supplementary contract. For WS 118P, Bell designed a two-stage version of their BOMI vehicle to reach Mach 18, an altitude of 175,000 feet, and an intercontinental range. Once again out of funds, Brigadier General H. M. Estes, Jr., Commander Det. 1 and Assistant Deputy Commander for Weapon Systems, HQ ARDC, estimated that some $4 million was needed to continue BOMI for the next 12 to 18 months and requested the Deputy Commander, Weapon Systems, HQ ARDC, to allocate $1 million for FY 1956 for its continuation. Concurrently, officials from the New Development Weapon Systems Office, Bombardment Aircraft Division, Directorate of Systems Management, Det. 1, and Bell visited Langley Air Force Base in Virginia to obtain additional views about BOMI from the NACA. During the period, the Directorate of Systems Management established an amicable working relationship with the NACA, inviting NACA's Ames and Langley laboratories to participate in BOMI aerodynamic and structural testing programs.[176]

Early in January 1956, the Air Force took another step toward developing a hypersonic boost-glide weapon system. The Intelligence and Reconnaissance Division, Directorate of Systems Plans, HQ ARDC, informed the New Development Weapon Systems Office, Directorate of Systems Management, that $800,000 would be allocated for BOMI's continuation. However, HQ Air Force believed BOMI should be focused

[176] Directorate of Systems Management, "Weekly Activity Report" (Wright-Patterson AFB OH, 22 December 1956).

towards fulfilling its GOR 92. Accordingly, HQ Air Force concluded a contract with Bell on 20 March 1956 for Reconnaissance System 459L--BRASS BELL--to adapt its system to the reconnaissance requirements. BRASS BELL should fly at Mach 15, attain an altitude of 100,000 feet, and achieve a 5,000-mile radius. Operationally, BRASS BELL would conduct reconnaissance and surveillance missions. To accomplish this, BRASS BELL needed photographic, ferret, and radar capabilities. The contract also called for design studies and systems analysis.

The NACA reported BOMI's application to BRASS BELL would not create any new research problems.[177] Its investigations corroborated Bell's definitions of the problem areas and Bell's methodology for the solutions.

Confident of its approach, Bell began subcontracting with industrial corporations, university research centers, and governmental agencies for analytical studies in the navigation (General Electric) and ferret systems (Airborne Instrument Laboratories), hypersonic tests (University of California, Princeton University, Ohio State University, Cornell University), heat source tests (University of Florida), dissociation (University of Michigan), liquid metal test circuits (MSA Research Corporation), model fabrication (Wall Colomony Corporation, Trinity Tool Company,

---

[177]J. W. Crowley, Associate Director for Research, "Comments on Project BOMI," Letter to Commander Det. 1, Directorate of Systems Management (Wright-Patterson AFB OH, 12 February 1956); Directorate of Systems Management, "Weekly Activity Report" (Wright-Patterson AFB OH, 12 January 1956); Uyehara, "Antecedents," pp. 35-36; HQ ARDC Intelligence and Reconnaissance Division, "BRASS BELL," R&D Report Card, System 459L, (Wright-Patterson AFB OH, 31 December 1956).

Kinzig Tool Company, Wind Tunnel Instrument Company), and wind tunnel tests (transonic, supersonic, hypersonic, and free-flight--Langley, Ames, and AEDC).[178]

Almost four years after Bell made its first proposal and after almost 18 months of feasibility studies, the Air Force began to accept the value of BOMI's hypersonic boost-glide concept. R&D problems inherent in the BOMI program no longer seemed insurmountable, and the value of the human crew seemed established. Yet, not everyone on the Air Staff felt completely confident about the availability of existing scientific and technical data. Accordingly, they could not fully sanction the development of a weapon system when the short-term requirements for an operational ICBM and an unmanned reconnaissance satellite seemed so pressing to them and the administration. Still, over BOMI's four years of development, HQ WADC, and subsequently the Directorate of System Management, had obtained the support of several Air Force commands, other Air Force research centers, other divisions within ARDC, and the NACA. The transition from the BOMI contract into the BRASS BELL contract marked the Air Force's first concerted attempt to push the state-of-the-art into the arena of space. It also marked the Air Force's preparation for manned strategic warfare in space: an ideology the administration did not overlook.

ROBO (Rocket Bomber)

Before the end of February 1956, the Strategic Systems Division, Directorate of Systems Plans, evaluated the proposals it received for a strategic bombardment and

[178] Bell Aircraft Company, "BRASS BELL Briefing," Bell Report D143-945-048 (Wright-Patterson AFB OH, 1 July 1957).

reconnaissance vehicle similar to Bell's BOMI. It signed contracts with three: Douglas, North American Aviation, and Convair. While the agreements covered a period from May through December 1956, the companies would be obligated to continue their studies through the end of FY 1957 (October 1957) with their own funds. The Strategic Systems Division wanted its boost-glide system to have an intercontinental range to eliminate the need for refueling or an advanced staging base. It should be available by 1965-1970. The vehicle could be manned or unmanned. While not specifying a speed, an altitude of 100,000 feet, and a 5,500 mile range (although the Strategic Systems Division preferred a global range) would be required. It would need to carry a 6,400-10,000-pound bombs. Although the Reconnaissance and Intelligence Division's BRASS BELL contract with Bell was devoted to reconnaissance, the Strategic Systems Division's contractors needed to investigate photographic, ferret, and radar reconnaissance techniques as well. While the studies needed to emphasize the problems of hypersonic flight (stability and control), the Strategic Systems Division estimated the severity of the aerodynamic heating problem also needed serious study. Even though it believed reentry data from ballistic missile technology would contribute to the solution of aerodynamic heating, a boost-glide vehicle would encounter greater fluctuations in reentry temperatures while a ballistic missile would be subjected to temperatures of greater magnitude. Additionally, particular emphasis would need to be placed on an accurate weapon delivery system. The Strategic Systems Division believed a 3,000-foot CEP would be reasonable. By 12

June 1956, HQ ARDC published System Requirement 126--ROBO--to sanction concurrently the requirement outlined by the Strategic Systems Division.[179]

HYWARDS

Regardless of published requirements, Lt. Gen. Power believed development projects would need to be constructively created to obtain funding. Because he felt the X-15 was a *fait accompli*, he suggested any promising system beyond the X-15 should be started immediately. In the fiscal spirit of Theodore von Kármán's *Toward New Horizons*, Power considered it worthwhile to start two or three systems at a cost of $1.5 billion dollars even though only one useful system might result. He believed R&D spending ceilings were being imposed by people without vision. To him such new technologies required rapid development. Reflecting current thinking about ballistic reentry as a quicker alternative means of reentry for manned spaceflight, he suggested future space vehicles might not need wings. Knowing a hostile and unimaginative political environment existed toward the long-term investments that winged spaceflight required, Power directed ARDC to investigate the possibility of recovering a manned capsule from orbit without the use of a winged vehicle. This could be accomplished by developing a manned final stage to a current ICBM. In turn, this effort could provide design data and operational experience toward subsequent

---

[179] HQ ARDC, "Rocker Bomber Study," System Requirement 126 (Andrews AFB MD, 12 June 1956); Uyehara, "Antecedents," pp. 43-46.

ballistic rocket systems for military transport and cargo.[180] These suggestions implied an emphasis on man-rating ballistic missiles (it would later evolve into Man In Space Soonest--MISS). Yet, Power's optimism aside, any new research systems would still be competing with the fiscal needs and mission requirements of existing systems such as the X-15, BRASS BELL, Atlas, Titan I, Vanguard, and WS 117L. As such, they would be difficult to fund unless the administration increased R&D funding or believed the weapon system should receive high priority.

Air Force leaders like Major General LeMay and Lieutenant General Power were conscious of the recall capability, the greater flexibility in target selection, and the increased tactical options manned bombers provided over an unmanned ICBM. They also knew the fifteen-minute detection warning time inherent with an ICBM increased the missile's survivability by decreasing the enemy's response time. Subsequently, both felt a manned boost-glide weapon system would encompass the best attributes of a manned bomber and would shorten detection warning time to three minutes. This reduced reaction time, coupled with the spacecraft's proposed operational altitude, made the system virtually invulnerable to Soviet attack and a vital element in deterring aggression.[181] While the Air Force's logic appeared sound, the ultimate success of any manned military space system would depend on the administration's perception of its utility within national space policy and its

---

[180] HQ ARDC, *HQ ARDC Semi-Annual History, 1 January -30 June*, (Andrews AFB MD: HQ ARDC, 1956), pp. 80-83.

[181] Directorate of Systems Plans, "Abbreviated Development Plan," attachment 3.

compatibility to other instruments of that policy such as unmanned reconnaissance satellites. Months before Sputnik, this element of the Eisenhower administration's agenda remained clouded in the Air Force's hopes to offset perceptions of renewed Soviet boost-glide developments.[182]

In this milieu of optimism and restraint, the Research and Target Systems Division, Directorate of Systems Plans, proposed a $4 million manned rocket boost-glide vehicle for research, Weapon System 455L (WS 455L), to HQ Air Force in March 1956.[183] Even though the Research and Targeting Division received limited responses from their queries to other sections of HQ ARDC about the future need for their boost-glide system, HQ Air Force approved WS 455L on 29 June and asked for a full development plan. Emphasizing the purely research nature of the vehicle, the Research and Targeting Division briefed HQ Air Force. After listening to their briefing, HQ Air Force officials believed WS 455L could help in fulfilling their GOR 92. Subsequently on 6 November 1956, it issued System Requirement 131 for HYWARDS--WS 455L.[184] The manned research boost-glider would serve as a test-bed for component and subsystem equipment, provide information on aerodynamics, human factors, structural and component problems, and military requirements. HYWARDS

---

[182]Wiley Ley, *Rockets, Missiles, and Space Travel* (New York: Viking Press, 1961), pp. 12-14.

[183] HQ ARDC, *HQ ARDC Semi-Annual History, 1 July-31 December* (Andrews AFB MD: HQ ARDC, 1955), Chapter IV.

[184] HQ ARDC, "Hypersonic Weapons R&D Supporting System 455L--HYWARDS," System Requirement 131 (Andrews AFB MD, 29 June 1956).

would travel at Mach 12 and attain 360,000 feet (in comparison to the X-15's Mach 7 and 250,000 feet). With the addition of two boosters, HYWARDS would be able to attain orbital velocity. The new research system would support all other hypersonic boost-glide programs; therefore, BRASS BELL and ROBO would not contain research phases as part of their development plans.

Economic Realities

For the coming election year, the administration drastically cut R&D funding for FY 1957, stopping the further development of all new weapon systems. Lt. Gen. Power notified HQ Air Force of the tremendous impact of the administration's cuts. Such severe reductions precluded aggressive exploration of new research vehicles, shattering the atmosphere Power was attempting to foster. Still, the administration's stinginess did not deter the Research and Targeting Division from submitting a revised and abbreviated development plan for WS 455L to HQ Air Force in January 1957. The division urged immediate approval and adequate funding. With its new plan, the division coordinated its efforts through the New Developments Weapon Systems Office, Bombardment Aircraft Division, Directorate of Systems Management, Det. 1, where a low level technical and management coordination capability for all hypersonic boost-glide vehicles continued. In fact, the degree of coordination could be seen in the proposed double-wall construction techniques and booster selections the Research and Targeting Division considered for HYWARDS.[185] Furthermore, NACA Langley and

[185] Bell Aircraft Company, "Hypersonic Systems Research Airplane," Proposal D192-945-001 (Wright-Patterson AFB OH, 21 May 1956).

Ames wind tunnel research identified the optimum hypersonic speed as Mach 18. Below this speed boost-glide vehicles approached their maximum heating environment; going above Mach 18 meant reduced heating rates in the atmosphere, where heating was a major problem. The research of engineers John Becker and Peter Korycinski at Langley revealed major advantages for a configuration having a flat bottom surface and delta wingform with the fuselage located in the cooler shielded area on the top side of the wing rather than placing the wing in the middle of the fuselage as indicated in Dornberger's original design. A flat-bottom configuration provided the lowest critical heating area for a given wing loading, reducing the amount of heat shielding required. This discovery represented the first clear indication that aerodynamic design could significantly alleviate some of the heating and structural concerns associated with hypersonic flight. The expected range of their aircraft would be 3,200 miles.

At Ames, Alfred Eggers and H. Julian Allen believed their earlier research at Mach 10 confirmed the need for a lifting-body approach. Using the increased interference lift generated from an underslung conical fuselage impinging on the aircraft's wings, they believed they could reach 2,000 miles. Yet, this configuration placed the entire fuselage in the hottest region of the hypersonic flow, increasing cooling requirements. The added weight required to keep the airframe cool quickly outweighed an advantages any higher L/D ratio earned.[186] The debate over the hypersonic design merits of a glider with a medium lift/drag ratio verses a lifting-body

---

[186]Richard P. Hallion, "Saga of the Rocket Ships," *Air Enthusiast*, March-June 1978, pp. 390-94, 464-65.

configuration with a low L/D ratio, a continuing theme in the ebb and flow of hypersonic flight, had begun.

Regardless of the administration's cuts for FY 1957 R&D funding, this new information helped keep optimism for hypersonic flight high; Det. 1 officials predicted HQ Air Force would not have to plan and develop additional boost-glide research systems if HYWARDS could be implemented.

Developments in Ballistic Missiles

Simultaneously, Air Force leaders directed the ARDC's WDD to study and evaluate solid propellant IRBMs. By April 1956, it contracted for IRBM studies while the Tactical Air Command (TAC), and USAF Europe (USAFE) issued qualitative operational requirements for IRBMs. Yet, Air Staff leaders could not validate these tactical operational requirements because limited R&D funds continued to place the fiscal priority on ICBM development. In May 1956, the United States detonated a hydrogen bomb suitable for an ICBM or IRBM warhead. By December, Eisenhower looked forward to a second term and expanded his list of programs for the nation's highest priority. In addition to continuing the Air Force's Atlas ICBM, Eisenhower included the Air Force's Titan I ICBM, the Army's Jupiter IRBM, and the Air Force's Thor IRBM.[187] With two ICBM programs and one IRBM program, the Air Force gained the largest portion of the DOD's missile appropriations.

---

[187]Ernest G. Schwiebert, *Air Force Response to the Soviet Threat* (Wright-Patterson AFB: ARDC, 1960), p. 113; Dwight D. Eisenhower, *The White House Years* (Garden City NJ: Doubleday, 1965), pp. 207-09.

While Eisenhower's second New Look policy evolved, the other services attempted to share the strategic warfare mission by developing their own IRBM missiles to counter the Air Force's IRBMs. These actions intensified interservice rivalry.[188] The resulting competition between the three services for IRBM development opened old concerns over who would receive what roles and missions and how much funding would be involved. Secretary of Defense Charles C. Wilson felt, once the missiles proved their feasibility, that a final decision on roles and missions could be resolved. On 26 November 1956 the time arrived; Wilson assigned a 200-mile-range IRBM for Army missiles. The remainder of land-based ICBMS/IRBMs (and, once again, the largest amount of funding) would be the Air Force's responsibility. The Navy would be responsible for sea-based IRBMs only.[189]

Consolidating Research

As the Air Force gained the lion's share of DOD's missile appropriations, ARDC officials presented the development plans for both HYWARDS and BRASS BELL to HQ Air Force. They did not prepare a development plan for ROBO. By 6 March, after two years of feasibility studies diffused throughout the aviation industry

---

[188] Legislative Reference Service, *United States Defense Policies Since World War II* (Washington, D.C.: GPO, 1957), pp. 17-23; Legislative Reference Service, *United States Defense Policies in 1957* (Washington, D.C.: GPO, 1959), pp. 1-24; Legislative Reference Service, *United States Defense Policies in 1958* (Washington, D.C.: GPO, 1960), pp. 1-28, 38-51.

[189] U.S. Congress, House, *DOD Appropriations for 1957*, 88th Congress, 2nd Session, Part 4 (Washington, D.C.: GPO, 1956), 52; Futrell, *Ideas, Concepts, Doctrine*, pp. 247-49.

and three divisions within HQ ARDC, HQ Air Force decided that the two plans complemented each other and considered consolidating them. Ironically, the Directorate of Systems Management's May 1955 insights regarding the validity of Bell's research proved true. Indeed, none of the other companies found any other feasible way of approaching the fundamental problems of hypersonic boost-glide technology. If this answer seemed difficult to obtain, funding proved more difficult. While ARDC wanted $5 million for HYWARDS and $4.5 million for BRASS BELL, HQ Air Force reduced these requests to $5.5 million for a combined plan. Nevertheless, Lieutenant General D. L. Putt, Deputy Chief of Staff, HQ Air Force, hesitated to yield even this amount to the boost-glide programs because the overall lack of Air Force R&D funds necessitated giving continued priority to WS 117L, the reconnaissance satellite the administration needed to augment U-2 overflights of the Soviet Union.[190] Furthermore, he believed the X-15 program would provide a more dependable source of hypersonic research data than a boost-glide programs, even though ARDC officials assured him the limitations of the X-15's powerplant, the method of construction, the type of equipment, and its top speed of Mach 7 meant it could not serve as a test-bed for HYWARDS. Considering these reservations, some officials within HQ Air Force recommended $1 million each for the two programs. On 30 April HQ Air Force informed HQ ARDC the two development plans would not be

[190]Uyehara, "Antecedents," pp. 55-57.

approved and that it should consolidate all its hypersonic boost-glide programs into a single plan.

Evaluating ROBO

Before the new plan could be completed, an Ad Hoc Committee of representatives from ARDC, WADC, the Air Force Cambridge Research Center, and the AMC met to evaluate ROBO. Advisory personnel from SAC, the NACA, and the Administration's Office of Scientific Research also attended. Because of the anticipated costs of a fully developed boost-glide weapon system, the evaluators needed to determine system costs, rate the contractors in order of preference, recommend the direction and magnitude of the effort for the next few years, disseminate study results, and indicate new directions of thought for any advanced plans. Only two contractors proposed unmanned versions of ROBO: Boeing and Republic. Republic's proposal involved a satellite-missile guidance station, placed in orbit by a three-stage booster. Boeing's proposal favored a winged intercontinental glide-missile similar to the company's earlier unmanned subsystem studies carried out in conjunction with its supersonic B-58 program on 23 December 1953. Boeing believed a manned version would involve a longer development cycle and it dismissed all the previous justifications for a manned system by saying it would not pose any great advantage over an unmanned glide-missile.

Contrary to Boeing's recommendations, WADC officials thought a manned boost-glide concept would be feasible and operational by 1970. They also suggested several unknowns: research in materials still needed to be accomplished; lack of hypersonic wind tunnels would delay ramjet engine development (if used) until 1962; rocket engines still needed to be man-rated for safety; and finally, questions regarding the pilots' physiological environment remained unanswered.

Cambridge officials focused on other problems. They observed how all the proposals employed an inertial auto-navigational system requiring nonexistent detailed gravitational and geodetic information to strike the target accurately. Additionally, the unknown factor of the Earth's rotational motion at hypersonic speeds would need to be considered in determining the accuracy of the boost-glider's guidance systems. Research center scientists also emphasized how communications would be hindered because of the ion sheath created when the aircraft reentered the Earth's atmosphere. Accurate studies of this atmospheric phenomenon and thermal heating would need to be conducted. Adequate data on the effects of wind turbulence and meteor dust impacts would also need to be determined. Subsequently, the presence of ionization trails, infrared radiation, and vehicle contrails could facilitate hostile detection. If this assumption proved accurate, countermeasures would need to be developed.

AMC officials believed that ROBO results made it clear that an additional six to eight years of basic research might be needed. More detailed knowledge of the hypersonic boost-glider's design would be needed before accurate logistical problems and the complexity of its launching facility could be determined. They estimated the cost would be extremely high.

After surveying the contractors' proposals and the analyses from the various agencies, the Ad Hoc Committee concluded that a hypersonic boost-glide system would be technologically feasible. With moderate funding, an experimental manned vehicle could be tested in 1965, an unmanned glide-missile in 1968, and ROBO in 1974. The committee emphasized the promise of hypersonic boost-glide technology for research, or as a weapon system. It recommended that HQ ARDC submit a comprehensive preliminary development plan to HQ Air Force, covering the entire range of boost-glide systems.[191]

Evaluating BRASS BELL

After more than a year's study of the BRASS BELL program, Bell--restricted from ROBO competition because of the BRASS BELL contract--reported five major problem areas in the Mach 17-18 hypersonic flight regime. First, verification of fluid flow for this regime would be critical because of the lack of facilities to simulate simultaneously the temperature, density, and speed environment the hypersonic glider would encounter. Because of this shortfall, only theoretical methods could be used initially to design the weapon system. Determining the actual temperature of the environment posed a second problem. Designing and testing a heat-protected aircraft would be the third problem. The effects of the atmospheric boundary layer on the resolution qualities and the operation of the aircraft's reconnaissance sensors would

[191] HQ ARDC, "Evaluation Report of the Ad Hoc Committee for ARDC System Requirement 126, ROBO," ARDC-TR-57-130 (Andrews AFB MD, 1 August 1957); HQ ARDC, "Supplement 1 to the Evaluation Report," ARDC-TR-57-130 (Andrews AFB MD, 1 October 1957).

constitute another difficulty. The last problem area would be defining the performance requirements of the subsystems.[192]

Although some questions arose about the probability of WS 117L's being completed before BRASS BELL, its importance to the administration as a means of maintaining a seamless reconnaissance capability, and the possibility that BRASS BELL would duplicate some of WS 117L's missions, Bell believed the systems complemented one another. Unlike WS 117L, BRASS BELL's flight path would not be predictable. It would yield reconnaissance information on demand rather than as available (when the constantly orbiting satellite flew over a specific area). The exact location of the target would not need to be known before launch; it could be passed to the pilot in flight or the pilot could make an area (rather than detailed) surveillance of the target. Additionally, it would increase the probability of routinely obtaining the reconnaissance information safely, as it physically returned the valuable data rather then delivering it through a less secure means.

Bell highlighted three notable achievements of the BRASS BELL study. The first was an increased knowledge of the structural design of materials under high temperature and heat exchange to reduce the temperature of leading edges and wing sheeting during hypersonic flight. Similarly, Bell improved the development of its double-wall construction to facilitate the outer wall's radiation of reentry heat back into the atmosphere, eliminating the need for the airframe to have high strength under

---

[192]Bell Aircraft Company, "BRASS BELL Briefing."

high temperatures. Its engineers estimated the weight of the double-wall construct to be equal to the weight of current aircraft fuselage construction.

Bell believed the Atlas program's more conventional liquid-fuel rocket engines could work well in BRASS BELL; however, the high specific impulse of its fluorine-hydrazine rocket engine would result in a considerable savings in the size and weight of both the aircraft and the booster, making its engine an attractive alternative. With a two-stage system, Bell believed the aircraft could attain Mach 17, an altitude of 170,000 feet, and a range of 5,500 miles. With a third booster, a range of 10,000 miles could be reached. Having worked with the Research and Target Division, Directorate of Systems Plans, Det. 1, on HYWARDS (through the office of the New Development Weapons System, Bombardment Aircraft Division, Directorate of Systems Management, Det. 1), Bell believed data from HYWARDS would provide timely research information for BRASS BELL. Because the Strategic Systems Division, Directorate of Systems Plans did not invite Bell to present a ROBO proposal, nor did it coordinate its research through the New Development Weapon Systems Office, Bell did not mention ROBO.[193] Ironically, much of Bell's work could have helped answer many of the questions raised by the ROBO Ad Hoc Committee.

As these three divisions of the Directorate of Systems Plans finalized their hypersonic boost-glide initiatives, HQ ARDC redesignated the WDD as the Ballistic Missile Division (BMD) on 1 June 1957. The new designation centralized the

[193]Ibid.

responsibility of the Air Force's growing missile defense systems into a single agency. Concurrently, BMD began to stake its claim to the high ground of space. At a SAB Ad Hoc Committee to Study Advanced Weapons Technology and Environment meeting at the RAND corporation, it presented a summary of follow-on ballistic missile systems and advanced space programs it believed should be initiated. If BMD could gain high-priority status for its Earth orbital or lunar flight programs, Det. 1's approach to the routine access of space would be in jeopardy.[194]

Sputnik: A Change in the Intensity of National Priorities

When the Soviets launched *Sputnik* on 4 October 1957, the question of establishing an international legal precedent for reconnaissance satellite overflight became moot, lost in the enormous repercussions of the event.[195] The orbiting of *Sputnik* shocked, then galvanized, the American people and Congress into committing vast resources to the nation's missile and space programs. While a hypersonic boost-glide weapon system had not become a Soviet reality, concerns for American prestige and security from Soviet space threats seemed to call for military countermeasures on the order of hypersonic boost-glide systems like Bell's BOMI or BRASS BELL. Still, the administration advocated a peaceful response to the Soviets' incursion into space,

[194] Air Force Ballistic Missile Division, "Presentation to the SAB Ad Hoc Committee to Study Advanced Weapons Technology and Environment," BMD Presentation (Washington, D.C., 29 July 1957).

[195] Paul B. Stares, *The Militarization of Space: U.S. Policy 1945-1984* (New York: Cornell University Press, 1985), p. 40.

even as the public and Congress clamored for dramatic action.[196] To placate the proponents of space weapons systems, and provide some insurance against potential Soviet threats, the administration allowed research on a variety of space weapon systems. As always, however, the higher priority on ICBMs and WS 117L restricted additional R&D funding for hypersonic boost-gliders.[197] Indeed, on 9 October 1957, the SAB Ad Hoc Committee to Study Advanced Weapons Technology and Environment urged the development of a second generation of missiles for use as ICBMs and as space boosters. The next priority would not be hypersonic boost-gliders but reconnaissance and weather satellites. Finally, the Ad Hoc Committee believed the military value of the moon merited an Air Force plan for a manned landing. Accordingly, it urged HQ ARDC to recognize BMD as the Air Force's permanent organization for all future ballistic missiles and satellites.[198]

Focusing Hypersonic Boost-Glide Technology on Dyna-Soar

Before *Sputnik*, Det. 1 leaders envisioned the three boost-glide roles as plausible ways to incorporate the reconnaissance capabilities of satellites, the strategic bombing role intrinsic to the Air Force's independence, and the latest developments in ballistic missile technology into Air Force doctrine to begin the human exploration of space.

---

[196]James R. Killian, *Sputnik, Scientists, and Eisenhower*, pp. 7-9.

[197]Stares, *The Militarization of Space,* p. 36; General Bernard A. Schriever, "The USAF and Space," *Air Force and Space Digest*, May 1964, pp. 161-62.

[198] SAB Ad Hoc Committee to Study Advanced Weapons Technology and Environment, "Report of the SAB Ad Hoc Committee to Study Advanced Weapons Technology and Environment," SAB Report (Washington, D.C., 9 October 1957).

Yet the cost of three parallel programs to realize the goal could not be justified within Eisenhower's budgetary policy or the priorities of his New Look strategy. Therefore, Lt. Col. Carleton G. "Stretch" Strathy, Chief, Research and Target Division, Directorate of Systems Plans, Det. 1, called on the New Development Weapons System Office, Directorate of Systems Management, to consolidate HYWARDS, BRASS BELL, and ROBO into a single program.[199]

It was still uncertain whether this direction would ever result in any boost-glide hardware. Almost everyone was thinking in terms of a prototype vehicle, the "Y" category of DOD vehicles designed as pre-production. As the largest R&D investments, they represented the future of the Air Force. "X" category research vehicles tended to be one-of-a-kind and continually suffered from lack of funding. For a prototype vehicle to be approved, however, the Secretary of Defense would have to agree to enter the weapon system into the inventory at a specific time. No matter what military mission proponents of the new hypersonic boost-glide weapon system chose, they could not guarantee that the operational boost-glide system would in any way resemble the prototype. How many versions would be required? How would the system be employed to perform its bombardment or reconnaissance mission routinely? What would be required of the launch and recovery facilities? Would the new BMD cooperate with booster acquisition? Would they need to contract for a separate booster if BMD failed to cooperate? What would the total costs be? These were far too many

[199]Directorate of Systems Plans, "Abbreviated Development Plan," attachment 1; Walter, " Project Dyna-Soar," pp. 15-17.

questions for a prototype weapon system and too many questions for the small budget of a research vehicle.

To explore the hypersonic flight regime with a boost-glider in 1957 required a different approach. The vehicle would need to be capable of gathering information about environmental effects on the aircraft and its human crew, plus it would need to be the foundation of a routine operational vehicle capable of accomplishing military missions in the same environment. It needed the research attributes of the "X" category vehicle and the military attributes of a "Y" category vehicle. It needed to be a conceptual test vehicle.[200] If HQ Air Force approved a development plan based on the tenet of a conceptual test vehicle, planners from the New Development Weapons System Office believed all these questions could be answered. Equally important, they might gain high priority status for their approach to manned military spaceflight.

After reviewing the two boost-glide development plans and the single summary study from the three divisions of the Directorate of Systems Plans, the proponents created a single abbreviated development plan for a dynamically soaring conceptual test vehicle--hence the name Dyna-Soar--to push the state-of-the-art. The first development phase of Dyna-Soar, derived from the HYWARDS program, would be a manned research vehicle to obtain aerodynamic, structural, and human factor data at speeds and altitudes significantly beyond the reach of the X-15. "Step I" Dyna-Soar would operate in a flight regime of 10,800 mph and 350,000 feet altitude compared to the X-

---

[200]Directorate of Systems Plans, "Abbreviated Development Plan," attachment 1; Walter, "Project Dyna-Soar," pp. 16-17.

15's 4,000 mph and 250,000 feet. In addition, Step I would provide a means to evaluate military subsystems. In establishing test criteria for Dyna-Soar, the New Development Weapons System Office highlighted its clear distinction between experimenting with a research or prototype vehicle (X/Y designations) and a conceptual test vehicle. Unlike the X-15, designed to provide information for research application, or the YB-52, designed to provide information for prototype pre-production, Step I Dyna-Soar would be designed to provide information for the development of a future weapon system.[201]

The second phase of Dyna-Soar (Step II--expansion phase) would produce a vehicle derived from the outline of the BRASS BELL study, a manned reconnaissance spacecraft capable of obtaining an altitude of 170,000 feet over a distance of 5,000-10,000 nautical miles at a maximum velocity of 13,200 mph.[202] The final phase of Dyna-Soar's development (Step III--exploitation phase) incorporated the ROBO design specifications to create a more sophisticated vehicle. It would obtain an orbital altitude of 300,000 feet at 15,000 mph. During this phase Dyna-Soar would become an operational weapon system capable of orbital nuclear bombardment, improved reconnaissance capabilities, and, eventually, satellite inspection (identification and neutralization).

---

[201]Uyehara, "Antecedents," pp. 35-36; Hallion, "Saga," pp. 90-91.

[202]HQ ARDC, "BRASS BELL," pp. 3, attachment 1.

Because of insufficient data, the Directorate of Systems Plans reasoned that the Dyna-Soar program could not immediately begin. Two intervals of preliminary investigations would have to come first. The initial interval would involve validation of various assumptions, theories, and data gathered from all the previous boost-glide studies. Additionally, it would provide design data and determine the optimum flight profile for the conceptual test vehicle. The second interval would refine the vehicle's design, establish its performance specifications, and define its research subsystems. In the 12 to 18 months it would take to complete these two intervals of preliminary investigation, studies for the Step II and Step III military missions could be started. Under this plan, flight testing for the conceptual test vehicle could begin in 1966, Step II would be operational in 1969, and Step III in 1974.[203]

On 17 October 1957, Lt. Col. Strathy presented the plan to HQ Air Force. Brig. Gen. D. Z. Zimmerman, Deputy Director of Development Planning at headquarters, gave enthusiastic endorsement. He believed ARDC should, in the wake of *Sputnik*, take a more courageous approach by immediately considering what it hey could do with more funding than originally requested. Another attendee at the briefing, John W. Crowley, associate Director for Research at NACA headquarters, strongly endorsed the conceptual test vehicle as a logical extension of the X-15

[203]Directorate of Systems Plans, "Abbreviated Development Plan," pp. 1-10.

program. In fact, the NACA's research in hypersonics focused on the refinement of the boost-glide concept and it planned new facilities for future research in the field.[204]

Conclusion

The technological Pearl Harbor of *Sputnik* caused Air Force leadership to reconsider space as a medium for warfare and the nature of warfare in space. It would no longer be the sole purview of "Buck Rogers." If BMD's ballistic missile technology offered a short-term solution to the first technological step to manned military space operations, what would be the long-term solution to the second?

If proponents could not gain high-priority status for Dyna-Soar could the Air Force continue to push the state-of-the-art? Det. 1 believed a non-proprietary approach to boost-glide technology would maximize the use of the conceptual test vehicle for later phases of the program (Step II and Step III) and minimize program costs. Using a low level of funding initially, $3 million for FY 1958, would insure a timely evolution of technical knowledge. Furthermore, should the two interval preliminary studies prove a boost-glide weapon system unsatisfactory, expenditures would be minimized. Should the boost-glider prove satisfactory, costs would still be minimized because the program could indeed be funded step-by-step.

The historical precedent for replacing a weapon system, the five years of boost-glide feasibility studies, and the apprehension about Soviet achievements combined to

---

[204]William C. Walter, "Visit to HQ Air Force on Project Dyna-Soar," Trip Report (Washington, D.C., 21 October, 1957); Brigadier General Homer A. Boushey, "Approval of Abbreviated Development Plan for System 464L," Letter (Washington, D.C., 15 November 1957).

enable Det. 1 to acquire the critical elements necessary to foster a favorable atmosphere for boost-glide technology. With Dyna-Soar, the Air Force maintained its institutional affinity for a manned strategic bombardment role, while it incorporated ballistic missile technology and reconnaissance satellite technology into a manned weapon system.

Almost a month later, Brig. Gen. Homer A. Boushey, Deputy Director of R&D, HQ Air Force approved HQ ARDC's abbreviated development plan for WS 464L, Dyna-Soar. On 25 November, his office issued Development Directive 94, allocating $3 million of FY 1958 funds for their hypersonic boost-glide R&D. The boost-glide concept of the New Development Weapon Systems Office offered the promise of pushing the state-of-the-art into space. Following Brig. Gen. Zimmerman's philosophy, Boushey advocated abandoning a minimum risk, minimum rate of expenditure. If the concept appeared feasible after the expenditure of FY 1958 and 1959 funds, the boost-glide program should be accelerated. Because the technological uncertainty of piloted hypersonic flight lingered, he directed them to study both a manned and an unmanned bombardment and reconnaissance weapon system during the two intervals of preliminary investigation. A decision on whether to use a piloted vehicle would be made after the analysis. Finally, the Development Directive stressed, the only objective for the conceptual test vehicle would be to obtain research data on the hypersonic boost-glide flight regime. Early and clear test results must be obtained before hardware development for a military version could proceed.[205]

---

[205] HQ Air Force, "Hypersonic Glide Rocket Weapon System," Development Directive (Washington, D.C., 25 November 1957).

Meanwhile, Maj. Gen. Schriever, Commander BMD, completed a 10-15 year plan for manned spaceflight exploration. The plan envisioned manned spaceflight in a minimum of time and with a minimum of new development. By using the existing missile technology and facilities within the BMD or currently under development, the Air Force could begin to investigate military astronautics and space technology at the earliest possible time.[206] By moving along both approaches to manned spaceflight, HQ ARDC believed that the Air Force could put the first man into space. As the Air Force pushed the state-of-the-art, proponents of boost-glide technology, like Major Colchagoff, hoped to propel their new convictions into the realms of space. Yet the Air Force's ideology of pushing the state-of-the-art to achieve such a manned military space agenda would not fit into Eisenhower's space-for-peace policy.

---

[206]Colonel L. D. Ely, "Manned Spaceflight Program," Memo to Colonel C. H. Terhune, Deputy Commander, Weapon Systems, BMD (Los Angeles CA, 13 December 1957); Air Force Ballistic Missile Division, *Chronology of Early Air Force Man-in-Space Activity, 1955-1960* (Los Angeles CA: Space Systems Division, 1965), p. 7.

CHAPTER 4

STAYING ON COURSE: THE SPACEFLIGHT REVOLUTION AND DYNA-SOAR, OCTOBER 1957-MAY 1959

> It is my view that once we have adopted a new development project, it is our responsibility in the Air Force to get solidly behind it and push for its completion with minimum delay and interference.
>
> Major General John W. Sessums, Jr.,
> Vice Commander, ARDC,
> Andrews AFB Washington, D.C.
> 11 July 1958[207]

With the approval of the abbreviated development plan, the direction of the Dyna-Soar program appeared clearly marked. An experimental glider, a reconnaissance vehicle, and a bombardment system comprised a three-step progression. Yet, during the existence of System 464L, officials in DOD subjected the program to severe criticism largely because of the administration's decision to continue with its freedom for space--or space-for-peace--policy. As the bureaucratic and legislative facets of Eisenhower's policies and programs matured, the feasibility of a boost-glide weapon system and the necessity of orbital flight in Dyna-Soar's program plan, were

---

[207]Major General John W. Sessums, Jr, "Dyna-Soar Program," Letter to Lieutenant General R. C. Wilson, Deputy Chief of Staff, Development, Air Force HQ (Washington, D.C., 11 July 1958).

points frequently questioned. By November 1959, the project office had to undertake an exacting investigation of the Dyna-Soar approach to manned spaceflight. Certainty of program objectives had momentarily disappeared. If the Air Force intended to keep Dyna-Soar under its authority rather than see it transferred to one of the administration's new agencies, it would need to convince the administration it should retain the program and, by retaining the program, it would conform to the administration's space policy. During the chaotic period the administration calmly resisted the political pressure to make sweeping changes to its space policy while it reexamined its international and domestic space strategy. Ultimately, it considered the most influential determinant for policy change to be the preservation of the principle and practice of unmanned satellite reconnaissance. Such reconnaissance capabilities would give the United States the opportunity to gain critical information about the closed Soviet society. The administration would not allow any program to jeopardize those principles and practices.[208]

Yet, the paradox of *Sputnik*'s undeniable importance yet imprecise significance made everything about space policy quite disturbing. Without question the spaceflight revolution meant change was imminent, but without the clairvoyance of what changes were about to happen, no one was absolutely sure which way to go. Criticism of America's missile and space programs filled the month between *Sputnik I* and *Sputnik II*, from 4 October to 3 November 1957. It was a critical time in the nation's history.

---

[208]James Bamford, *The Puzzle Palace* (Boston: Houghton Mifflin, 1982).

The demand for action could not be ignored. Time and again the public and Congress raised the question: why had the missile and space programs failed to produce a winner and how could these programs be revitalized to assure one in the immediate future?

Eisenhower did not believe a space race with the Soviets was the answer. On more than one occasion the president did declare that interservice rivalry had to stop, implying that eliminating such bickering was one of the answers. *Newsweek* magazine offered another. It called for a designated "czar" of the military services to end the divisiveness and put the nation ahead of the Soviet Union in technology.[209] Trevor Gardner provided a counterpoint. He placed the failure on national policy. America did not have a vigorous space program in 1957 because of its preference for economy, an insistence that space programs offer returns commensurate with their costs, and a determination to keep the military out of space for the sake of foreign relations. The administration's Research and Development Board, the DOD, the State Department, and the White House made these decisions over a period from 1945 to 1957. National policy had said "No" to both the Navy and the Air Force's efforts between 1946 and 1948, rejected Project Orbiter in 1955, held back the Vanguard effort for two critical years, and refused permission for the ABMA to launch their satellite.[210] The answer could be found in a new national space policy centered on the military.

---

[209] Editorial, *Newsweek*, 18 November 1957.

[210] Trevor Gardner, "But We Are Still Lagging," *Life*, 4 November 1957.

Congress, the armed forces, and much of the population also believed appointing czars would not solve the problem. Adding more layers of bureaucracy to the existing missile organizations would further slow the process of space development. For these critics, the question in 1957 became: should the existing czars in fact be overthrown or perpetuated?[211] Their answer could be found in streamlining the existing system to facilitate space policy management.

In this unfolding public debate between opponents and proponents of various space policies and programs, no one denied the essential need for civilian-scientific programs. Too little was known about space. For that reason, however, many administration officials denied the need for a military space program. While they admitted ignorance regarding the exact nature of space warfare, proponents believed that space--as a medium--would eventually shatter the older military concepts about the land, sea, and air. As such, should the United States only seek the civilian-scientific exploration of space? The services believed America should explore the military utility offered by space and the opportunities provided by the civilian-scientific exploration of space. For the military, the inability of strategists and tacticians to prepare handbooks or manuals on space warfare overnight did not detract from the seemingly obvious significance of space--the ultimate high ground.

---

[211] U.S. Congress, Senate, Hearings Before the Preparedness Investigations Subcommittee on Armed Services, *Inquiry Into Satellite and Missile Programs*, 85th Congress, 1st and 2nd Sessions (Washington, D.C.: GPO, 1957), p. 220.

In the first two years after *Sputnik*, the services knew they must reconcile the requirements of national security in space with the president's space-for-peace policy, a policy favoring a civilian-scientific program over the military. As the Air Force and its sister services formulated their space policies, Eisenhower calmly orchestrated his solution to the spaceflight revolution. He stayed on course by firmly reestablishing, through bureaucracy and legislation, his authority over the military's desires to be the nation's leading agency. Amid the administration's reorganization and redistribution of military space programs, the Air Force retained control of Dyna-Soar by assuring Step I would not have orbital capability. Nevertheless, Dyna-Soar's development directive clearly stated that the Air Force intended to create a conceptual test vehicle in Step I for a weapon system capable of orbital flight in Step III. Additionally, if proponents like Maj. Gen. Sessums believed Dyna-Soar would make man's first step towards the routine access of space possible, it would certainly need to be capable of orbital flight. Such military requirements seemed to conflict with Eisenhower's space-for-peace policy. A day of atonement could be coming.[212]

Reaction to *Sputnik*

On 7 August 1957, Eisenhower announced the resignation of Charles Wilson and the nomination of Neil H. McElroy as the new Secretary of Defense. The new secretary, like the president, considered the horrors of a possible nuclear holocaust in space unacceptable. Simultaneously, the president and his foreign policy advisors

---

[212]Lee Bowen, *An Air Force History of Space Activities, 1945-1959* (Washington, D.C.: USAF Historical Division Liaison Office, 1964), pp. 168, 81-83.

clung tenaciously to their space-for-peace policy begun in 1955. Indeed, the chief executive would not compromise his position until after *Sputnik* and the failure of Vanguard in December 1957, when he regretfully conceded the need for a military space program. Still, if a military program needed to be developed, he wanted it small. Eisenhower hoped to focus world attention on America's interest in peace by emphasizing the civilian-scientific character of space exploration rather than its control through military means.[213] In answering the public outcry for action, the president would certainly look to his new defense secretary to help control the military's desires to establish a number of space programs.

On 17 October General Donald L. Putt, Deputy Chief of Staff, Development, HQ Air Force, directed Lieutenant General Samuel E. Anderson, Commander, ARDC, to assemble an ad hoc committee to consider ways for the Air Force to assist in countering America's loss of prestige in the wake of *Sputnik*. Composed of SAB members, aircraft industrialists, plus a small group of ARDC personnel as technical advisors, the committee met on 21-22 October under the chairmanship of Dr. Edward Teller, an internationally known physicist who helped develop the atomic and hydrogen bombs. The report specifically stated that America's technological decline resulted from administrative and management practices. These practices kept either responsible civilian or military service agencies from establishing a stable, yet imaginative, R&D program. The committee made two suggestions. First, it recommended simplifying

---

[213]*New York Times*, 9 October 1957.

the management by consolidating the existing R&D organizations, the development, and the operation of ballistic missile and spaceflight programs from the Office of Secretary of Defense down to the services. Second, it wanted to put ballistic missile and spaceflight programs on a maximum effort basis, without reservation to time, dollars, or people and, most important, ensure the entire effort had the priority of governmental and national interest.[214]

Round III Research

Concurrently, on 16-18 October, a "Round III" meeting of the NACA took place at the Ames Aeronautical Laboratory. NACA officials intended to discuss and coordinate the four NACA laboratories' work on HYWARDS because the merits of high L/D (lift to drag) ratios versus medium L/D ratios for hypersonic flight had polarized the labs' opinions. A. J. Eggers championed Ames's preference for the high L/D ratio. His research suggested his boost-glider would have a range advantage of some 1,300 miles if launched at the same speed as the Langley medium L/D ratio glider. John Becker championed Langley's view. He showed how the weight associated with the higher L/D ratio, for equal system weights, nullified this range advantage. By using a wing 40 percent smaller, the range of the glider increased from 4,700 to 5,600 nautical miles. The associated 4,000-pound reduction in weight depreciated the importance of the lower L/D ratio. Additionally, as the Ames engineers began to realize their high L/D ratios would be fraught with enormous heat

---

[214]Edward Teller, *Report of the Teller Ad Hoc Committee* (Wright-Patterson AFB OH: HQ ARDC, 1957).

protection problems, high L/D/ ratios began to fall from favor. These heating problems did not have easy solutions.[215]

Equally important, eleven days after the *Sputnik* launch, everyone felt mounting pressures to solve the problems of manned satellites, particularly the critical reentry problem. The Ames view, again expressed by Eggers, suggested the NACA should be working on the satellite problem rather than on the HYWARDS hypersonic suborbital boost-glider issue. Very low L/D ratios would work quite well for ballistic satellite reentry, making its technology easier to develop than hypersonic boost-glider technology. Thus Langley was left to pursue boost-glider reentry technology as well as provide the logic and the promotional support for boost-glider systems within the NACA.

SPUTNIK II: Additional Bureaucracy

As the NACA pondered the merits of L/D ratios for HYWARDS, Air Force officials knew McElroy's interest in the Army's Explorer could bode ill for Air Force interests. On 29 October, as the secretary's office examined the Army's proposal, Air Staff representatives briefed the Secretary of Defense on the background and status of WS-117L, suggesting a small increase in funding for FY 1959 would enable them to orbit the reconnaissance satellite in 1960. While the administration wanted to gain international acceptance of unmanned satellite overflight for reconnaissance purposes, it

---

[215]Richard P. Hallion, ed., *The Hypersonic Revolution: Eight Case Studies in the History of Hypersonic Technology*, vol. 1 (Wright-Patterson AFB OH: Aeronautical Systems Division, 1987), pp. 400-05.

would not want a reconnaissance vehicle to be America's first satellite. No one answered the Air Force papers until after the launch of Explorer I on 31 January 1958.

After the Soviets launched *Sputnik II* on 3 November 1957, the protests from the media created another outcry for action. Meanwhile, the services and Congress pressed for an active military weapon system to counter the Soviet "threat" envisioned with the launches of *Sputnik I* and *II* (*Sputnik II* launched a dog and capsule weighing 1,121 pounds, the equivalent of a nuclear weapon, into orbit on 2 November 1957). To placate the proponents of space weapon systems, and provide some insurance in case circumstances dictated a change, all three services pursued preliminary research on a variety of space weapons.[216] In the midst of this criticism from the services, Congress and the press, the debate over the appropriate course of bureaucratic action continued. Eisenhower announced the first of his bureaucratic solutions with the appointment of Dr. James R. Killian, president of MIT, as the Special Assistant to the President for Science and Technology. The President's Science Advisory Committee (PSAC) would aid Killian in formulating a national space policy to integrate a subordinate military space program into the dominant civilian-scientific program, and not vice-versa. The administration hoped Killian's strategy would quiet the cries for action to surpass the Soviet's space achievements.[217]

---

[216] National Security Council, *U.S. Policy on Outer Space*, NSC 5814/1, Annex A, Soviet Space Systems (Washington, D.C.: GPO, 18 August 1958).

[217] *New York Times*, 8 November 1957.

As the president began to increase his bureaucratic authority over the service's space programs and championed his space-for-peace policy, Langley researchers John Becker and P. F. Korycinski achieved some exciting preliminary results in their research on internal cooling requirements for hypersonic boost-gliders. Radiation from the boost-glider's hot wing surface would balance the peak frictional heating of its skin temperatures up to 2,200 degrees Fahrenheit. Additionally, if these boost-gliders operated at high angles of attack, no cooling would be required for skin temperatures up to 2,000 degrees Fahrenheit. It would be possible to eliminate skin coolant from Dyna-Soar's design.[218]

Asserting Authority Over the Military's Space Programs

As the NACA's research offered a solution to hypersonic boost-glider cooling requirements, Secretary of Defense McElroy abolished the Office of Special Assistant for Guided Missiles and created the Office of Director of Guided Missiles on 17 November. The new office would direct all activities in the DOD relating to research, development, engineering, production, and procurement of guided missiles. While the administration would have preferred to use only civilian boosters for its space programs, it would take more time and money to create duplicate civilian boosters. Using military boosters would be more efficient and give the administration an opportunity to further control the burgeoning military space policy by controlling the logistics of spaceflight. William Holaday would head the office. Unfortunately, no

[218]Hallion, *Hypersonic Revolution*, pp. 406-07.

one defined Holaday's relationship to the services or to the president's new advisor, Dr. Killian.[219] Holaday would have to find the limits of his authority by trail and error.

As the administration created new elements of bureaucratic authority to quiet critics and assert its space policy, Brigadier General Boushey forwarded an Air Force policy statement to Air Force Chief of Staff, General Thomas D. White, on 6 December 1958, assuring the loyalty of the Air Force to the administration's national space-for-peace policy. However, Boushey also asserted the need for the United States to control the medium of space. Because there could be no division between air and space, the Air Force would be the logical military service to exercise control of the indivisible field of aerospace.[220] The policy captured an unpleasant dichotomy for the military. Eisenhower repeatedly expressed a space-for-peace policy, so phrased--as in pre-*Sputnik* days--to exclude the military from any region beyond the aerodynamic capabilities of airpower. Had this principle been applied to the freedom of the seas, the navies of the world would have been excluded from the oceans and forced to sail within three miles of their nations' borders. No one in the Air Force denied the ideal of space-for-peace, but the restrictions on the military did not match the obligations of the military to ensure the security of the nation. The services expressed their acceptance of the president's space-for-peace policy over and over again; but until international

---

[219]U.S. Congress, Senate, Hearings Before the Preparedness Investigations Subcommittee on Armed Services, pp. 211-14, 346-49.

[220]Bowen, *An Air Force History of Space Activities*, pp. 183-84.

agreements could guarantee all nations would follow the same ideal, they believed the United States needed the capability to control space to ensure the liberty of free people everywhere.[221] The services did not publicly criticize the administration's policy. Instead, they sought to determine for themselves how effective international space law would be, how it would curtail their activities, and how far they should go in presenting a case for military space projects.

Two weeks later, HQ ARDC issued System Development Directive 464L, stipulating that the mission of the Dyna-Soar Step I conceptual test vehicle would be to obtain data on the Mach 7+ boost-glide flight regime in support of future weapon system development. It suggested a system development plan for Dyna-Soar I and its subsequent weapon system programs be completed by 31 October 1958. HQ ARDC set July 1962 as the date for the first flight of the conceptual test vehicle. Finally, it approved immediate initiation of the program by directing the Directorate of Systems Management to begin the source selection process by evaluating any technical changes because the preparation of the Abbreviated Development Plan on 10 October 1957, six days after *Sputnik*.[222]

---

[221] U.S. Congress, House, Hearings Before the Select Committee on Astronautics and Space Exploration, *Problems of Congress Formulating Outer Space Legislation*, Memo from Eileen Galloway to Representative J. W. McCormick, 85th Congress, 2nd Session (Washington, D.C.: GPO, 1958pp. 100-01.

[222] HQ ARDC, "System Development Directive 464L" (Andrews AFB MD, 12 December 1957).

On 7 January 1958, Holaday formally asked the Air Force to suggest ways of expediting the military space effort. Holaday believed the resulting paper would help the director of the new Advanced Research Project Agency (ARPA), Roy W. Johnson, during his indoctrination period. The Air Staff's Directorate of R&D prepared a summary statement on the Air Force's astronautical development program, listing five systems and 21 subsystems to carry out six types of missions for national security. Two areas crossed over into the interests of the civilian-scientific arena--space research and manned spaceflight. Assistant Secretary of the Air Force Richard E. Horner forwarded the proposal to Holaday on 25 January requesting his approval and the resources to develop their program. Holaday disregarded the Assistant Secretary's request and used the paper as he said he would: to brief Johnson during his February indoctrination.[223]

In his State of the Union address, Eisenhower responded to the services' and the nation's lingering doubts about the role of a military space program within his space-for-peace policy. Referring to interservice rivalry, he said some weapon systems--meaning space programs--did not fit into any of the service's existing roles and missions. Naturally, this caused jurisdictional disputes. The president felt the situation demanded important bureaucratic changes in the DOD and stated he would later send

[223]Bowen, *An Air Force History of Space Activities*, pp. 132-33.

specific legislation to Congress.[224] Three months later the chief executive submitted his request.

Source Selection Board and a Military Space Program

By 25 January 1958, the working group of the source selection board, chaired by William E. Lamar, Assistant Chief, Bombardment Aircraft Division, Det. 1, Directorate of Systems Management, HQ ARDC, screened a list of 111 contractors to determine potential bidders for the Step I Dyna-Soar design. Of these contractors, the working group considered Bell, Boeing, Chance Vought, Convair, General Electric, Douglas, Lockheed, Martin, North American, and Western Electric capable of carrying out the development. Later, the list was amended to include McDonnell, Northrop, and Republic.[225] From these contractor's design efforts the final selection would be made. While proponents of hypersonic boost-glider technology wanted to place the first man into orbit, Gen. Putt told the ARDC commander, the vital nature of maintaining America's international prestige by placing an American in space before the Soviets made the question of technological capability paramount. Therefore, if the design requirements of a satelloid (a capsule or glider boosted directly into orbit)

---

[224]*New York Times*, 9 January 1958.

[225]William E. Lamar, Assistant Chief, "Hypersonic Strategic Weapon System," Management Report (Wright-Patterson AFB OH, 4 February 1958).

approach proved less stringent than a hypersonic boost-glider approach, a satelloid would be technologically and politically preferable for Dyna-Soar Step I.[226]

The appointment of Killian seemed to mean that the president recognized the inevitable need of some form of military space program. Eisenhower confirmed this idea on 5 February 1958 in a press conference when he mentioned the influence of Killian and said the DOD would continue to control military space projects even after the establishment of a civilian space agency.[227] Concurrently, the PSAC began working on its first comprehensive statement of U.S. interests in space. As PSAC formulated its ideas, the DOD assumed a military program would be needed and planned accordingly.

Not to be outdone by the administration, the United States Senate established a Special Committee on Space and Astronautics the following day. The House followed suit on 5 March with its Select Committee on Astronautics and Space Exploration. Both organizations would come to the assistance of the Secretary of Defense by retroactively approving his establishment of ARPA. The administration wanted this agency to assure a troubled nation that a military space program would exist.[228]

---

[226]Lieutenant General Donald L. Putt, Deputy Chief of Staff, "Advanced Hypersonic Research Aircraft," Letter (Washington, D.C., 31 January 1958).

[227] *New York Times*, 6 February 1958.

[228]U.S. Congress, House, Hearings Before the Select Committee on Astronautics and Space Exploration, pp. 100-10.

On 7 February 1958, McElroy formally established ARPA to act as a fourth military service, with the authority to direct all the R&D projects within the DOD as the secretary might assign. Holaday and Johnson knew they most work closely together to be effective. On the other hand, both agencies would be dependent on the authority of the Assistant Secretary of Defense (Research and Engineering), Paul D. Foote, and the Secretary of Defense.[229] The creation of ARPA seemed to indicate the administration would place a military space program ahead of a civilian space effort, but this illusion lasted only as long as it took to create a new civilian agency by giving it ARPA's space programs. In fact, from February through September, ARPA served as the nation's space agency. Afterwards, the civilian -scientific space agency would far exceed ARPA's authority and scope of responsibility, but NASA would not come to life until 1 October 1958.

Throughout February, the Air Force made three last attempts to retain control of its space programs. On the 24th, McElroy replied to the Air Force's requests. Having ignored its requests of 1 and 14 February, he approved the acceleration of WS-117L but put it under the direction of ARPA, not the Air Force. Also, he requested that a fund status summary of all Air Force space projects be submitted to ARPA. The same would be true for all the services. Unquestionably, development authority for space programs had shifted to ARPA. Subsequently, the Secretary of Defense could control the growth and responsibilities of ARPA by limiting the agency's responsibility

---

[229]Bowen, *An Air Force History of Space Activities*, p. 107.

to individually assigned projects or granting it overall authorization for wide areas. ARPA director Johnson would choose to reassign components of the service's former projects back to them, or to an outside agency. In turn, he would deal directly with a service's developing agency, such as the Air Force's BMD, rather than HQ Air Force or ARDC. While the services knew from experience this type of out-of-channel communication would confuse the developing agencies and slow program development, it would take a year for Johnson to recognize his mistake and redirect his communications back through normal channels.[230]

Four days later, Johnson expressed his interest in the Air Force's manned spaceflight (Dyna-Soar and Man-in-Space-Soonest--MISS) and WS-117L programs. Believing these systems deserved high priority, he wanted the Air Force to concentrate on these two fields even to the detriment of lower priority projects. Specifically, the ARPA director wanted WS-117L accelerated but with the Atlas missile as its primary booster rather than the Air Force's Thor. Additionally, he wanted a complete clarification of the program.[231] Accordingly, Air Staff representatives briefed Johnson on 19 March. In the briefing, they covered unmanned systems, the possibilities of a lunar military base and of substituting MISS for Dyna-Soar. The Air Staff preferred the capsule method of MISS over the hypersonic boost-glide approach of Dyna-Soar

---

[230] U.S. Congress, House, Hearings Before the DOD Subcommittee on Appropriations, *The Ballistic Missile Program*, 85th Congress, 1st Session (Washington, D.C.: GPO, 1957).

[231]Director ARPA Roy Johnson, "Reconnaissance Satellites and Manned Space Exploration" (Wright-Patterson AFB OH, 28 February 1958).

because the booster and space systems technology to accomplish MISS could be attained before the equivalent technology for the hypersonic flight of Dyna-Soar. In a race to put the first man in space, the Air Staff believed the capsule approach might well be the only hope of accomplishing the mission before the Soviets.[232]

In the weeks following ARPA's activation, the Air Force began a new space study program. Air Force leadership did not want to be technologically blind-sided by the space age like it had been by the missile age from 1947 through 1954. As Arnold suggested in 1944, the Air Force of the future would need to look as far as possible into the future. It wanted to create an integrated concept of space operations ahead of current requirements. Of necessity, the programs would be relatively small, conducted by industry on a voluntary basis, and funded voluntarily as well. From time to time ARDC would release to industry general descriptions of an area of potential operational significance. In turn, industry would undertake a study to determine the kinds of weapon systems likely to be required for that military operation. They should consider all the factors of development, production, and costs. These studies would be evaluated by ARDC, the School of Aviation Medicine, interested major commands, RAND, HQ Air Force, and the NACA. From February through August, ARDC and industry produced a series of seven study requirements (SRs) under three strategic systems: Strategic Orbital Systems (SR 181, SR 178, SR 187); Strategic Lunar Systems (SR 192, SR 183); and Strategic Interplanetary Systems (SR 182). The

---

[232]Bowen, *An Air Force History of Space Activities*, p. 139.

seventh series (SR 184--a study for a 24 hour reconnaissance system) would be considered a possible support program--along with the WS-117L satellites, the meteorological satellite, MISS, and Dyna-Soar--for the Strategic Orbital System.

As the Air Force established its program to study military applications for space, PSAC released a policy paper listing three reasons for space exploration: first, to acquire scientific knowledge; second, to further national prestige; and third, to guarantee American military strength. This represented the first top-level indication of what the administration's national space policy would be in the post-*Sputnik* era. The following day, ARPA director Johnson began the nation's space program with three projects. While the president approved the endeavor, he reminded Johnson that ARPA would act as the national space agency only as long as it took to establish a civilian agency and transfer the programs to them. Also, as on 7 December 1957, the Chief of Staff, Gen. White, repeated the Air Force's aerospace doctrine. For all practical purposes air and space were a single element, forming a continuous, indivisible medium for all sorts of flight operations. As in the past, when the Air Force's capability to control the air dictated freedom of movement on the land and seas, so in the future, the capability to control space would ensure freedom of movement on the land, the seas, and through the atmosphere.[233]

Though many Air Force officers made similar statements to the public, the Air Staff did not have a systematic plan to "indoctrinate" the public, Congress, and the

---

[233]General Theodore D. White, "Air and Space Indivisible," *Air Force*, March 1958.

administration. Indeed, by end of 1958, the administration's space policy divided the Air Force's space programs among ARPA and NASA, thwarting its January 1958 efforts to establish the Air Force as the premier military space agency. Regardless, the Air Staff felt it must underscore the reasons why national security would be enhanced by reassigning the Air Force programs given to ARPA back to the Air Force. In the last days of 1958, the Air Staff would again assert the doctrine of an air-space continuum as its argument for allowing the Air Force to supervise the nation's military space programs.

Proposals for the Source Selection Board

By March 1958, the source selection board had received proposals from nine of the 13 contractors. Essentially, they could be divided into two approaches of development: an orbital satelloid concept and a suborbital boost-glide concept. In the satelloid concept, a glider would be boosted to an orbital velocity of 25,500 feet per second and an altitude of 400,000 feet, achieving global range as a satellite. In the boost-glide proposal, the glider would follow an equilibrium flight path after expenditure of the booster. By using a high L/D ratio, the glider could obtain a velocity of 25,000 feet per second and an altitude of 300,000 feet, circumnavigating the Earth.

Three contractors considered the satelloid approach the most feasible. Republic conceived of a 16,000-pound, delta-wing glider, boosted by three solid propellant stages. The vehicle, along with a 6,450-pound space-to-Earth missile, would be propelled to a velocity of 25,700 ft./sec. and an altitude of 300,000 feet. Lockheed considered a 5,000-pound glider similar in design to Republic's. While Lockheed believed this vehicle could operate as a satelloid, it suggested using a modified Atlas booster, one lacking sufficient thrust for orbital velocity. A 15,000-pound vehicle similar to the X-15 comprised North American's proposal. Its booster would consist of a one-and-a-half stage liquid fueled propellant unit with an additional stage in the glider. Operated by a two-man crew, the vehicle would have two small liquid-fueled engines for maneuvering and landing. The glider would be propelled to a velocity of 25,600 feet per second and an altitude of 400,000 feet.

Six contractors concentrated on the boost-glide concept. Douglas considered a 13,000-pound, arrow-wing glider, which was to be boosted by three modified solid-propellant stages of the Minuteman system. An additional stage would provide a booster for advanced versions of Dyna-Soar. McDonnell offered a design similar to that of Douglas but with a modified Atlas unit. Convair recommended a delta-wing glider weighing 11,300 pounds. This contractor did not consider the various possibilities for the booster system but did incorporate a turbojet engine to facilitate landing maneuvers. Martin and Bell co-proposed a two-man, delta-wing vehicle, weighing 13,300 pounds, which would be propelled by a modified Titan engine. Employing Minuteman's solid-propellant unit, Boeing offered a smaller glider, weighing 6,500 pounds. Finally, Northrop proposed a 14,200-pound, delta-wing glider, which was to be boosted by a combination liquid and solid propellant engine.

After reviewing the proposals, William Lamar and John Becker, a NACA co-chairman, Scientific and Technical Area, observed how, with the exception of the

North American vehicle, all of the contractors based their configurations on a delta-wing design rather than a lifting-body or a capsule. The size of the proposed vehicles appeared small compared with the size of a current fighter aircraft such as the F-106. While McDonnell and Republic offered the vehicles with the biggest payload, they also required the largest boosters. Boeing's proposal appeared at the other extreme. It could carry only 500 pounds, including the weight of the pilot. It represented, however, the only design in the L/D ratio of ~ 2, the ratio the working group believed would offer the greatest mission flexibility for suborbital and orbital flight.[234] Of the three contractors proposing the satelloid concept, Lockheed's fell short of global range. Of the six contractors offering the boost-glide approach, only the Martin-Bell team and Boeing proposed a first-step vehicle capable of achieving the orbital velocity needed to send a man into orbit and affording America an opportunity to regain its national prestige. The other four considered the possibility of attaining global range in their advanced versions.[235]

Asserting Legislative Authority: NASA and the DOD Reorganization Act

As the source selection board made its recommendations on an appropriate boost-glide design for the Air Force's sole space program, the president committed himself officially to the primacy of a civilian-scientific approach to space by legislatively asking Congress to create another bureaucratic agency, the National

---

[234]Hallion, *Hypersonic Revolution*, pp. 416-17.

[235]Clarence J. Geiger, *History of the X-20 Dyna-Soar* (Wright-Patterson AFB OH: Air Force Systems Command, 1963), p. 31.

Aeronautics and Space Administration (NASA). NASA would conduct all space activities except those primarily associated with military requirements. The message confirmed the nation's two-fold approach to space and, more significant, identified the agency with the highest priority--the civilian.[236]

A day later, Eisenhower submitted his DOD Reorganization Act to Congress. He believed separate ground, sea, and air warfare no longer existed. Regarding the development of new weapon systems, he wanted to strengthen the authority of the Office of the Secretary of Defense (OSD) by making its authority clear and direct. Therefore, he suggested the elimination of the Office of Assistant Secretary of Defense (Research and Engineering) and replacing it with a Director of Defense Research and Engineering (DDR&E). The DDR&E would have three main functions: to be the principal advisor to the Secretary of Defense on scientific and technical matters; to supervise all research and engineering activities in the DOD; and to direct, control, assign, or reassign research and engineering activities requiring centralized management. While reporting to the three civilian service secretaries, DDR&E would outrank the ARPA director and the Director of Guided Missiles, Deputy Secretary of Defense, and the Secretary of Defense. By 6 August it was law. The president appointed Dr. Herbert F. York, a member of the SAB and the Institute of Defense Analysis, as the first DDR&E.

---

[236] *New York Times*, 13 January 1958; *New York Times*, 3 April 1958; President's Science Advisory Committee, *Report of the President's Science Advisory Committee* (Washington, D.C.: GPO, 1958).

Meanwhile, the Secretary of Defense began to qualify and quantify the military's responsibilities in space. In March 1958, he suggested NSC's Planning Board consider issuing a national security policy on space. Following his lead, the board established an Ad Hoc Subcommittee on Space to receive the comments of the National Science Foundation, the Central Intelligence Agency, the three services, and various other government agencies. The result would be the Preliminary United States Policy on Space--NSC 5814/1.[237] Although NSC 5814/1 highlighted the significance of a military space program, it placed the political implications above any perceived military necessity. Specifically, it would be politically dangerous to allow the Soviet Union to remain permanently superior to the United States in astronautics. Its ability to launch heavy payloads into orbit, seemingly at will, made it even more important for America to work toward international control and cooperation. All of the responsibilities NSC 5814/1 outlined would be the purview of NASA. In this role, NASA would be more than a space agency, it would become an adjunct to the State Department.

The services took advantage of their invitation to assist the NSC in its preparation of NSC 5814/1. While fully supporting the ideal of space-for-peace, they also expressed their warning against emasculating the military space program to achieve a civilian-scientific space program. After their presentation to the NSC, the Air Force undertook a second study--for Air Force eyes only--on the feasibility of

[237]National Security Council, NSC 5814/1.

international space law and its effects on its military space program. It would take five months to complete and would reorient the Air Force's approach to their military space programs.[238]

Contractors for Dyna-Soar

By the beginning of April, the Directorate of Systems Management's source evaluation and selection working group completed its evaluation of the contractors' proposals. On 16 June 1958, HQ Air Force announced that Martin and Boeing would both develop Dyna-Soar.[239] In the ensuing period they should revise and improve their designs through the mock-up stage. Both received a briefing on the new design criteria based on Air Force/NACA research.

Major General R. P. Swofford, Jr., then Acting Deputy Chief of Staff for Development, HQ Air Force, clarified the need for two contractors and their responsibilities. A competitive period between Martin and Boeing would extend from 12 to 18 months at which time selection of a single contractor would be made. While Gen. Swofford anticipated that $3 million would be available from FY 1958 funds and $15 million would be set for 1959, the contractors must work within the constraints of available funding. The decision to operate Dyna-Soar Step I as a boost-glider or a satelloid system would remain open. Dyna-Soar would constitute a major Air Force

---

[238]Bowen, *An Air Force History of Space Activities*, p. 185.

[239] Directorate of Systems Management, "Weekly Activity Report" (Wright-Patterson AFB OH, 10 April 1958); HQ Air Force, "AFDRD-AN-31317," Telecommunication Message [hereafter cited as TWX] to Commander, Det. 1, HQ ARDC (Wright-Patterson AFB OH, 16 June 1958).

effort to develop a weapon system to fly higher, faster, and farther than any existing manned strategic jet bomber and reconnaissance systems. Yet the contractors should not limit their prospects solely to a strategic role. Additionally, any weapon system coming from Dyna-Soar should complement other systems planned for the period. Because of these considerations, all their proposals must include complete weapon system analysis to justify their methodology. In fact, the development of a weapon system should be given first priority.

Concurrently, hypersonic flight must be an integral part of any of the contractor's proposed configurations. Although some aspects of hypersonic flight still needed verification, they should not delay initiation of Dyna-Soar Step I until weapon systems payloads or mission profiles could be defined. In fact, Gen. Swofford felt the contractor's work on WS-117L and MISS would aid them in these two fields. Subsequently, unnecessary duplication should be avoided .[240] Gen. Swofford hoped these guidelines to the contractors would ensure the quick development of a hypersonic weapon system for space operations. The Air Staff had other ideas as well.

Before *Sputnik,* Air Force space activities centered on the Office of Deputy Chief of Staff, Development, where Brig. Gen. Boushey, Deputy Director of R&D, held the responsibility of coordinating space projects. Following *Sputnik*, HQ Air Force believed, like the administration, that bureaucratization of space policy and

---

[240]Lieutenant General R. P. Swofford, Jr., "Selection of Contractor for WS 464L (Dyna-Soar) Development," Letter to Commander, ARDC (Andrews AFB MD, 25 June 1958).

programs would be advantageous. Accordingly, it hoped to establish a special agency specifically dedicated to space. After an aborted attempt at creating the Directorate of Astronautics, Deputy Secretary of Defense, Donald A. Quarles, gave his approval for a new Air Force agency. Because of the administration's space-for-peace policy, Chief of Staff Gen. White was still cautious about using the term "astronautics" in the title of the new agency. Instead, he established the Directorate of Advanced Technology, Deputy Chief of Staff, Development, effective 15 July 1958. Gen. White tasked the agency to supervise the formulation of advanced technology within the Air Force; to provide technical information and advice to the Air Staff as new programs developed; to coordinate with ARPA, the Army, the Navy, and other interested government agencies; and to maintain a liaison with civilian universities, industry, and representatives of foreign governments engaged in R&D.

Brig. Gen. Boushey became the first director. He promptly organized the agency into four assistantships: Boost-Glide Systems, Space Projects and Systems Studies, Manned Military Space Systems, and Unmanned Military Space Systems.[241] Interestingly, the Assistant Chief of Staff for Guided Missiles continued to retain responsibility for coordinating the requirements for ballistic missile resources, including boosters and test facilities. This meant the BMD did not report to Boushey, but to the Assistant Chief of Guided Missiles, creating another layer of coordination and potential for conflicting interests.

---

[241]Bowen, *An Air Force History of Space Activities*, pp. 111-12.

Maintaining Dyna-Soar Under Air Force Jurisdiction

Apparently some questioning concerning the validity of the Dyna-Soar program and its approach to bombardment and reconnaissance occurred at HQ Air Force, because on 11 July, Major General J. W. Sessums, Jr., Vice-Commander of ARDC, told Lieutenant General R. C. Wilson, Deputy Chief of Staff, Development, Air Staff that personnel should stop doubting the necessity for Dyna-Soar. Once a new project had been sanctioned by HQ Air Force, Gen. Sessums believed, full support should be given for its completion.[242] In reply, Gen. Wilson assured Gen. Sessums the Air Staff considered Dyna-Soar an important project. Indeed, it still carried a 1A priority status. Additionally, Dyna-Soar represented a weapon system capable of succeeding manned strategic jet bomber and reconnaissance systems. Anticipating the interest of ARPA and the forthcoming NASA in the development of systems such as Dyna-Soar, the Air Force needed to defend the requirements for its projects to DOD if it planned to retain jurisdiction over them. For Dyna-Soar, this meant emphasizing its suborbital Step I capability as a follow-on for manned strategic jet bomber and reconnaissance systems rather than its Step II and Step III orbital capabilities. Gen. Wilson closed by reassuring Gen. Sessums of his full endorsement of the Dyna-Soar program.[243]

---

[242]Sessums, "Dyna-Soar Program."

[243]Lieutenant General R. C. Wilson, Deputy Chief of Staff, "Dyna-Soar Program," Letter to Major General John W. Sessums, Jr., Vice Commander ARDC (Andrews AFB MD, 23 July 1958).

Considerable discussion occurred within the Air Staff concerning NASA's undetermined responsibilities regarding existing military space programs. As early as 31 January 1958 the Air Force formally asked the NACA to join them in developing a manned, orbiting, research vehicle. By 20 May 1958, Air Force Chief of Staff, Gen. White and the NACA director, Dr. Hugh Dryden, signed an agreement for the NACA's participation in system 464L. The Air Staff did not know how this agreement would affect the new agency's relationship with the Air Force. Not until 14 November 1958 would the Air Force and NASA reaffirm this agreement.[244]

While the Dyna-Soar program had the verbal support of HQ Air Force, ARDC commander, Lieutenant General S. E. Anderson, felt the program needed additional funds. He reminded the Deputy Chief of Staff, Development, Gen. Wilson, that HQ ARDC had considered only one contractor when requesting $32.5 million for FY 1959. The Air Staff limited this amount to $15 million for the contributions of both the Boeing and Martin contracts. Consequently, $52 million would be required for Dyna-Soar in FY 1959. If the Air Staff planned for System 464L to represent a major step in manned spaceflight, then, the ARDC commander emphasized, the delay inherent in the reduced funding must be recognized and accepted.[245] Such a delay would certainly mean Dyna-Soar would relinquish its opportunity to place the first

---

[244]Geiger, *History of the X-20 Dyna-Soar*, p. 32.

[245]S. E. Anderson, Commander ARDC, "FY 1959 Dyna-Soar Funding," Letter to Lieutenant General R.C. Wilson, Deputy Chief of Staff, Development, HQ Air Force (Wright-Patterson AFB OH, 24 July 1958).

American into orbit. As the primary system to send a man into orbit before the Soviets, BMD's MISS program would now have higher priority. Gen. Wilson agreed with Gen. Anderson's estimation. The approved funding level for FY 1959 would delay the program by one year. Still, the stipulated $18 million for both FY 1958 and 1959, although a minimum amount, would permit final contractor selection. Gen. Wilson further assured that the ARDC commander the Air Staff would try to alleviate the situation. In fact, he thought there might be a possibility for increasing FY 1959 funding.[246] However, as long as Dyna-Soar remained an Air Force program, all its funding would come from the Air Force' R&D budget.

Reestablishing National Space Policy

On 16 July 1958, Congress enacted the long-debated National Aeronautics and Space Administration Act of 1958. In doing so, Congress affirmed that America's preeminent interest in space would be peaceful. The supremacy of the civilian agency over the military assured this goal. On the other hand, activities primarily associated with weapon system developments, military operations, or the defense of the United States--including relevant R&D--would still be the responsibility of DOD. The Space Act authorized the president to be the final arbiter between NASA or DOD for a specific project. Also, three new agencies resulted from the Act: the National Aeronautics and Space Administration, the National Aeronautics and Space Council

---

[246]Lieutenant General R. C. Wilson, Deputy Chief of Staff, "Dyna-Soar Funding," Letter to Lieutenant General S. E. Anderson, ARDC Commander (Andrews AFB MD, 12 August 1958).

(NASC), and the Civilian-Military Liaison Committee (C-MLC). The NASC consisted of the president, Secretary of State, Secretary of Defense, NASA administrator, chairman of the AEC, and four additional presidential appointees. It would assist the president in surveying aeronautical and space activities while it provided for effective cooperation between NASA and the DOD.[247] The act also said NASA, under the guidance of the president, could engage in a program of international cooperation, a foreign policy tie-in with the Department of State. Within a month, Eisenhower selected Dr. T. Keith Glennan, president of Case Institute of Technology in Cleveland, and Dr. Hugh L. Dryden, director of the NACA, as the new administrator and deputy administrator of NASA. By 31 October, he reassigned Holaday from the Director of Guided Missiles to chairmanship of the C-MLC.

Thus, by the summer of 1958, the administration reestablished its authority by successfully creating, through bureaucratization and legislation, three documents collectively expressing the nation's space policy--the 26 March PSAC report, the Space Act of 29 July, and the 18 August NSC 5814/1. Each of these affirmed the limited role of the military and the primacy of the civilian-scientific role.

While the services lost control of their space projects to ARPA in the first half of 1958, it quickly became evident that the birth of NASA would force a day of reckoning between the two agencies, a day for the real division of the national space

---

[247] U.S. Congress, House, Report 1758, *The National Space Program*, 85th Congress, 2nd Session (Washington, D.C.: GPO, 1958); PL 85-568, *National Aeronautics and Space Act of 1958* (Washington, D.C.: GPO, 1958).

program. Because part of the act was aimed at eliminating unnecessary duplication, the administration welcomed the confrontation. The danger of continued duplication came in the assignment of borderline projects to the civilian agency. Because Eisenhower refused to admit publicly that the United States was in a space race with the Soviets, he continued to portray NASA's objectives as civilian-scientific, as outlined in his space-for-peace policy. They were devoid of the urgency endemic to national defense issues. Under these circumstances, ARPA director Johnson believed it would be better to keep borderline projects (like missile development) under military control, or tolerate some duplication, rather than prevent the military from using the kinds of vehicles civilians saw no pressing need to use.

As soon as the act went to Congress, Johnson of ARPA and Dryden of the NACA/NASA began to establish a jurisdictional committee to determine their likely areas of responsibility. Four categories developed: first, defensive space systems and ICBMs; second, unmanned reconnaissance satellites; third, military developments for, and applications of, space technology (including Dyna-Soar Step III and MISS); and finally, research and scientific projects. While category four programs obviously belonged to NASA, as much as the first and second categories belong to ARPA, category three programs became the gray area of dispute.[248]

---

[248] U.S. Congress, House, Hearings Before the Subcommittee of the Committee on Appropriations, *Department of Defense Appropriations*, 85th Congress, 2nd Session (Washington, D.C.: GPO, 1958).

Eisenhower's desire to maintain his space-for-peace policy made him reluctant to grant the military a space activity that might be construed as civilian-scientific in origin. Unquestionably, he considered any borderline project the purview of NASA first and foremost. The president believed it would be far better to err on the side of discretion rather than risk any misinterpretation of his intentions in the international arena. By the end of October, only eleven projects remained under DOD's control. One of these was Dyna-Soar, but MISS went to NASA. Although NASA did not immediately gain the ABMA, Johnson knew it would only be a matter of time before it did. Because NASA programs would be civilian-scientific in origin, administrator Glennan did not feel any sense of urgency about the tasks before him, including manned spaceflight.[249] Yet, if proponents of civilian-scientific programs planned to gain a sense of propriety, they would need rocket boosters to accomplish their missions. Glennan cast aside the old taboo about using military boosters for the peaceful exploration of space and called upon the DOD to supply him with information, services, equipment, facilities, and personnel. The president supported him. McElroy complied.[250] Again, once these programs passed from military to civilian control, the emphasis shifted. The significance the military placed on these systems would be

[249] U.S. Congress, Senate, Hearings Before the NASA Authorizations Subcommittee of the Committee on Aeronautics and Space Science, *NASA Authorization for Fiscal Year 1960*, 86th Congress, 1st Session (Washington, D.C.: GPO, 1958); U.S. Congress, Senate, Report of the NACA Special Committee on Space Technology, *Recommendations to NASA for a National Space Program*, 86th Congress, 1st Session (Washington, D.C.: GPO, 1958).

[250] Bowen, *An Air Force History of Space Activities*, pp. 151-52.

entirely different than NASA. Under NASA, program development tended to slow down. NASA's tempo for booster development, research in fuels, creating nonchemical engines, and developing Project Mercury did not match the crisis pace of a military weapon system like Atlas. The Air Force believed a faster pace in these areas of development was necessary for national security.[251]

The Effects on Air Force Space Policy

The creation of ARPA and NASA devastated the Air Force because it believed its future depended on maintaining control of the aerospace continuum. Entirely outside the control of DOD, NASA pursued spaceflight as an end, rather than a means to a goal. Yet the Air Force believed America's national defense was at stake. Favored by the president as an expression of his space-for-peace policy, NASA imposed its will on the DOD. Indeed, the Bureau of the Budget offered its benedictions in accordance with the White House's preference for the civilian agency. Unquestionably, NASA seemed destined to play the major role in America's space efforts, far more than the NACA played in aeronautical affairs. Air Force leaders hoped the cooperative atmosphere they shared would continue to prevail.

On 6 August 1958, Major General V. R. Haugen, Assistant Deputy Commander for Weapon Systems, Detachment 1, made another plea to the Deputy Chief of Staff for Development. He estimated that inadequate funding would push the flight date for the research vehicle back by eight months. Such austerity would hinder

---

[251]U.S. Congress, Senate, Hearings Before the NASA Authorizations Subcommittee of the Committee on Aeronautics and Space Science, Part 1, pp.6.

the future developmental test program and cause excessive design modifications. General Haugen strongly urged the Air Staff to augment FY 1959 funding to a total of $52 million. Additionally, the full release of the planned $15 million should be made immediately available.[252] If the Air Force planned to control the Dyna-Soar program, they must command the policy governing it.

While the administration hoped its legislative and bureaucratic efforts would elicit cooperation and understanding from the public, it did not among the Democrats. On the Senate floor on 14 August 1958, Senator John F. Kennedy (D-Mass) delivered a dramatic missile-gap speech. Its impact angered Republican Senator Homer Capehart of Indiana so much he threatened to clear the galleries on the grounds Kennedy's statements disclosed information harmful to national security.[253] Democrats would not be waiting until the last minute to fan the fires of discontent within the public. Like any political party out of the White House, they sensed an opportunity and planned to exploit it in the coming presidential election.

By 22 August, the Deputy Chief of Staff, Plans and Programs, completed the Air Force's second study on the feasibility of an international law for space and its effects on the military space program. This "for-AIR FORCE-eyes-only" study, entitled "Study on Sovereignty over Outer Space," served as the basis for developing

---

[252]Major General V. R. Haugen, Commander, "Status of Dyna-Soar," Letter to Lieutenant General R. C. Wilson, Deputy Chief of Staff, Development, HQ Air Force (Wright-Patterson AFB OH, 6 August 1958).

[253]McDougall, *The Heavens and the Earth*, pp. 112-13.

future international space law studies by the Air Staff. In this paper, the Air Force stated that the U.S. Government should not commit itself to a single issue. America would need time to evaluate the new conditions created by the space age. Accordingly, the military should urge and assist in obtaining international cooperation on projects not pertinent to national security, thereby contributing to the president's national objective. Simultaneously, the Air Force should seek approval of an adequate R&D program while formulating programs to meet the scientific, commercial, and military needs of the United States. First and foremost, the Air Force's goal should always be to prevent Soviet dominance in space.[254]

Yet the Eisenhower administration sought to create a political framework for establishing an international agreement allowing the use of unmanned reconnaissance satellites. By negotiating with the Soviets on arms control and by brining before the United Nations proposals for the cessation of all military activities in space, Eisenhower planned to achieve his goals.[255] To emphasize its intentions, the Eisenhower administration renamed the "non-military" aspects of these negotiations "peaceful" in an effort to qualify certain passive military roles for future development.[256] This policy continued until the end of the Eisenhower years.

---

[254]Bowen, *An Air Force History of Space Activities*, p. 186.

[255]National Security Council, NSC 5814/1.

[256]Dwight David Eisenhower, *Farewell Radio and Television Address to the American People, 17 January 1961*, vol. 8 of *Public Papers of the Presidents, Dwight D. Eisenhower 1953-1961* (Washington, D.C.: GPO, 1961), pp. 1035-40.

On 4 September, Colonel J. L. Martin, Jr., Acting Director of Advanced Technology, HQ Air Force, offered additional clarification on Dyna-Soar's funding situation to Det. 1. The two separate efforts by Boeing and Martin should only be maintained until study results pointed to a single, superior approach. Indeed, this effort should be terminated within 12 months, rather than 12-18 months. Col. Martin told them the Air Staff was aware the $18 million level would cause delays. The Air Staff, however, believed these funds would provide the necessary information for selecting a single contractor. Also Martin announced the release of the $15 million previously requested. Once the working group identified a contractor, additional FY 1959 funding--if available-- could then be used by the selected contractor to make rapid technological progress. Last, Col. Martin directed them to stop using the term "conceptual test vehicle" to refer to Dyna-Soar Step I. In its place, he suggested the words "experimental prototype."[257] As a prototype of the next generation of manned strategic jet bomber and reconnaissance systems, the Air Staff hoped to obtain more funding from DOD.

The Dyna-Soar project office in Dayton OH felt the competitive period could be terminated by April instead of July 1959; however, a greater risk to the program's success would be incurred because of the shortened research period. Still, additional

---

[257]Colonel J. L. Martin, Jr., "Action on Dyna-Soar," Letter to Commander, Det. 1, Directorate of Systems Management, HQ ARDC (Andrews AFB MD, 19 September 1958).

funding could be effectively used to accelerate research.[258] These efforts to increase the Dyna-Soar allotment had no effect. On 30 September 1958, HQ Air Force informed Det. 1 of the cancellation of the $10 million procurement funds for FY 1959. Only $3 million remained for Dyna-Soar's development from FY 1958, with $5 million for FY 1959. In his 12 August letter to ARDC commander General Anderson, Deputy Chief of Staff, Development, General Wilson again mentioned the possibility of increased funding for FY 1959. Apparently, a figure of $14.5 million was being considered; however, HQ Air Force eventually informed ARDC that this proposed increase would not be made. HQ Air Force further directed the contractors to adjust their expenditure rates to ensure the $8 million total would prolong their efforts through 1 January 1959.[259] Clearly the Air Force's retention of Dyna-Soar did not mean it would receive the lion's share of funding. In fact, by retaining jurisdiction of Dyna-Soar the Air Force could only give it what funds remained after ARPA redirected Air Force assets to its programs. Additionally, hypersonic flight became, as in the 1952-1957 period, a long-range objective, subject to the vicissitudes of short-term objectives.

---

[258]Det. 1 Commander, HQ ARDC, "RDZSXB-3117," TWX to HQ Air Force (Wright-Patterson AFB OH, 16 September 1958).

[259] HQ Air Force, "AFDAT-58885," TWX to Commander, Det. 1 (Andrews AFB MD, 30 September 1958).

The Importance of Reconnaissance Satellites for Dyna-Soar

On 10 September 1958, Johnson redefined WS-117L, breaking it into three separate projects with different designations. Previously, the system designation changed from "Pied Piper" to "Sentry." Johnson kept this name for the photographic and ferret satellite. By August 1959 it would again be renamed; this time to SAMOS, a name chosen by WS-117L project director, Colonel Fritz Oder, in the belief no one could produce an acronym from it. They would--Satellite and Missile Observation System.[260] He stripped away a series of experiments from WS-117L to form Discoverer. This program would test a new vehicle configuration and its subsystems, including biomedical experiments and recovery techniques. The infrared subsystem of WS-117L became the Missile Defense Alarm Satellite (MIDAS).[261] All three of these projects would be assigned to ARDC's BMD, further strengthening its function as the Air Force's sole point-of-contact for space missions as it diminished the Dyna-Soar weapons system project office's (WSPO) claim to a mission in space and a commensurate slice of the funding pie.

From 20 through 24 October 1958, Lamar and Lieutenant Colonel R. M. Herrington, Jr., Chief of the Dyna-Soar WSPO, briefed HQ Air Force on the necessity of releasing funds for Dyna-Soar. These discussions resulted in several conclusions. The objectives of the program would remain unchanged, but further justification would

---

[260]Jeffery T. Richelson, *America's Secret Eyes in Space* (New York: Harper & Row, Publishers, Inc, 1990), p. 44.

[261]Bowen, *An Air Force History of Space Activities*, p. 164.

have to be given to DOD officials. The position of the former NACA, now NASA, in the program was reaffirmed. Additionally, ARPA would participate in Step III system studies relating to Dyna-Soar.[262] These managerial decisions, however, did not offer immediate hope for increased funding.

Early in November 1958, Herrington and Lamar again briefed officials of both ARDC and HQ Air Force on the continuing question of Dyna-Soar funding. General Anderson, after hearing their presentation, stated he supported the program but thought references to space operations should be deleted in the presentations to the Air Staff. While the long-range objective of Dyna-Soar would remain orbital flight, the short-term objective should reflect Dyna-Soar's follow-on characteristics as the next generation of manned jet bomber and reconnaissance system. Later, during a briefing to General Wilson, Air Staff officials indeed decided that the suborbital follow-on aspects of the military prototype system should be emphasized. With the sanction of the Air Force Vice Chief of Staff, General LeMay, WSPO representatives gave their presentation to R. C. Forner, the Air Force Assistant Secretary for R&D. The latter suggested Dyna-Soar would be terminated if the briefers presented it as a strong weapon system program to DOD officials. Accordingly, Secretary Horner felt the program should be slanted towards the development of a military research system, not even a prototype for the development of a future weapon system. As a military

---

[262]Geiger, *History of the X-20 Dyna-Soar,* p. 35; Directorate of Systems Management, "Weekly Activity Report" (Wright-Patterson AFB OH, 31 October 1958).

research system Dyna-Soar would no longer threaten the administration's space-for-peace policy. Subsequently, a memorandum would be sent to the Secretary of Defense requesting release of additional funds for Dyna-Soar.[263] While Herrington and Lamar achieved their funding objectives, their final goal of the Dyna-Soar program--the development of an operational weapon system--was now in jeopardy.

Concurrent with the high-level Dyna-Soar briefings, NASA-USAF representatives organized a conference on manned spaceflight. At the conference, NASA representatives showed an excited interest in the Air Force's strategic lunar system (SR 192) and lunar observatory studies (SR 183). While some questioned the military value of these study requirements, they could not deny their civilian-scientific worth. NASA especially wanted to know more about the strategic lunar systems status within the Air Force and, in return for the information, offered full reciprocity.[264]

Also in November, the Dyna-Soar project office completed a preliminary development plan supplanting the abbreviated plan of October 1957. Instead of the three-step approach, the Dyna-Soar program would follow a two-phase development. Because the military research vehicle would be exploring a flight regime significantly more severe than any existing Air Force system, the first phase would involve a glider capable of evaluating aerodynamic characteristics, pilot performance, and subsystem operation. Dyna-Soar I would be a manned glider with a highly swept, delta wing,

---

[263] Directorate of Systems Management, "Weekly Activity Report" (Wright-Patterson AFB OH, 14 November 1958).

[264] Bowen, *An Air Force History of Space Activities*, pp. 155-56, 159.

weighing between 7,000 and 13,000 pounds. A combination of Minuteman solid rockets would lift the vehicle (at a weight of 10,000 pounds) to a velocity of 25,000 feet per second and an altitude of 300,000 feet. By employing a liquid-fuel rocket, such as the Titan system, a 13,000-pound vehicle could be propelled to a similar speed and height. A retrorocket system to decelerate the glider and an engine to provide maneuverability for landing procedures would also be necessary.

Assuming a March 1959 approval for the preliminary development plan, the Dyna-Soar office reasoned that the airdrop tests could begin in January 1962, the suborbital, manned, ground-launch tests in July 1962, and the first, piloted, global flight in October 1963. Concurrent with this first phase, weapon system studies would be conducted. It set the earliest operational date for a weapon system as 1967. The WSPO felt a Dyna-Soar weapon system would perform reconnaissance, air defense, space defense, and strategic bombardment missions.[265] Regardless of the military potential of a Dyna-Soar weapon system beyond the research phase, the immediate problem of obtaining funds, not an outline of Dyna-Soar objectives, occupied center stage in the current act of the continuing drama of Dyna-Soar.

Dyna-Soar Funding and the Soviet Threat

By 4 December 1958, the Secretary of the Air Force requested that the Secretary of Defense release $10 million for the Dyna-Soar program. Apparently DOD

[265]Directorate of Systems Management Det. 1, HQ Air Force, "Preliminary Development Plan, System 464L" (Wright-Patterson AFB OH, November 1958), pp. 2-3, 8-11, 32-33.

did not feel the need to act immediately. On 30 December, HQ Air Force informed Det. 1 that it should not expect release of these funds until January 1959.[266] The project office urgently requested DOD to issue procurement authorizations immediately.[267] Finally, on 7 January, the Deputy Secretary of Defense, Donald A. Quarles, issued a memorandum to the Secretary of the Air Force, approving the release of $10 million for Dyna-Soar development. The deputy secretary emphasized that these funds constituted an approval for an R&D project only. They did not represent DOD recognition of Dyna-Soar as a weapon system. The $14.5 million increase would not be released until after the Air Force made a decision on the Boeing-Martin competition.[268]

Simultaneously, leaders of the Soviet Air Force began to reconsider boost-gliders as a logical follow-on to their manned strategic jet bomber systems. As the Soviet Union's boost-glide activities came to the attention of American intelligence agencies, they considered the Soviets' renewed interest in hypersonic flight as another reason for America to reciprocate. Failure to match Soviet boost-glide developments, as the United States had done with satellite technology, could have equally grave consequences for America's national security.

---

[266] HQ Air Force, "AFDAT-54520," TWX to Commander, Det. 1 (Andrews AFB MD, 30 December 1958).

[267] Directorate of Systems Management Det. 1, HQ Air Force, "RDZSXB-12-31619-E," TWX to HQ Air Force (Wright-Patterson AFB OH, 31 December 1958).

[268] Deputy Secretary of Defense, "Release of Dyna-Soar Funds," Memo (Washington, D.C., 7 January 1959).

Within the jurisdiction of OKB (General Design Bureau) 1, V. M. Myasishchev, Chief of OKB-23, reviewed the possibilities of hypersonic flight. Believing a two-phased approach would be the best, he and his fellow engineers envisioned a vehicle capable of 3,727-4,348 mph(6000-7000 kilometers/hour) and altitudes of 262,400-382,000 feet(80-100 kilometers) for the first phase. For the second phase, a vehicle capable of Mach 10 (or greater) and altitudes of 328,000-492,000 feet (100-150 kilometers) would be needed. Begun simultaneously with the creation of the 1957 abbreviated development plan for Dyna-Soar, Myasishchev's first variant, VKA (air-space apparatus) 23, consisted of a piloted delta-winged glider with small winglets. Elevons (combination elevators and ailerons) would provide maneuverability for the glider as it reentered the atmosphere. Myasishchev planned to use one of OKB-1's *Semyorka* rocket boosters, a product of "chief designer" S. P. Korolev, to power his boost-glider. Given the governmental designation 1388/618, its development began on 10 December 1959.[269]

A month after the Soviet Union officially sanctioned the development of VKA-23, HQ Air Force requested the Dyna-Soar office to provide it with a detailed program schedule. Concerning Dyna-Soar military test systems, the WSPO's planning should be based on the following projected funding: $3 million for fiscal year 1958, $29.5 million for 1959, and $35 million for 1960. Headquarters again directed the competitive period for the contractors to end by 1 April, with a final selection

[269]V. M. Petrakov, "Two Projects of V. M. Myasishchev," *Journal of the British Interplanetary Society* 47, 9 (September 1994):350-51.

announcement by 1 July 1959. While emphasis on a weapon system would be minimized during high level briefings, joint Air Force and ARPA weapon system studies would proceed under separate agreement with Dyna-Soar contractors. The Air Staff also directed the WSPO to consider two other developmental approaches. The first approach assumed DOD definitely changed Dyna-Soar's objectives to center solely on a research vehicle, similar to the X-15. Planning for this approach would be based on a projected funding of $78 million for fiscal year 1961, $80 million for 1962, $80 million for 1963, and $40 million for 1964. In the second approach, the Dyna-Soar program would include weapon system objectives. For this approach, a funding total of $650 million extending from fiscal year 1961 through 1967 would be assumed. The next day, HQ Air Force partially revised its directions. They extended the source selection process through 1 May 1959.[270]

In January 1959, ARPA director Johnson briefed the JCS on a number of space programs. Looking toward the future, he spoke of a satellite for electronic countermeasures, a space surveillance platform, and a maneuverable recovery space vehicle (MRS V). The latter would ensure a means of attack, defense, and escape from the space environment; indeed, Johnson expressed his confidence in a role for a military man-in-space. Accordingly, he referred to the regrettable loss of MISS to NASA (it became project Mercury), but remarked favorably on the Air Force's Dyna-

---

[270] HQ Air Force, "AFDAT-55061," TWX to Commander, Det. 1 (Andrews AFB MD, 14 January 1959); HQ Air Force, "AFDAT-48049," TWX to Commander, Det. 1 (Andrews AFB MD, 16 January 1959).

Soar program. Johnson believed it would surpass NASA's Mercury. With Dyna-Soar, the true potential of a manned space vehicle could be explored. It could maneuver in and out of orbit, operate from and return to a predetermined military site, all while remaining under a pilot's control. While Air Force officials considered his remarks gratifying, they could predict the loss of Dyna-Soar to ARPA or NASA. ARPA saw the need for a manned maneuverable spacecraft and believed it could justify its takeover of Dyna-Soar if the Air Force advanced Dyna-Soar's orbital potential. Concurrently, NASA claimed to be the agency for manned spaceflight and could demand the transfer of Dyna-Soar if ARPA took it as a manned space vehicle. As a safeguard, the Air Staff continued to depict Dyna-Soar as the next logical follow-on to existing manned strategic jet bomber and reconnaissance systems rather than the long-term objective of an orbital weapon system. Meanwhile, the Air Staff would continue its development as rapidly as possible given the constraints of weak funding and OSD's strong opposition.[271]

Simultaneously, BMD commander Major General Bernard A. Schriever, while gladly acknowledging the good work done by ARPA, criticized its disregard of proven management concepts, its practice of splintering projects throughout the services, and its failure to recognize the urgency of defining a military posture for space. He believed ARPA should be phased out by the end of FY 1959, leaving the DDR&E to formulate space policy. Also, he wanted the services to be allowed to do their own

---

[271]Bowen, *An Air Force History of Space Activities*, pp. 167-68.

R&D, as they had before the creation of ARPA, according to the definite military roles and missions within each service.[272] As Schriever highlighted what he saw as ARPA's inability to manage the space programs under its jurisdiction, the Air Staff completed a statement on doctrine.

By 30 January 1959, the Air Staff completed its doctrinal statement. It spoke of the air-space continuum as "aerospace"--a term coined a year earlier by Dr. Woodford A. Heflin of the Air University's Research Studies Institute--and justified the Air Force's claim as the single service of military responsibility. Appearing before the House Committee on Science and Astronautics on 3 February, General White reasserted the Air Force's strong support of the administration's space-for-peace policy, but he also reasserted his belief in a strong deterrent force to ensure the free world's access to space. Again calling on the vision of an indivisible aerospace continuum, he expressed his concerns for the Air Force's jurisdictional responsibility.[273] While critics disputed the Air Force's claim to space, Gen. White did not retract the claim. As the debate continued throughout 1959, the criticism gradually lost its sharpness. By December 1959, the concept of an indivisible aerospace continuum officially become part of Air Force doctrine in *AFM 1-2*.

---

[272]Ibid, p. 176.

[273] U.S. Congress, House, Hearings Before the Committee on Science and Astronautics, *Missile Development and Space Sciences*, 86th Congress, 1st Session (Washington, D.C.: GPO, 1959), pp. 73-74.

Three days after General White's Congressional appearance, the Dyna-Soar WSPO sent a message to HQ Air Force notifying them that the 1 May source selection date would be impracticable. Still, the office did anticipate a presentation to the Air Council by 1 June. It continued by emphasizing the incompatibility of the Air Staff's funding forecasts with the flight dates specified to the contractors. Only heavy expenditures during the beginning of phase two, after source selection, could result in the questionable flight dates. The Dyna-Soar office, consequently, requested HQ Air Force to provide a more realistic funding schedule.[274]

In mid-February, the Dyna-Soar office clarified its position. The approval of only $5 million in development funds for FY 1959 (the release of $10 million had been for procurement), instead of the revised request of $28 million, would seriously affect the program, reducing its applied R&D program. Critically long lead-time items like flight test range facilities and range instrumentation could not be secured. Furthermore, the WSPO based its originally requested $187 million for FY 1960 on a more extensive applied research effort during FY 1959 than what actually took place under the Air Staff's reduced funding level. HQ Air Force projected only $35 million for FY 1960, which would prolong the program.[275] On 17 February, the Air Staff asked the project office to provide additional information on the program based on FY

---

[274]Det. 1 Commander, HQ ARDC, "RDZSXB-30164-E," TWX to HQ Air Force (Wright-Patterson AFB OH, 6 February, 1959).

[275]Det. 1 Commander, HQ ARDC, "RDZSXB--59RDZ-3995," TWX to HQ Air Force (Wright-Patterson AFB OH, 13 February, 1959).

1960 funding levels of either $50 million or $70 million.[276] It was not the $107 million originally requested, but it was greater than the $35 million allotted.

More Authority over the Military Space Program

The depreciation of the status of Dyna-Soar by DOD, exemplified by Secretary Quarles's memorandum of 7 January, did not alter the necessity, in the opinion of the Air Force, for a boost-glide weapon system. On 17 February 1959, Air Force headquarters revised its General Operation Requirement (GOR) 92, previously issued on 12 May 1955. Instead of referring to the need for a high-altitude reconnaissance system, the Air Force now concentrated on a bombardment system. HQ Air Force said this system would operate at the fastest attainable hypersonic speed--within and above the stratosphere--and should complete at least one circumnavigation of the Earth. The system should be operational in the 1966 to 1970 period.[277]

As HQ Air Force exercised its jurisdiction over Dyna-Soar by revising GOR 92, the BMD successfully launched Discoverer I, the first nation's military satellite, from Vandenberg AFB, California, on 28 February 1959. It did not carry a recoverable reconnaissance capsule. Instead, the flight was supposed to fulfill six main test objectives: proving the capability of its airframe and guidance subsystems; testing its stabilization equipment; certifying its means of controlling the internal

---

[276] HQ Air Force, "AFDAT-56643," TWX to Commander, Det. 1 (Andrews AFB MD, 17 February, 1959).

[277] HQ Air Force, "General Operational Requirement 92, Revised" (Andrews AFB MD, 17 February, 1959).

environment; providing a means of noting the reaction of mice and small primates to weightlessness; establishing the adequacy of the capsule recovery techniques; and verifying the proficiency of ground support equipment and personnel. When its stabilization control system malfunctioned, it tumbled out of control.[278]

Two months after the successful beginning of America's vital unmanned reconnaissance enterprise, Maj. Gen. Schriever, BMD commander, was promoted to Lieutenant General and assumed command of ARDC. Lieutenant General S. E. Anderson, previously ARDC commander, became commander of the Air Material Command.

As the control of the Air Force's R&D went to the architect of the nation's ICBM and reconnaissance satellite system, a fourth important document in the administration's space-for-peace policy appeared from the NSC's Operations Coordinating Board (OCB). First, OCB's plan recommended legal analysis of each international space issue. Second, it recommended the U.S. negotiate an international agreement for registering all satellite orbits and their respective radio frequencies through the U.N. Third, America should formulate agreements for the peaceful use of space with any nation obtaining the technology to launch a satellite into space. Finally, the administration should prepare world opinion psychologically and politically for American reconnaissance satellites. OCB'S plan indicated a modification in the NSC's thinking toward a military space program. NSC now believed satellite reconnaissance

---

[278] *New York Times*, 1 March, 1959; *New York Times*, 2 March, 1959; Bowen, *An Air Force History of Space Activities*, p. 179; Burrows, *Deep Black*, pp. 107-109.

would be valuable as a means of verifying arms control agreements with the Soviet Union. The board believed changes in the world situation and domestic space organizations required a complete review of the president's space policy. With Eisenhower's concurrence, they entrusted the effort to an ad hoc committee of the NASC.[279]

As an ad hoc committee of the NASC began to revise the administration's original perceptions about space-for-peace, a DOD directive resolved the lingering question of whether DDR&E outranked the ARPA director. ARPA projects would be subject to DDR&E supervision and must be coordinated with DDR&E in the same manner as the programs within the military departments. The directive created another layer of bureaucracy between the Secretary of Defense and ARPA, insuring the administration's space-for-peace policy continued to emphasize its civilian-scientific aspects over the military.[280]

After cooperating with the Air Force since November 1958 on its study requirement for strategic lunar systems (SR 192) and lunar observatory (SR 183), NASA created a Lunar Exploration Group in early April 1959. The Air Force did not have a representative on the group. A short time afterwards, NASA announced its

---

[279]Bowen, *An Air Force History of Space Activities*, p. 96.

[280] U.S. Congress, Senate, Hearings Before the Subcommittee on the Government Organization for Space Activities of the Committee on Aeronautics and Space Sciences, *Investigation of Governmental Organization for Space*, 86th Congress, 1st Session (Washington, D.C.: GPO, 1958).

long-range plans for the civilian-scientific exploration of the moon.[281] This attitude become more noticeable as weeks passed and came to cover much wider areas as well. NASA officials felt they must avoid any impression of compromising their devotion to the administration's space-for-peace. The best way seemed to be disassociating their programs from the military. Equally important was the Air Force's insistence on pursuing the program with military urgency, an unacceptable notion to NASA officials who, adjusting their plans to budgets in the 1958-1959 period, could not conceive of a lunar base except in a 20 year time frame. Despite the differences, HQ Air Force refused to compromise its efforts to better relations with NASA. Gen. White, Air Force Chief of Staff, insisted on full cooperation, even at the risk of losing Air Force programs.[282]

On 13 April 1959, York exercised his authority over the Air Force's objectives for Dyna-Soar. The primary goal would be the suborbital exploration of hypersonic flight up to 22,000 feet per second. Dyna-Soar would be launched by a booster already in production or planned for the national ballistic missile and space programs. Dyna-Soar would be manned, maneuverable, and capable of controlled landing. York considered the testing of military subsystems and the attainment of orbital velocities secondary objectives, the accomplishment of which should only be implemented if they did not adversely affect the primary objective. DOD now authorized the additional

---

[281] NASA, *NASA Release 59-116*, 17 April (Washington, D.C.: NASA, 1959).

[282] Bowen, *An Air Force History of Space Activities*, pp. 160-161.

$14.5 million of FY 1959 funding. Additionally, DOD officials wanted to know if this figure, plus a proposed $35 million for FY 1960, would be sufficient to carry out the program. If not, then an alternate program should be submitted for review.[283]

Recovering Valuable Treasures

As DOD restrained Dyna-Soar to lower funding and repeated its insistence on making it solely a research program, BMD successfully launched Discoverer II from Vandenberg AFB, California, on 13 April 1959. It contained the first recoverable film capsule. BMD had equipped the satellite with a retrorocket ejection system to initiate its reentry. The Division planned for its valuable treasure to free fall into the waiting "arms" of the recovery task force. So the division hoped. The recovery task force--consisting of nine C-119s, four RC-121s, and three destroyers--operated off the coast of Hawaii. After the film capsule failed to eject when requested by the ground controllers, the canister finally ejected automatically on the seventeenth pass. It would not be recovered by the United States.[284] Indeed, none of the first thirteen treasures would be recovered. After a few successes, the crews would still occasionally fail to "catch" the capsules with the C-119's trapeze gear. It would never be a "sure thing," by any means. Naturally, this made the method ripe for modification. One alternative would be a lifting body--the SV-5a--developed by Martin for the BMD to facilitate a

[283]HQ Air Force, "AFDAT-59299," TWX to Commander, Det. 1 (Andrews AFB MD, 24 April 1959).

[284]*New York Times*, 14 April 1959.

maneuverable recovery at a landing site of its selection.[285] Basically, BMD suggested an unmanned lifting-body version of Dyna-Soar's Step II configuration.

As BMD contemplated alternative means to recover intelligence data from space, Senator John F. Kennedy suggested the nation had another valuable treasure worth recovering from potential Soviet destruction. In a speech delivered in April 1959, Kennedy pinpointed the main problems of the nation's defense posture as the ability to secure strategic striking power from enemy attack, and the need to develop an antiballistic missile system (ABM). Even if the missile gap ended, he emphasized, and the nation's arsenal of ICBMs equaled the Soviet Union's, America would still be on the short end of the stick.[286]

While Kennedy exhorted the need to protect the nation's ICBMs, HQ ARDC did not agree with York's directions. In an effort to fulfill the conditions established by GOR 92, ARDC issued System Requirement 201 on 7 May 1959. The purpose of Dyna-Soar would be to determine the military potential of a boost-glide weapon system and provide research data on flight characteristics up to and including orbital flight. Concurrently, studies would be made concerning a weapon system based on this type of hypersonic vehicle. HQ ARDC then directed Det. 1 to prepare a development plan

---

[285]Ibid.

[286]Lawrence Freedman, *The Evolution of Nuclear Strategy* (New York: St. Martin's Press, 1981), 76-90.

for Dyna-Soar by 1 November 1959.[287] ARDC commander Schriever believed the military objective of Dyna-Soar should not be secondary to a research objective.

Maj. Gen. Haugen, Det. 1 commander, echoed the ARDC commander in his reply to York. Haugen "strongly recommended" that the attainment of orbital flight and the testing of military subsystems be considered the primary, not secondary, objective. He further stated that Dyna-Soar constituted the only manned program to determine the military potential of the near-space regime. DDR&E should not compromise the extremely important Dyna-Soar program by imposing funding restrictions that limited safety, reliability, and growth potential in deference to short-term monetary savings.[288]

General Haugen's organization then drew up a position paper substantiating these recommendations. The detachment firmly believed both the primary and secondary objectives should be achieved. Sole concentration on the first set of objectives would prevent investigation of reentry from orbit and adequate testing of military subsystems. Haugen recommended a program involving the manufacture of eight unmanned vehicles, eight manned vehicles, and 27 boosters, all to be employed in a total of 25 launchings. This would cost a total of $665 million. While modifying the program to conform to only the primary objectives would reduce the cost by $110

---

[287] HQ ARDC, "Systems Requirement 201" (Wright-Patterson AFB OH, 7 May, 1959).

[288] Major General V. R. Haugen, Commander, "Dyna-Soar I Program Guidance," Letter to HQ Air Force (Wright-Patterson AFB OH, 15 May 1959).

million, it would seriously lessen the possibility of evolving a weapon system from Dyna-Soar.[289]

Replying to General Haugen, the Deputy Chief of Staff for Development, HQ Air Force, established $665 million as the maximum figure for the Dyna-Soar program.[290] This amount excluded the $18 million expended during contract competition. For planning purposes $77 million would be allocated for FY 1960.

As HQ Air Force assured the Dyna-Soar WSPO it would receive its overall funding request, S. P. Korolev, OKB-1, and P. V. Tsybin, Director of OKB-256, began preliminary design work for yet another Soviet manned boost-glider on 17 May 1959. According to the design, Sandal (*Lapotok*) would be placed into a circular orbit 186.36 miles (300 kilometers) high by a modified *Semyorka* booster, similar to the one used to launch the *Vostok* spacecraft. After 24-27 hours, it would reenter using the lift from its unique shape, while slowing to a speed of 1,640 ft./sec.-1,968 feet/second (500-600 meters/second). At an altitude of 20 kilometers, it would extend its folded wings to increase its lift and maneuverability.

The Sandal's fuselage measured 29.52 feet long (9 meters), 9.84 feet (3 meters) wide, and 5.58 feet (1.7 meters) high. With its folded wings extended, its wing span would be 24.6 feet (7.5 meters). OKB-256 envisioned a structure consisting of a steel

---

[289]Directorate of Systems Management Det. 1, HQ ARDC, "Dyna-Soar Substantiation of RDZ Program," Report to HQ ARDC (Wright-Patterson AFB OH, no date, 1959).

[290] HQ Air Force, "AFDAT-51437," TWX to Commander, Det. 1 (Andrews AFB MD, 28 May 1959).

skin welded to a heavy-duty frame. Protected by an organic-silicon thermal insulation, combined with ultrafine fiber, it used air ducts and liquid lithium to cool the structure. The folded wings would remain in the cool aerodynamic "shadow" of the fuselage when the boost-glider began its hypersonic reentry.

By 1960, Korolev and Khrushchev abandoned boost-glider technology--as Stalin had done in 1953-- as a follow-on to manned strategic jet bomber systems. For political and propaganda reasons, Khrushchev would agree to a simpler, more reliable, solution to the problem of placing the first man into orbit. The ballistic configuration of the *Vostok* would be selected over the more expensive and time consuming configurations of the Sandal and the VKA-23. OKB-256, like OKB-23, would be absorbed into another bureau, OKB-1. Chief designer Tsybin would become Korolev's deputy designer, making considerable contributions to a modified version of the *Vostok* spacecraft, the *Soyuz*, *Soyuz T*, and numerous unmanned spacecraft. V. K. Myasishchev would become the head of TsAGI, the Central Aerohydrodynamics Institute.[291]

Conclusion

Sputnik marked a significant and historic advance in technology. As such, it deserved the congratulations the president gave the Soviet government on 9 October

---

[291]Valentin Bobkov, "Unknown Spacecraft," in *History of the Soviet Space Program*, in *What's New in Life, Science, and Technology: Space Program and Astronomy Series*, ed. I. B. Afanasyev (Moscow: JRPS-USP-92-003, 13 December 1991), 48-49.

1957.[292] Yet this scientific spectacular came from a communist Soviet Union. The triumph created dismay everywhere outside the iron curtain. As a congressional committee suggested, the United States faced terrifying prospects of direct nuclear attack from Soviet missile bases.[293] In addition, the nation faced a new set of challenges to its preeminence in technology, the loss of international prestige, and the Soviet's unequivocal claim to primacy in space.

Out of the national humiliation came a calm realization. The administration must reexamine its international and domestic space policy, defense organization and strategy, and the desirability of a civilian-scientific space program far beyond the ambitions of Vanguard. Indeed, the administration must renew its authority over national space policy and its associated programs. Additionally, almost everyone attributed America's misfortune to indifference by the public and the government.[294] The press demanded and the government attempted a judicious appraisal of the situation. In international affairs, the president decided on, and Congress approved, a resurrection of the pre-*Sputnik* space-for-peace policy. In turn, the chief executive

---

[292] U.S. Congress, House, *Military Aid and Supply Programs in Western Europe*, House Report 1371, 90th Report by the Committee on Government Operations, 85th Congress, 2nd Session (Washington, D.C.: GPO, 1959).

[293] Ibid.; U.S. Congress, House, *Organization and Management of Missile Programs*, House Report 1121, 86th Congress, 1st Session (Washington, D.C.: GPO, 1959).

[294] Ibid.

qualified it to reflect a restricted military program and an ambitious civilian-scientific program.

Yet the administration's three-fold space-for-peace policy--international, civilian-scientific, and military--experienced considerable change between October 1957 and May 1959. As Eisenhower stayed on course with his space policies and programs, he ensured that military programs other than satellite reconnaissance remained subordinate to the civilian programs. When everyone cried for the simplification of the DOD's missile organization, a year and a half later, the administration did not eliminate the "czars." Eisenhower elaborated on them. ARPA, NASA, and DDR&E tightened and strengthened the administration's authority over the nation's space policy.

Initially, confusion resulted from the overlapping agencies and programs. It increased as the international situation kept the question of whether space would be a civilian responsibility used for peaceful purposes or a military responsibility used for national defense. By the first half of 1959, the administration's answers to the spaceflight revolution began to bear fruit. Yet a disturbing pattern began to emerge. For every cluster of American accomplishments, the Soviets, seemingly without fuss or furor, surpassed those achievements. Naturally, this generated criticism on Capitol Hill, throughout the military and among the press. Most critics singled out the space-for-peace policy. Though widely supported as the ideal, it bureaucratically divided America's space program into two seemingly unsynchronized parts: one sought to move with the tempo of military necessity and one sought to progress with the philosophical calm of deliberate research.

During this period of renewed debate, the Air Force attempted to frame its own version of space policy while it attempted to influence and conform to the administration's space-for-peace policy. As the doctrine of the indivisibility of the aerospace continuum took shape, the Air Staff exercised its authority over the single space program remaining solely under its jurisdiction--Dyna-Soar.

Yet the luxury of such a technologically challenging and necessarily expensive undertaking came at a price. The Air Force would need to emphasize Dyna-Soar's suborbital characteristics as a follow-on to manned strategic jet bomber and reconnaissance systems if it planned to retain the military potential of orbital flight. Additionally, ARPA, NASA, and DDR&E required the Air Force to use its resources to support all the space programs no longer under its jurisdiction. Naturally, these designated responsibilities took Air Force funding, which the Step I suborbital portion of the Dyna-Soar program would not receive. Additionally, as the administration's space-for-peace policy shifted to embrace reconnaissance satellites, the Air Force would also shift its emphasis toward gaining a greater portion these vital national assets. Ultimately, the Air Force's changing focus meant the Air Staff could not afford the increased expenditures needed to quickly attain the R&D Dyna-Soar required to demonstrate its capabilities as a follow-on to manned strategic jet bomber and reconnaissance systems or as the means of launching the first American into orbit. Concurrently, the proven capabilities of ICBMs and the less threatening and less destabilizing characteristics of reconnaissance satellites meant Dyna-Soar would need to match or surpass their abilities or lose its military justification for existence within Eisenhower's space-for-peace policy.

CHAPTER 5

STRUGGLING TO MAINTAIN THE MILITARY MISSION, JUNE 1959-DECEMBER 1960

> In retrospect, I think we should have recognized at the beginning that it [Dyna-Soar] was a nonsensical program.
>
> Dr. Herbert F. York,
> Director of Defense Research and Engineering,
> Office of the Secretary of Defense.[295]

Looking back, Herbert York doubted that a man in space could perform better than a machine--or even better than someone on the ground remotely performing the same mission. Specifically, either the mission could be accomplished better within the atmosphere or it could be performed better by an unmanned satellite. While he freely admitted a human would have greater "flexibility" performing the same mission in space as a machine--a man could do far more, quicker, and with greater assurance of success--he insisted the Air Force continually failed to establish clearly the relevance of using a human's "flexibility" to perform Air Force space missions. Saying a human's judgment would be necessary in a military space system did not mean a human would need to be on orbit with the system. In a great many cases, York persisted, a human could perform the function as well, if not better, in a control room on the ground rather

[295]York, *The Advisors*, pp. 130-31.

than in an orbiting capsule. He believed the administration settled this military argument the year after *Sputnik* by giving the man-in-space mission to NASA. What York required from the Air Force was proof of the utility of a military man in space. Yet how could the Air Force prove the utility of a placing a military man in space if the OSD refused to allow the development of single manned military program?

According to York, the DOD had no interest in spaceflight and exploration as ends in themselves, but rather in the application of spaceflight to the defense of the United States and its allies. DOD space efforts would be considered only as an integral part of the total defense effort to enhance the nation's military capabilities. Hence, it would not be logical to formulate a long-range military space plan, or program, separate and distinct from the nation's overall defense plans and programs. If the Air Force planned to prove the utility of a military man in space, it would need to persuade the relevant agencies through studies and system comparisons, both historical and current. Only by substituting a manned military space system for another planned system could the proponents of hypersonic flight gain the opportunity they needed.

Ironically, Dyna-Soar offered the administration just such an opportunity. As a space-based reconnaissance system, its capabilities would rival the soon-to-be developed, but highly classified, SR-71 "Habu," a Mach 3+ strategic reconnaissance aircraft. On 29 August 1959, Lockheed's design won the competitive bid. Manufacturing began on 30 January 1960.[296] Like the SR-71, Dyna-Soar could yield

[296]Paul Crickmore, *Lockheed SR-71 Blackbird* (London, England: Osprey Publishing Limited, 1986), pp. 21-22.

near-realtime photographic and ferret information through reconnaissance over any area in the world, delivering the crucial data immediately to a friendly base. While its speed, altitude, and electronic countermeasures (ECM) capabilities would initially keep the "Habu" out of harm's way, to gather information the aircraft would necessarily violate international airspace laws through its overflights. Dyna-Soar's Step II orbital capability, like unmanned reconnaissance satellites, would not have violated international law. Indeed, because the United States made no official complaint of the Soviet Union's satellite overflight with *Sputnik*, the skies would be open to establish permanently the right of any nation to send its reconnaissance satellite over another nation. With the Soviets' launch of Cosmos 4 on 26 April 1962, a tacit agreement would exist between the Soviet Union and the United States for space-based reconnaissance overflights. Unlike the SR-71, Dyna-Soar would have been a legal means of gaining a far wider range of photographic and ferret information. Additionally, in its Step III configuration, its increased payload capacity would have brought a far greater range of reconnaissance resources to bear on each overflight target--more than any single reconnaissance satellite.

Regardless of these possibilities, doubts about the future of Dyna-Soar again began to appear during the summer of 1959. Many Air Force R&D specialists felt the growing prospects of military operations in space seemed more exciting than the Step I boost-glide operations in the atmosphere. Additionally, some Air Force officers--including Maj. Gen. Schriever--believed NASA's Mercury program would likely fail, making it necessary for the Air Force to put the first American in orbit. They based their reasoning on the failure of the civilian-scientific oriented Vanguard program and partly on the belief NASA research types, as opposed to BMD individuals who managed and operated space systems, would bungle Mercury. Should Mercury fail, these proponents of the Air Force's primacy believed Dyna-Soar would be the candidate for the first manned orbital flight. Because of this reasoning, some questioned Dyna-Soar's design methodology. Should it be a sophisticated winged system or a simpler, quicker to develop--and perhaps more reliable--ballistic system, similar to BMD's MISS program given to NASA to become Mercury?[297] Or should it be a lifting-body?

DDR&E'S Guidance for Dyna-Soar

By 11 June 1959, the Air Force Council considered $77 million excessive for Dyna-Soar's FY 1960 budget. Reluctantly, the Deputy Chief of Staff, Development, HQ Air Force, Lieutenant General R. C. Wilson, was forced to recant on his suggested planning figure. The Dyna-Soar WSPO would need to use $35 million in place of the $77 million.[298] During a briefing on 23 June 1959, however, officials of the project office and Dr. Joseph V. Charyk, Assistant Secretary of the Air Force for R&D, further discussed the questions of funding and program objectives. Charyk did not fully agree with York's restriction of Dyna-Soar to suborbital flight. The assistant secretary considered the overall purpose of the program to be the exploitation of the

---

[297]Hallion, *The Hypersonic Revolution*, p. 425.

[298] Directorate of Systems Management, "Weekly Activity Report" (Wright Patterson AFB OH, 12 June 1959).

potentialities of boost-glide technology. Consequently, he believed orbital velocities should be attained early in the program. For FY 1960, he favored $77 million instead of $35 million but wondered how much a total funding level of $300 million to $500 million would compromise the program. Certainly it would eliminate the evolution of a weapon system from the Step I Dyna-Soar. Charyk then suggested that York appeared to be quite concerned over the effort to modify an existing booster for Dyna-Soar.[299] Supported by the field commands involved with hypersonic research, the Air Staff spent the next five months finding answers to satisfy the various agencies within the Office of the Secretary of Defense. Meanwhile, Dyna-Soar development stood still. At times it would seem no answer could satisfy all of the decision makers. Simultaneously, it appeared that the OSD, with administration concurrence, might withdraw financial support from Dyna-Soar, then turn the bits and pieces over to NASA. This would free Air Force funding for more reconnaissance satellite development. As the Air Force began to receive some space programs back from the disintegrating authority of ARPA, DOD officials began to consider these fiscal possibilities.

Anticipating the need for a booster with greater capabilities, Charyk welcomed the linkage of a heavy payload like Dyna-Soar to an orbital booster. Although both contractors offered similar delta-wing designs, they differed in their selection of

[299]William E. Lamar, Deputy Director, "History of Dyna-Soar to Present," Presentation to HQ ARDC (Wright-Patterson AFB OH, 20 February 1963); Lieutenant Colonel B. H. Ferer, Assistant, "Dyna-Soar Briefing to Dr. Charyk," Memo on the 23 June Briefing to Dr. Charyk (Washington, D.C., 23 June 1959).

boosters. Boeing only considered an orbital Atlas-Centaur combination. Martin officials offered a suborbital Titan A (later renamed the Titan I) and an orbital Titan C. The modifications required for the Titan C represented a somewhat greater effort than simply mounting a glider on top of the missile; but, because of the overall increase in boosting capabilities these modifications offered, the source selection board recommended use of Martin's orbital booster. It deemed the Boeing glider superior. The Secretary of the Air Force, James H. Douglas, Jr., did not agree with the source selection board's booster decision. Development of a new booster capable of orbital velocities clearly would not be in accordance with York's direction. To keep program costs down and meet his guidance, the secretary recommended further study of Dyna-Soar's configuration and size to determine whether the glider could be modified to permit its compatibility with the basic suborbital Titan A system. Furthermore, Secretary Douglas did not think funding should be increased to configure Dyna-Soar as a weapon system. Consequently, the Secretary of the Air Force directed a reassessment of the Dyna-Soar program, with the ultimate objective of reducing the over-all expense by eliminating its military objectives and restructuring it for a suborbital Titan A booster. Accordingly, HQ Air Force directed Det. 1 to examine the possibilities of a lighter vehicle and analyze a development program based on a total cost of not more than $500 million.[300]

---

[300] HQ Air Force, "AFDAT-53166," TWX to Commander Det. 1, HQ ARDC (Andrews AFB MD, 10 July 1959).

The problem of designating a booster, managing the booster's development and procurement, and most important, defining the purpose of the program, became intertwined in a series of discussions following Secretary Douglas' instructions. After a 14 July meeting with Dr. Charyk, Gen. Boushey, Colonel William L. Moore, Jr. (who succeeded Col. Herrington as Chief of Dyna-Soar Weapon System Project Office in July 1959), and Lieutenant Colonel B. H. Ferer (Assistant, Boost-Glide Systems, Deputy Chief of Staff, Development), Gen. Haugen directed the preparation of a presentation to answer the questions raised by Secretary Douglas. It would also outline the participation of BMD in the Dyna-Soar program. After reviewing this briefing on 22 July 1959, Lt. Gen. Schriever, ARDC commander, instructed Gen. Haugen's directorate of systems management to prepare a detailed management plan for booster development.[301] Five days later, York introduced a new complication. He requested the Air Force secretary and the director of ARPA to investigate the possibility of developing a common booster for Dyna-Soar booster and the second stage for the Saturn booster. DDR&E would not make a commitment for Dyna-Soar's propulsion system until the Air Force considered this proposal. Apparently, York planned to revive the Titan C option for System 464L and modify this booster for ABMA's Saturn program.

---

[301] HQ ARDC, "RDG-23-7-5-E," TWX to HQ BMD (Andrews AFB MD, 23 July 1959); Directorate of Systems Management Det. 1, HQ Air Force, "Report on Dyna-Soar Meeting," 59RDZ-23128 (Wright-Patterson AFB OH, July-August 1959).

Unaware of York's new requirement, Gen. Haugen and Brigadier General 0. J. Ritland, BMD commander, completed a tentative agreement concerning the management of Dyna-Soar's booster development. During a series of meetings on 11 and 13 August, however, Generals Schriever and Anderson could not agree on a method of booster procurement nor could BMD complete its evaluation of the booster. Because of the impasse, William Lamar, Assistant Deputy for Advanced Systems, Directorate of Systems Management, gave a booster presentation to Charyk, (with Generals Wilson, Ferguson, and Haugen attending) without the sections pertaining to BMD's participation. After hearing the preliminary data on Titan C and the Saturn second stage, Lamar asked Charyk to recommend that booster contractor selection begin for Dyna-Soar. He declined. Furthermore, Charyk believed that the previous subcontractor selection process lacked competitiveness. He also considered the proposed funding too high.[302] While Charyk saw the value of hypersonic research, he did not share the Air Staff's confidence or fiscally support Dyna-Soar's military objectives.

ASSET

As the Office of the Secretary of Defense refused to support, fiscally, the Air Staff's confidence in the military justification for Dyna-Soar, the Research and Technology Division, Flight Dynamics Laboratory (FDL), ARDC, began an in-house

[302]Herbert F. York, Director of Defense Research and Engineering, "Saturn, Dyna-Soar Propulsion," Memo to the Secretary of the Air Force and ARPA (Washington, D.C., 27 July 1959).

study of hypersonic flight under Projects 1366 (Aerodynamics and Flight Mechanics) and 1368 (Structural Configuration Concepts for Aerospace Vehicles). Both of these constituted a portion of yet another on-going Applied Research Program--750A (Mechanics of Flight).[303] Although the applied research projects did not directly support Dyna-Soar, their research into structures and mechanics of hypersonic flight would directly contribute to Dyna-Soar.

Originally slated to ride on top of a modified Air Force Blue Scout sounding rocket, the models of the gliders never made it. The service could not spare the boosters for applied research programs like FDL's. A more successful follow-on contract would begin in April 1960. This follow-on study would combine the earlier hypersonic research interests into a single program--the Aerothermodynamic/Elastic Structural Systems Environmental Tests or ASSET.

Just as DOD and NACA had used the X-series of manned aircraft, FDL intended to substitute ASSET for the lack of adequate ground test facilities and as a stimulus to evaluate, refine, and develop hypersonic facilities. Alfred Draper designed the ASSET gliders to resemble the front nose of Dyna-Soar. They consisted of a small--flat-bottomed--70 degree swept delta wing (a wing area of 14 square feet), and a body resembling a sharply tapered cone combined with a cylinder. The similarity to Dyna-Soar enabled the ASSET vehicle to take advantage of a large body of wind tunnel

[303] USAF Flight Dynamics Laboratory, "Advanced Technology Program: Technical Development Plan for Aerothermodynamic/Elastic Structural Systems Tests (ASSET)" (Wright-Patterson AFB OH, 9 September 1963), pp. 1-5, 27, 43-44.

studies completed or underway relating to the similar Dyna-Soar configuration. ASSET would assess, through free-flight tests, the applicability and accuracy of theories, analytical prediction methods, and experimental techniques available for the solution of hypersonic reentry problems in structures, aerothermodynamics, and aerothermoelastics. This was a fundamental concern of Dyna-Soar engineers.

A Step I Booster

By the middle of August, BMD completed its evaluation of possible Dyna-Soar boosters. Largely because of serious stability and control problems, BMD rejected the Atlas-Centaur combination in favor of the Titan C. Concerning York's second proposal, West Coast officials believed it would be impractical to employ a precisely identical booster stage for both Dyna-Soar and the second stage for Saturn. Because Titan C would essentially be cluster of four LR87 AJ-3 engines, ballistic division engineers recommended employing two of these propulsive units as a Saturn second stage.[304] Discussions among Charyk, York, and BMD officials soon followed. Ultimately, they could not agree on a Dyna-Soar booster. Finally, on 25 September, while refusing to designate a booster, Charyk and Generals Wilson, Ferguson, and Boushey decided Titan C would not be employed in the program.[305] This left Titan A

---

[304]Brigadier General C. H. Terhune, Jr., "Dyna-Soar Booster Evaluation," Letter to Det. 1, HQ ARDC (Los Angeles CA, 13 August 1959).

[305]Brigadier General Homer A. Boushey, "Required Action on Dyna-Soar," Letter to HQ ARDC (Andrews AFB MD, 29 October 1959).

as the sole Dyna-Soar booster and the Office of the Secretary of Defense's support of Dyna-Soar's military objectives unresolved.

As officials within the OSD debated booster selection, Lieutenant General W. F. McKee, AMC Vice commander, took up the question of booster procurement and proposed a management plan to Gen. Schriever. Because of the wide participation of government agencies and industry, he believed control of Dyna-Soar should be centralized in a specific organization. While the system would be procured under two contracts, one for the glider and one for the propulsion unit, the glider contractor glider should be given responsibility for integration of the entire system. Additionally, this contractor would act as the eventual weapon system contractor. Overall management would be vested in a joint ARDC and AMC project office located at Wright-Patterson Air Force Base. Concerning the procurement authority of the Aeronautical Systems Center (ASC) and the Ballistic Missiles Center (BMC)--both agencies of the Material Command--Gen. McKee suggested that the aeronautical center should negotiate the two contracts, utilizing the experience available at the ballistic center. However, ASC would delegate the authority for contracts covering engineering changes to BMC. This would be limited to actions not affecting the overall cost of the program, the compatibility between the booster and the glider, and over-all system performance. General McKee closed by recommending ARDC and AMC forward a message to Air Force headquarters outlining this proposal.[306]

[306]Lieutenant General W. F. McKee, Vice Commander, "The Dyna-Soar Program," Letter to Commander, ARDC (Los Angeles CA, 23 September 1959).

General Schriever, on 2 October, informed AMC officials that he agreed with General McKee's proposed message to USAF headquarters. The plan, however, did not adequately reflect the increased role that ARDC agencies at Wright Field would play. Schriever further stated ARDC would establish a single agency for booster R&D to incorporate both the BMD and BMC. General Anderson did not understand the ARDC commander's statement concerning the increased management responsibility of the Wright agencies. He felt the AMC plan stressed this aspect. General Anderson further emphasized how the Material Command recognized BMD's technical responsibility for the Dyna-Soar booster. The commanders agreed to delegate the necessary procurement authority. On the other hand, the ARDC commander did not think it would be necessary to delegate the authority to negotiate contracts. This authority, along with overall technical management, should rest in the ARDC and ASC weapon system project offices.[307] Gen. Schriever intended to ensure ARDC's control in both the aeronautical and booster agencies of the joint ARDC/AMC project office.

Confident that the military objectives of Dyna-Soar would strengthen national security and American prestige, General Boushey reexamined Dyna-Soar requirements established by York's 13 April memorandum. Orbital flight and testing of military subsystems could only be permitted, York insisted, if these efforts did not adversely affect the central objective of suborbital, hypersonic flight. General Boushey repeated the opinion of HQ Air Force: in the interest of national security and international

[307]General S. E. Anderson, Commander AMC, TWX to Lieutenant General B. A. Schriever, Commander ARDC (Los Angeles CA, 14 October 1959).

prestige both sets of objectives should definitely be achieved. Assuming a total funding of $665 million rather than the $500 million proposed by the OSD, HQ Air Force directed ARDC to formulate a two-phase development approach for a 9,000 to 10,000-pound glider.[308]

By 1 November 1959, the Dyna-Soar office completed an abbreviated development plan to fulfill ARDC's 7 May 1959 System Requirement 201. Dyna-Soar would determine the military potential of a boost-glide weapon system and provide research data on hypersonic flight characteristics up to and including global flight. As suggested by the Office of the Secretary of Defense, the project office once again structured the program in a three-step approach. In Step I, a manned glider, ranging in weight from 6,570 to 9,410 pounds, would be propelled to suborbital velocities by a modified Titan booster. Step II encompassed manned orbital flight of the basic glider and interim military operations. A weapon system, founded on technology from the previous steps, comprised Step III.[309] The project office anticipated 19 air-drop tests, beginning in April 1962. The first of eight unmanned suborbital flights were to occur in July 1963. The first of eight piloted, suborbital launches would take place in May 1964. The WSPO scheduled the first manned global flight of Step II for August 1965. To accomplish this program, the project office estimated the development cost would total $623.6 million from FY 1960 though FY 1966. On 2 November, the Weapons

[308]Boushey, "Required Action."

[309]Directorate of Systems Management Det. 1, HQ Air Force, "Abbreviated Development Plan, System 464L" (Wright-Patterson AFB OH, 1 November 1959).

Board, HQ Air Force, approved the revised Dyna-Soar plan. The Air Council, HQ Air Force, sanctioned the three-step program and approved of the ARDC/AMC management and booster procurement arrangement.

With the Air Council's sanction, Generals Schriever and Anderson forwarded a joint ARDC and AMC letter to HQ Air Force on 4 November. After detailing the essentials of the program, the two commanders outlined their agreement on booster procurement. The Dyna-Soar WSPO would utilize the "experience" of BMD in obtaining a booster for Dyna-Soar. Additionally, the proposed program would make full use of the existing national booster program, essentially satisfying one of York's requirements. Concurrently, they would attain the Air Force's objective of global flight, essentially not satisfying York's other requirement. Generals Schriever and Anderson closed by urging the source selection process to be completed.[310]

Phase Alpha

Following this advice, the Secretary of the Air Force, on 9 November 1959, announced the Dyna-Soar contractors. The Boeing Airplane Company won the competition and was awarded the systems contract. The Martin Company, however, was named associate contractor with the responsibility for booster development.[311]

---

[310] S. E. Anderson, Commander AMC and Bernard A. Schriever, Lieutenant General, "Dyna-Soar Selection," Joint letter to HQ Air Force (Wright-Patterson AFB OH, 4 November 1959).

[311] Directorate of Systems Management, "Weekly Activity Report" (Wright-Patterson AFB OH, 13 November 1959); Directorate of Systems Management, TWX RDZSXB-31261-E (Wright-Patterson AFB OH, 13 November 1959).

Regardless of Charyk's concerns about competitiveness, the same two contractors gained portions of the Dyna-Soar program. Additionally, Martin would now be free to pursue an additional contract with the BMD for research on a proposed lifting-body recovery system for SAMOS.

By mid-November, all the agencies within the OSD seemed satisfied with the revised development plan and managerial procedures, including the military objectives outlined in Steps II and III. On 17 November, as the Secretary of Defense approved the transfer of SAMOS, MIDAS, and Discoverer to the Air Force, HQ Air Force directed the R&D command to implement Step I. It should also begin planning for Step II of the Dyna-Soar program.[312] Three days later, Charyk gave the Air Force authority to negotiate Step I contracts for FY 1960. However, there was an obstruction. The assistant secretary told the Deputy Chief of Staff, Development, that the OSD would need detailed financial plans and work statements before to obligating any funds for the Dyna-Soar program--now designated System 620A. No commitments could be made before the Office of Secretary of the Air Force and the DDR&E obtained a concise understanding of the direction of the project.[313] They did not trust the Air Force to keep Dyna-Soar solely as a research system. Also, the Air Force's newly reacquired managerial responsibilities for the development of the critically

---

[312] HQ Air Force, TWX to Commander, ARDC (Andrews AFB MD, 17 November, 1959).

[313] Dr. Joseph V. Charyk, Assistant Secretary of the Air Force, "D&F 50-11-284 Dyna-Soar Program," Memo to Deputy Chief of Staff, Development, HQ Air Force (Washington, D.C., 20 November, 1959).

important reconnaissance satellites resulted in conflicting decisions and indecisions among themselves, the CIA, and various agencies within the OSD. The offices of the Secretary of the Air Force and the Secretary of Defense, as well as PSAC officials, preferred to decrease overall system costs by using less complicated subsystems on the satellites. To gain at least one operational system quickly, they placed the highest priority on obtaining these simpler satellites, rather than support the Air Force's philosophy of concurrent development of all subsystem design levels.

Nor did they believe the medium L/D glider recommended by Boeing, and approved by the WSPO selection board, necessarily represented the best approach to the critical aerothermodynamic, structural, and materials problems so vital to the success of Dyna-Soar. Additionally, the changes and fund limitations imposed by Charyk's office, as a result of the completion of the competitive study and evaluation in June, needed to be considered. Given the chance, these officials believed that the Air Force would upset the administration's space-for-peace policy by making this highly publicized program a weapon system.

In an effort to obtain funds for FYs 1959 and 1960, Gen. Boushey and his staff met with Charyk on 24 November. Charyk made it clear that he would not release any funds for Dyna-Soar. Instead, he wanted to institute a "Phase Alpha" to examine the three-step approach, the proposed Titan I booster, the Dyna-Soar's size, and the program's flight test objectives. No funds would be obligated until the program office completed Phase Alpha. Furthermore, once the Air Force began to implement Dyna-Soar, the assistant secretary wanted to review the program step-by-step, releasing outer space, based on sound scientific and technological progress. The report declared that all space projects served national security needs. Indeed, the Soviets' recent achievements (orbiting a canine passenger, launching an interplanetary probe, and impacting the moon with a spacecraft) raised their international prestige even higher than their 4 October 1957 launch of *Sputnik*. While NASC still could not fully define the military significance of space, it seemed apparent that unmanned reconnaissance satellites would be needed to enforce whatever international agreements might eventually be reached to prevent a war in space. Until then, these reconnaissance satellites could prevent another *Sputnik*.

The committee's observations formed the backbone of NSC 5918/1, completed on 12 January 1960. The president signed it on 26 January. Although it strengthened the cause of a military space program by supporting the use of unmanned reconnaissance satellites, it still placed the strongest emphasis on the civilian program. Additionally, the report continued to support the administration's consistent downgrading of the majority of the military's space efforts. As long as Eisenhower could depend on secret U-2 flights for information on the closed Soviet society, or possibly the new SR-71 under development by Lockheed's "skunk works," the steady development of the military's unmanned reconnaissance satellites would be all he required of a military space program. These systems could yield critically strategic reconnaissance information on Soviet weapons development; in turn, the president would use this information to decide which weapons systems the nation needed to develop to counter the Soviets. Additionally, these satellites would reduce, if not eliminate, the need for U-2 flights.

In January 1960, the president and the NSC expressed the same view officially and explicitly, although not publicly. They acknowledged that the Soviet Union's recent "firsts" resulted in substantial and enduring gains in Soviet prestige.[317]

Meanwhile, as the Soviet Union gained increased international prestige with its unmanned satellites and ballistic reentry capsules, Khrushchev gave his approval for the development of V. M. Myasishchev's VKA-23 boost-glider. After three years of research, the Soviet Union would officially begin its hypersonic boost-glide program. Yet, like America's Dyna-Soar, critical problems of aerothermodynamics, structures, and materials would need to be solved before the final configuration would take shape or military subsystems could be tested. The glider's complex structure, coupled with the need to protect its pilot and other vital subsystems, necessitated extensive research. To help solve these problems, Myasishchev worked closely with S. P. Korolev's OKB-1 rocket bureau, responsible for the development of the *Vostok* series of manned spacecraft.[318]

---

[317] National Security Council, *NSC 5918/1*, U.S. Policy on Space (Washington, D.C.: NSC, 1960).

[318] V. M. Petrakov, "Two Projects of V. M. Myasishchev," *Journal of the British Interplanetary Society* 47, 9 (September 1994):350-51.

Establishing the Direction for Phase Alpha

Concurrently, in the United States, the Dyna-Soar WSPO began to institute Phase Alpha, appraising the Dyna-Soar approach to manned, orbital flight. Early in December 1959, the Aero and Space Panel of the SAB--chaired by Courtland D. Perkins, a Princeton University professor and chairman of the Aeronautical Engineering Department--offered some recommendations for Phase Alpha. The panel pointed to the inadequacy of technical knowledge in the areas of aerodynamics and structures. Consequently, it felt test programs to alleviate these deficiencies should be formulated. Concerning the entire program, the scientific advisory group strongly supported the methodology of Dyna-Soar's medium L/D ratio previously suggested by the selection board. While the program could be severely limited by the OSD through fiscal constraints and the absence of a high military priority for its approach to achieving the military objectives in Step II and III, the Aero and Space Vehicles Panel insisted Dyna-Soar was important. If properly directed, it could yield significant information in the broad research areas of hypersonic science and engineering.[319]

Charyk concurred with the overall assessment of the panel. In Phase Alpha, emphasis would be placed on the identification and solutions of technical problems. The objective of Step I would be the development of a test vehicle to solve these

---

[319] Aero and Space Vehicle Panel of the Scientific Advisory Board, "Dyna-Soar," Report of the Aero and Space Panel, SAB (Washington, D.C., January 1960).

problems rather than any consideration of its use as a weapon system. Based on this approach, Charyk authorized the release of an additional $2.5 million for the study.[320]

From 2-4 December 1959, the Aero and Space Vehicles Panel of the SAB and eleven consultants, mostly from industry, met at NASA's Ames Research Center to review Dyna-Soar. The panel knew of the many limiting factors affecting the Dyna-Soar program. For example, one ground rule stated that Dyna-Soar must be programmed to survive in an austere budgetary environment. Dyna-Soar should be considered an expensive program and must survive without a recognized high priority for the validity of its military objectives. The major motivating force would be the national desire to achieve a more sophisticated space capability, with manned military systems a strong possibility. It would be imperative for them not to consider the program as a crash, high-technical-risk gamble where all factors could be considered secondary to achieving an important military capability in the shortest amount of time. Instead they should consider the program reasonably poised, rather than critically poised, for development. The type of program where time could be taken to ensure the all the technical possibilities could be exploited, that is a civilian-scientific approach reminiscent of NASA's approach to space programs. Because Dyna-Soar would, in their opinion, develop into the most important space program in the country, great care

[320]Dr. Joseph V. Charyk, Assistant Secretary of the Air Force, "Dyna-Soar "Phase Alpha Program," Memo to Deputy Chief of Staff, Development, HQ Air Force (Washington, D.C., 4 January 1960).

should be taken to ensure that it was capable of developing technical information in the broadest research areas of science and engineering.

One important member of the panel was Alfred J. Eggers, who harbored a personal distaste for winged boost-gliders. As he saw the situation, the problem of placing sizable payloads in space would be exacerbated by having to cope with the added weight of wings, especially considering the marginal ability of the available boosters to lift such weights. Regarding the boost-glider's maneuverability during reentry, the lateral range, and conventional landing capabilities, Eggers suggested if the Air Force wanted these qualities then a medium L/D approach would provide them; but if the Air Force wanted the maximum possible payload in space, it should use a simple lightweight semiballistic reentry system. Eggers spread his philosophy effectively and pervasively, contributing to Charyk's decision to proceed with Phase Alpha.[321]

Those involved in the program, both from the Air Force and from NASA, believed that Eggers represented a major threat to the medium L/D ratio winged approach. Realizing his M-1 blunt half-cone reentry vehicle with a L/D ratio of $\sim 1/2$ would not likely find a sponsor in NASA because they had already selected Max Faget's ballistic shape for Mercury, Eggers proposed a more slender half-cone with a L/D ratio of ~ 1 known as the M-2. It could conceivably be landed as a glider. Eggers felt the M-2's greatest selling point was its "wingless, lifting-body" approach,

---

[321]Hallion, *The Hypersonic Revolution*, pp. 426-27.

even though it aerodynamically had to resemble Dyna-Soar to achieve an acceptable level of maneuverability at slow-speeds. Langley's John Becker, anticipating Eggers's M-2 proposal, built his presentation around two half-cone shapes. William E. Lamar from the WSPO presented the latest Dyna-Soar studies. Both Becker and Lamar knew from their low-speed testing that the winged glider approach would develop a L/D ratio as great as 5 during slow-speed landings. Thus the main virtue of Becker's the half-cones and Eggers's M-2 would be an increased payload volume, a useless feature for a Step I Dyna-Soar design because it contained more than enough fuselage volume for its anticipated research payload.[322] A military payload might be another matter, but Lamar believed the requisite subsystems could be made to fit.

Becker closed his presentation with a review of the impressive benefits achievable with a winged boost-glider in the medium L/D ratio range, reminding the SAB that the sophisticated performance of these vehicles involved only a nominal overall weight increment, on the order of one-third, over comparable ballistic systems. This modest increment would certainly be tolerable as booster capability advanced beyond the Atlas, the limiting factor in selecting the small ballistic capsule for

---

[322] Aero and Space Vehicle Panel of the Scientific Advisory Board, "Report of the Aero and Space Vehicle Panel of the SAB on Dyna-Soar" (Washington, D.C., 2-4 December 1959).

Mercury.[323] A large majority of the consultants agreed with Lamar and Becker: the medium L/D ratio would be the proper technological approach for Dyna-Soar.[324]

The panel held an executive session on 5 December 1959. Chairman Perkins opened by stating that Dyna-Soar could still easily be killed, but, because the Air Force wanted Dyna-Soar, the SAB should help retain it. To do so, the panel felt Phase Alpha should concentrate on a comprehensive program of aerodynamic model testing--considerably beyond the Boeing Company's proposal--to raise the confidence level. Indeed, Phase Alpha should not become an exercise in doing better with the existing information in an attempt to refine the current configuration and to modify the program's steps. Instead, primary emphasis should be placed on accomplishing the necessary aerodynamics and structures tests. This would generate the level of technical confidence to satisfy all the agencies within the OSD.[325]

After Charyk amended his 20 November directive to allow booster contracts with Boeing and Martin, the Air Force and Boeing signed a contract for the Phase Alpha study. Still, funding could not exceed the $1 million ceiling until Charyk approved the detailed financial and work statements from the WSPO. Regardless, the Air Force remained undecided as to whether contractors, or Air Force agencies, would provide Boeing with booster analysis. By the end of January 1960, the Dyna-Soar

---

[323]Hallion, *The Hypersonic Revolution*, p. 427.

[324]Aero and Space Vehicle Panel of the Scientific Advisory Board, "Report."

[325]Ibid.

office recommended that BMD and the Space Technology Laboratories (STL) provide the booster studies. Because Phase Alpha needed to be completed by March 1960, the project office did not think there would be sufficient time to complete a contract with Martin for a Phase Alpha booster study.[326] The Aeronautical Systems Center (ASC) objected. It believed the existing contracts with Boeing could not be extended to allow participation in the booster studies.[327] ARDC headquarters disagreed and resolved the issue on 3 February, the Ballistic Missiles Center (BMC), the AMC counterpart to the ARDC's BMD, would arrange contracts with STL and Martin. The ASC would extend the Boeing contract.[328]

The Wright Air Development Division and the New *AFM 1-2*

To improve the R&D of the newly reacquired reconnaissance systems from ARPA, the management of weapon system development transferred on 15 December 1959 from ARDC HQ to a restructured agency, the Wright Air Development Division (WADD) [formerly Wright Air Development Center (WADC)]. Concurrently, the Air Staff released the new *AFM 1-2,* the Air Force's doctrinal manual sanctioning its policy of an indivisible aerospace continuum. The Air Staff felt its new doctrinal statement

---

[326] Directorate of Systems Management, Weekly Activity Report (Wright-Patterson AFB OH, 18 December 1959); Directorate of Systems Management, Weekly Activity Report (Wright-Patterson AFB OH, 15 January 1960); WADD, "RDZSXB-30061-E," TWX to HQ ARDC (Wright-Patterson AFB OH, 20 January 1960).

[327] WADD, "RDZSXB-1-1420-E," TWX to HQ ARDC (Wright-Patterson AFB OH, 28 January 1960).

[328] Directorate of Systems Management, Weekly Activity Report (Wright-Patterson AFB OH, 5 February 1960).

epitomized the Air Force's space policy; space was viewed as a medium for performing the conventional roles and missions of the Air Force. Historically and logically its claims to the overall responsibility of space could be justified. The OSD generally agreed. Although prophecy could be dangerous in an age of technological change, the new doctrine also fit the Air Force's projected needs and capabilities for the decade of the 1960s. Nevertheless, in the first half of 1959 the Air Force could not claim the requisite space programs to justify its aspirations for space leadership. In late 1959, the Air Staff persuaded the OSD to reassign a few space programs and their missions back to the Air Force to fill the vacuum created in 1958 by their loss to ARPA and NASA. Ultimately, the Air Force pursued a slow course of action, accelerating development of specific hardware with the approval of ARPA and NASA. In doing so, it obtained official sanction from NASA and the Secretary of Defense for its management of these programs.[329] Conversely, when HQ Air Force could not persuade NASA officials or the OSD of the usefulness of a specific program, or when these same officials found fault with a specific program, its future was questioned. Dyna-Soar seemed to fall perilously close to the latter category throughout 1959.

Booster selection in Phase Alpha was only one of the booster problems. ARDC headquarters needed to settle the question of booster procurement for the entire Dyna-Soar program. Although they previously forwarded a joint letter outlining their

---

[329]Lee Bowen, *An Air Force History of Space Activities*, pp. 190-91.

agreement on booster procurement on 4 November 1959, Generals Schriever and Anderson had not reached a formal agreement.

Early in December 1959, General Schriever assigned technical responsibility for booster development to the BMD. Schriever hoped General Anderson also intended to delegate contractual authority to his BMC counterpart to BMD.[330] Anderson essentially agreed with Schriever's position, but he objected to any agreement made between the Dyna-Soar WSPO and BMD where the respective AMC elements did not participate. Consequently, the air material commander urged the two commands to complete a joint agreement concerning the development of the Dyna-Soar booster.[331]

While the question of booster development remained open, the Air Staff issued further guidance for Phase Alpha. In the middle of January 1960, Brig. Gen. Boushey, Assistant for Advanced Technology, HQ Air Force, gave more specific instructions concerning the direction of the Phase Alpha study. The review would examine selected hypersonic configurations for controlled manned reentry to determine the technical risks involved, and to define a test program for Step I that facilitated the release of development funding. Additionally, configurations would be evaluated on the basis of cost, development planning, scheduling, technical risk, and the future value of the

---

[330] Lieutenant General Bernard A. Schriever,"Management of Dyna-Soar Project"; HQ ARDC, "Statement of Agreement, System 620A, Dyna-Soar I for the Air Force Ballistic Missile Division, ARDC," Memo to HQ BMD (Wright-Patterson AFB OH, 1959).

[331] S. E. Anderson, Commander AMC, "Management of the Dyna-Soar Program," Letter to Lieutenant B. A. Schriever, ARDC Commander (Los Angeles CA, 11 December 1959).

results to be obtained from the configuration.[332] Further ground rules for the study included a "once-around" global capability for the test vehicle to provide growth after the initial flights with the Titan I booster at suborbital velocities. All the vehicles would be required to have the same 1,000 pounds of payload, 75 cubic feet of volume for equipment, subsystems, one crew member, and a reusability of four flights. To a certain extent this did not mirror the Aero and Space Panel's recommendations. The inclusion of orbital capability, four-flight reusability, and piloted landing restrictions, reflected an operational rather than research agenda. In order to evaluate the efforts of Boeing, Martin, BMD, and the space laboratories, Colonel W. R. Grohs, vice-commander of WADD, directed the formation of an ad hoc committee.[333]

In February, the WADD ad hoc committee, with representation from the Air Force Flight Test Center, the Air Force Missile Test Center, the AMC, and the NASA, began to determine the kind of research vehicle the Air Force would require to solve the problems of hypersonic manned reentry from orbit. Concurrently, the ad hoc committee contracted with several companies, placed under the direction of Boeing, to investigate the potentialities of several categories of configurations. The committee considered variable geometric shapes (such as the drag brake of the AVCO Manufacturing Corporation), a folding wing glider (Lockheed Aircraft), and an inflatable device (Goodyear Aircraft). Additionally, it analyzed ballistic shapes (such

---

[332]Brigadier General Homer A. Boushey, Letter to HQ ARDC (Andrews AFB MD, 15 January 1960).

[333]Clarence J. Geiger, *History of the X-20 Dyna-Soar*, pp. 58-59.

as a modified Mercury Capsule from McDonnell) and lifting-body configurations (offered by members of the ad hoc committee and General Electric). Finally, Bell, Boeing, and Chance Vought offered gliders with varying lift-to-drag ratios.

After examining these various configurations, the ad hoc committee concluded that the development and fabrication of a ballistic shape or a lifting-body configuration with a L/D ratio up to 0.5 would only duplicate the findings of NASA's Mercury program. Conversely, a glider with a high L/D ratio of 3 would not only provide a maximum amount of information on reentry but would also demonstrate the greatest maneuverability in the atmosphere, allowing the widest selection of landing sites. Such a glider, however, presented the greatest technical risk in design. Consequently, the ad hoc committee decided that the previously investigated medium L/D glider configuration, with a L/D ratio in the range of 1.5 to 2.5, offered the most feasible approach for advancing knowledge of hypersonic reentry problems.[334]

On 8 February 1960, Schriever and Anderson reached an understanding detailing the position of their West Coast complexes in the Dyna-Soar program. While management and financial authority for the entire program rested in the Dyna-Soar WSPO, the BMD and BMC, with the approval of the system office, would define the statements of work and complete contractual arrangements for the booster development. However, all changes in the booster program significantly altering

---

[334]Geiger, *History of the X-20 Dyna-Soar,* p. 59; Lamar, "History of Dyna-Soar."

performance, configuration, cost, or schedules would necessitate the approval of the project office.[335]

This became a vital element in future struggles between BMD and the Dyna-Soar WSPO over booster modifications. Ironically, the Dyna-Soar WSPO lost most of these struggles, despite subsequent agreements. Delays in Dyna-Soar's development resulted as the WSPO adjusted to meet the inflexibility of BMD.

Another Panel Review

At the end of March 1960, the Aero and Space Vehicles Panel, SAB, again reviewed the Dyna-Soar program and the results of the Alpha study. If orbiting the greatest amount of weight in the shortest development time were the overriding requirement, the panel reasoned the modified ballistic approach would be preferable. The members believed, however, that the glider configuration would vastly increase the technical knowledge of materials and structures. Additionally, the glider provided the greatest operational flexibility. The panel emphasized further the importance of attaining early orbital flight. Consequently, it suggested a reexamination of the need for a suborbital Step I and more precise planning for the orbital Step II.[336]

---

[335]S. E. Anderson, Commander AMC, "AMC and ARDC Management Procedures for the Dyna-Soar Program," Memo to Lieutenant General B. A. Schriever, ARDC Commander (Los Angeles CA, 8 February 1960).

[336] Aero and Space Vehicle Panel of the Scientific Advisory Board, "Dyna-Soar and Phase Alpha Review," Report of the Aero and Space Vehicles Panel, SAB (Washington, D.C., 15 April 1960).

The Aero and Space Vehicles Panel also emphasized the difficulty in predicting the behavior of structures using coated heat shields. It recommended Dyna-Soar participation in ARDC's Blue Scout (609A) sounding rocket program. The system office agreed. It decided to place full-scale sections of the glider nose on four of the rocket's hypersonic flights.[337] Although subsequent planning reduced the number to two flights, HQ ARDC refused to release funds for even these tests. Consequently, Colonel Moore terminated Dyna-Soar flight tests on the Blue Scout on 5 October 1960. The project director gave several reasons for this decision: low probability of obtaining sufficient data with only two flights, insufficient velocity of the Scout boosters, and the high cost for Dyna-Soar participation.[338]

As the Aero and Space Vehicles Panel gave their vote of confidence regarding Dyna-Soar's configuration, details for the glider's construction began to take shape. As conceived by the Phase Alpha committee, the glider would be a low-wing, delta-shaped vehicle, weighing about 10,000 pounds. For several reasons the committee selected a radiant rather than ablative approach to protecting the glider from the heat of reentry. Research showed that an ablative surface burned away unevenly as it reentered the atmosphere. Uneven decay would affect the glider's flight control as it attempted to maneuver within the atmosphere. Additionally, the need to keep

---

[337]William E. Lamar, Chairman, "Conference at NASA Regarding RVX-2 Test for Dyna-Soar," Memo (Wright-Patterson AFB OH, 1961).

[338]Colonel William L. Moore, Chairman, "Dyna-Soar HETS Program," Letter to HQ ARDC (Wright-Patterson AFB OH, 5 October 1960).

operational costs as low as possible by requiring four flights between refurbishing eliminated an ablative surface because the material would need to be replaced after each flight. To undergo the extreme heat of reentry, the internal framework would be composed of braces made of René 41, a nickel superalloy original designed to cope with the heat and strength requirements of jet engines. This metal could withstand a temperature of 1,800 degrees Fahrenheit. The upper surface of the glider would be fabricated of René 41 panels. The lower surface would be a heat shield, designed for a maximum temperature of 2,700 degrees. It would consist of metal sheets made of molybdenum attached to insulated Rene' 41 panels. Because the leading edges of the wings would have to withstand similar heat conditions, they would be composed of coated molybdenum segments. The severest temperature, ranging from 3,600 to 4,300 degrees Fahrenheit would be endured by the nose cap. It would be constructed of graphite with 13 zirconia rods.[339]

Meanwhile, in the Soviet Union, from March through September 1960, V. M. Myasishchev further refined the VKA-23 boost-glider. As a result of various program studies, the preliminary appearance and fundamental characteristic of the Soviet boost-glider stabilized. It would use thermal tiles, similar to what would later be used on the Soviet space shuttle Buran and on America's space shuttles, to protect the wing profiles. To seal the ends of the tiles, they filled the gaps with quartz wadding,

---

[339]Directorate of Systems Management Dyna-Soar WSPO, WADD, "System Development Plan, Dyna-Soar (Step I) Program, 620A" (Wright-Patterson AFB OH, 1 April 1960).

impregnated with silicone resin. For the greatest stress zones, an ultra-lightweight ceramic foam would be used. As before, OKB-23 engineers went to OKB-1 to discuss various test results and to analyze possible subsystem components.[340]

A New Development Plan

As boost-glider research in the Soviet Union paralleled Dyna-Soar research, the Dyna-Soar WSPO, in conjunction with the WADD ad hoc committee, completed a new development plan further elaborating the three-step program presented in the November 1959 development plan. Step I would achieve four objectives: explore the maximum heating regions of the flight regime, investigate maneuverability during re-entry, demonstrate conventional landing, and evaluate the ability of man to function during hypersonic flight. While Step I would be limited to suborbital flight, the purpose of Step IIA would be to gather data on orbital velocities. Additionally, it would test military subsystems, such as high-resolution radar, photographic and infrared sensors, advanced bombing and navigation systems, advanced flight data systems, air-to-surface missiles, rendezvous equipment, and the requisite guidance and control subsystems military hardware. While Step IIB would provide an interim military system capable of operational reconnaissance and satellite inspection missions, the objective of Step III would be a fully operational weapon system.

Mirroring the concerns of York and Charyk, the Dyna-Soar WSPO only outlined the last two steps. The first consideration of the project office would be the

[340]Petrakov, "Two Projects," pp. 352-53.

suborbital Step I. In order to demonstrate the flying characteristics of the glider up to speeds of Mach 2, the WSPO scheduled a program of 20 air-drop tests from a B-52 to begin in July 1963. Beginning in November 1963, five unmanned flights with another glider would be conducted to Mayaguana in the Bahamas Islands and to Fortaleza, Brazil. For these flights, the glider would attain velocities ranging from 9,000 to 19,000 feet per second. Eleven piloted flights, scheduled to start in November 1964, would follow, progressively increasing the velocity to the maximum 19,000 feet per second. They would employ landing sites in Mayaguana, Santa Lucia in the Leeward Islands, and finally, near Fortaleza.

To accomplish this Step I program, the Dyna-Soar office estimated $74.9 million would be required for FY 1961, $150.9 million for 1962, $124.7 million for 1963, $73.6 million for 1964, $46.8 million for 1965, and $9.9 million for 1966. Including $12.8 million for 1960, these figures totaled $493.6 million for the suborbital program.[341] Comparatively, NASA spent $91.6 million in 1961 for Project Mercury, $55.4 million in 1962 and $12 million in 1963. The total for Project Gemini, the two-man follow-on to Mercury, was $55 million in 1962, $287.6 million in 1963, $419.2 million in 1964, $308.3 million in 1965, and $163.5 million in 1966.[342]

During the first week in April 1960, officials of the Dyna-Soar project office presented the new development plan and the results of Phase Alpha to Generals

---

[341]Dyna-Soar WSPO, "System Development Plan."

[342]Jane Van Nimmen, Leonard C. Bruno, and Robert L. Rosholt, *NASA Historical Data Book, Volume I* (Washington D.C.: NASA, 1988), pp. 148, 156.

Schriever, Anderson, and Boushey, and to the Strategic Air Panel and the Weapons Board, HQ Air Force. On 8 April, Dyna-Soar representatives explained the program to the Assistant Secretary of the Air Force for R&D, C. D. Perkins. The representatives received his approval to begin work on the suborbital Step I.[343] Shortly afterwards, the Assistant Secretary of the Air Force, Material, P. B. Taylor authorized negotiations of FY 1961 contracts for this suborbital phase of the program to include R&D, plus design and fabrication of a military test system. On 22 April, DOD endorsed the new program, permitting the release of $16.2 million of FY 1960 funds.[344] At last all the agencies within the OSD seemed confident in the technological approach and were willing to provide fiscal support for the Dyna-Soar WSPO's efforts. When York approved the 19 April request, he repeated his program guidance from 13 April 1959. Secondary objectives of orbital flight and testing military subsystems could only be initiated if they did not infringe on the primary objective of developing a hypersonic manned, suborbital, maneuverable vehicle capable of controlled landings. While studies for military subsystems could proceed, research must come before any military hardware development. Indeed, York remained unconvinced of any military necessity for Dyna-Soar. The SAC did not agree. It stressed its operational requirement for the capability to return a man from space to a predetermined ground

---

[343] Directorate of Systems Management, Weekly Activity Report (Wright-Patterson AFB OH, 8 April, 1960); Directorate of Systems Management, Weekly Activity Report (Wright-Patterson AFB OH, 16 April, 1960).

[344] HQ Air Force, "AFDAT-89082," TWX to HQ ARDC (Andrews AFB MD, 26 April, 1960).

base. To meet or exceed similar Soviet capabilities, SAC believed the system would need to be ready by 1970. While the struggle over a hypersonic weapon system continued, the requisite contractors for Step I were selected.

Getting A "Go"

By 24 April, Charyk approved contractual arrangements for the entire Step I program rather than for particular fiscal years. Consequently, the Air Force completed a contract with Boeing as system contractor. By 8 June 1960, the Martin Company received responsibility for the booster airframe. A day later, BMD made arrangements with the Aerospace Corporation to provide technical assistance for the Step I program. Meanwhile, on 27 June, the Air Force authorized the Aero-Jet General Corporation to develop the booster engines. By 6 December 1960, the Air Force had granted authority to the Minneapolis-Honeywell Regulator Company for the primary guidance subsystem. Ten days later the Air Force gave responsibility to the Radio Corporation of America for the communication and data link subsystem. Dyna-Soar development-- at least Step I-- was finally on its way.

As American contractors began work on Dyna-Soar, Soviet engineers conducted their own "Phase Alpha" study of V. M. Myasishchev's VKA-23 design. On 8 April 1960, a prominent OKB aviation engineering specialist met with of OKB-23 representatives to examine the boost-glider's design methodology and the direction of the program. They considered a number of alternative reentry methods: helicopter recovery, retractable wings, liquid metal for cooling, and a return to ballistic shapes. Ultimately, they could not agree on the best method. OKB-23 believed this impasse presented a disturbing situation because America's development of Dyna-Soar and the high priority of boost-glider research in the Soviet Union demanded a decision. While arguments on the form and type of VKA-23 continued, they did agree on the first stage booster. OKB-23 would use an existing Korolev booster for the first suborbital phase of the VKA-23's development program and develop another for the second orbital phase.[345] As Soviet engineers continued to discuss the merits of Myasishchev's design, America's ability to continue "seeing" into the closed Soviet society through the "eyes" of manned U-2 reconnaissance flights ended. America would be "blind" until Discoverer 14 returned its photographs on 18 August 1960.

The U-2 Shootdown

On 1 May 1960, the Soviets shot down Francis Gary Powers's U-2 spyplane. The loss of the aircraft and the capture of its pilot meant the United States would cease to overfly the Soviet Union, depriving the CIA and other members of the intelligence community of a means of obtaining photographic evidence of Soviet strategic military developments.[346] Three weeks after the U-2 incident the next generation of technological spy equipment--passive early warning satellites--made its first successful appearance with the launch of a MIDAS (Missile Defense Alarm System) satellite--

---

[345]Petrakov, "Two Projects," pp. 351-52.

[346]George B. Kistiakowsky, *A Scientist at the White House: The Private Diary of President Eisenhower's Special Assistant for Science and Technology* (Cambridge MA: Harvard University Press, 1976), p. 245.

MIDAS 2. If the Soviets launched a missile we could "see" its infrared signature, America's vision was improving but the administration was still blind.

By 26 May the need for intelligence information, coupled with the continuing technical difficulties of the Discoverer (CIA code name CORONA) and SAMOS programs, forced the administration to act.[347] Simultaneously, the internecine warfare between the Air Force and the CIA over control of the nation's space reconnaissance assets and the power they represented created an additional incentive for action. These resources would soon be the glamorous centerpieces of a national intelligence collection system.[348]

On 10 June 1960, Eisenhower directed Secretary of Defense Thomas S. Gates, Jr., who succeeded McElroy on 2 December 1959, and George B. Kistiakowsky, the Harvard chemist and Los Alamos veteran who had succeeded Killian as the president's science advisor, to study the Air Force-managed and CIA-supported reconnaissance satellite programs. Gates appointed a panel of three: Under Secretary of the Air Force, Joseph Charyk, Deputy DDR&E, John H. Rubel, and Kistiakowsky.[349] The most obvious target of the panel's scrutiny would be Boushey's Directorate of Advanced Technology, responsible for the coordination of satellite development for the Air Force chief of staff. The panel believed the problem lay with managerial rather

---

[347]Richelson, *America's Secret Eyes in Space*, p. 44.

[348]Burrows, *Deep Black*, p. 203.

[349]Carl Berger, *The Air Force in Space Fiscal Year 1961* (USAF Historical Liaison Division Office: Office of Air Force History, 1966), p. 34.

than hardware difficulties. The remedy would be equally apparent. The nation needed a new central agency to oversee the development of space reconnaissance systems after independently identifying the specific tasks each satellite needed to accomplish and matching these tasks with technologically feasible solutions.[350]

System Development Requirement 19

While the special presidential panel formulated a development strategy for the nation's reconnaissance satellite assets, HQ Air Force further recognized the three step program by issuing System Development Requirement 19 on 21 July 1960. With the stepped approach, the Air Force would develop a manned glider capable of demonstrating orbital flight at an altitude of 80 nautical miles, maneuverability during hypersonic glide, and controlled landings on a 10,000-foot runway. Furthermore, Dyna-Soar was to lead to a military system capable of space maneuver, rendezvous, reconnaissance, and satellite inspection. Headquarters looked forward to the first manned, suborbital launch, which was to occur in 1964.[351]

While DOD approved and funded the Step I program, the Dyna-Soar project office firmly believed studies for the advanced phases of the program should concurrently be initiated, as authorized by the Assistant Secretary of the Air Force, Material, Taylor. How else could they prove the utility of manned military space operations? In early August 1960, the project office asked HQ ARDC to release $2.32

[350]Burrows, *Deep Black*. p. 204.

[351] HQ Air Force, "System Development Requirement 19" (Andrews AFB MD, 21 July 1960).

million through FY 1962 for this purpose. If it released these funds immediately, the project office anticipated completion of preliminary program plans for Steps IIA, IIB, and III by December 1961, January 1962, and June 1962, respectively.[352] Later in the month, the Dyna-Soar office again reminded HQ ARDC of the urgency in releasing these funds.[353] While awaiting approval to begin military test system studies, the proponents of lifting-body research found new support from within the reconnaissance satellite community.

On 8 August 1960, AMC's BMC sent out a request for proposal (RFP) for both ballistic and maneuverable lifting-body reentry vehicles for their highly classified SAMOS missions. Twelve failed attempts to recover the Discoverer data capsules prompted DDR&E to look for an alternative means of recovery. The Martin Company, which recently lost the glider competition of the Dyna-Soar program to Boeing, responded by submitting a response on 12 October 1960. By 14 November, the Air Force awarded a contract to Martin for Project 726, a lifting-body reentry vehicle based on Alfred Eggers's M-1 configuration, one of his proposals for the Dyna-Soar Phase Alpha study (the M-2B was the second). With a diameter of 102 inches and an ablative heat shield, the M-1 design used a 13-degree blunt half-cone shape, flown flat side up. It could maneuver during reentry by deflecting the flaps attached to the

---

[352]Directorate of Systems Management WSPO, WADD, "Dyna-Soar Step II and Step II Funding" (Wright-Patterson AFB OH, 2 August 1960).

[353]Directorate of Systems Management WSPO, WADD, "WWZRM-8-1041-E," TWX to HQ ARDC (Wright-Patterson AFB OH, 23 August 1960).

body, trailing aft. This configuration offered a hypersonic L/D ratio of 0.5 and a reentry cross-range of up to 170 miles from the orbit plane. With virtually no subsonic L/D ratio, the M-1 could not land horizontally.[354]

Eggers and his associates at NASA's Ames were stirring a growing nationwide interest in the potential of lifting-body reentry vehicles, as opposed to the boost-glider approach of Dyna-Soar. As Project Mercury began to reach the hardware stage in 1960, many optimistic aerodynamicists looked beyond even the Gemini spacecraft to an even more advanced spacecraft design. The lifting-body concept offered a third alternative.[355]

While the contract included full-scale flight testing, it did not include operational missions. To ensure its compatibility for operational missions, Martin would use a simulated camera for the original camera equipment. The design would incorporate space for data packages of various shapes.

As Martin considered new reentry designs for SAMOS, on 10 August 1960 Discoverer 13 achieved seventeen orbits and a successful splashdown in the Pacific Ocean. The new technology delivered results and many believed that the Soviets would now attempt to eliminate these vital assets.[356] This fostered renewed action

---

[354]Captain John Vitelli, *The Start Program and The SV-5 Configuration* (Los Angeles CA: Satellite and Missile Systems Office, Office of Information, Historical Division [hereafter cited as SAMSO/HD], 1967), pp. xiii-1; Martin Company, "Martin Program Plan," Program 202 (Los Angeles CA, September, 1961), p. 1.

[355]Vitelli, *The Start Program*, p. 1.

[356]Stares, *The Militarization of Space*, pp. 53-55.

among the services for an antisatellite (ASAT) capability and fueled political campfires for the upcoming presidential race.

Birth of the National Reconnaissance Office

On 25 August 1960, George Kistiakowsky met with Eisenhower to show him some new intelligence information from Discoverer 14 and remind him about the SAMOS situation. During this special NSC meeting, the two discussed the capabilities, organization, and processing of space-based reconnaissance assets. Ultimately, they made a key decision eliminating previous managerial and hardware uncertainties. This signaled the start of the highest priority project since the Manhattan Project of World War II and the postwar Atlas efforts.[357]

The main result of this meeting was the creation of the highly classified National Reconnaissance Office (NRO), a national-level organization whose photographic assets would not be controlled by the Air Force, the CIA, or any other single agency. Still the Air Force would retain a considerable role, albeit at the civilian secretarial level. It provided the organization with its first director, Dr. Charyk, and its supporting staff. Charyk would maintain his position as Under Secretary of the Air Force. Indeed, Charyk became the first in a series of Air Force officials who wore the "black hat."[358] To provide cover for NRO, an Office of Missile

---

[357]Berger, *The Air Force in Space Fiscal Year 1961*, p. 35.

[358]Kistiakowsky, *Scientist*, pp. 382-84; Berger, *The Air Force in Space Fiscal Year 1961*, pp. 34-35; Burrows, *Deep Black*, p. 206; Richelson, *America's Secret Spies,* pp. 46-47.

and Satellite Systems within the Secretary of the Air Force was established by 31 August. No intermediate review or approval channel would exist between a program manager's field office to the Secretary of the Air Force. SAC or any other Air Force major command would not, in any way, be involved. Additionally, briefings would be given on a strictly "need-to-know" basis (for the Air Staff and other Air Force representatives) as required for SAMOS support (and other subsequent reconnaissance resources) support, or in the coordination of related matters.[359] The vital importance of this office to national security, the power and prestige the Eisenhower administration (and subsequent administrations) placed in this office, and the singular relationship this office entertained with industry, made every competing program, such as Dyna-Soar, or any other highly visible manned military space operation, an easy target for funding cuts. The highly classified nature of the NRO and its valuable assets meant the OSD would consistently require little, if any, justification to restrict funding to programs competing for the same missions as the operational assets of the NRO. Dyna-Soar was no exception.

The apparent source of delay for the authority to negotiate Steps II and III military study contracts, issued by Assistant Secretary Taylor on 19 April 1960, stemmed from a specific reference to Step I of the program. Colonel E. A. Kiessling, Director of Aeronautical Systems in HQ ARDC, met with Professor Perkins on 22 and 23 September. The assistant secretary agreed with their assessment. This reference to

---

[359]Berger, *The Air Force in Space Fiscal Year 1961*, p. 42; Richelson, *America's Secret Spies*, p. 49.

Step I did not prohibit Steps II and III studies. Exploratory studies and planning for Steps II and III could proceed. The restraint only applied to the expenditure of FY 1961 funds for the purchase of operational equipment for the advanced phases. HQ Air Force confirmed this decision on 12 October when they approved Steps II and III studies by issuing Development Directive 411.[360] By 6 December, HQ ARDC had issued a system directive for Step III, allotting $250,000 for this work. By the middle of 1961, however, events would make the three-step approach questionable. Consequently, the Air Staff would postpone the Step III investigation and, early in 1962, would cancel the study.[361] As the NRO began to routinely provide critical intelligence information to the administration, the political and operational strength of the NRO grew proportionately stronger.

The 1960 Presidential Campaign

In October 1960, Khrushchev told Myasishchev's OKB-23 to participate in the design of a multistage military rocket booster for V. N. Chelomey's OKB-52. When Myasishchev told Chelomey it would be impossible to complete the design of the first stage, because Chelomey failed to coordinate the work of the various bureaus working for him, Chelomey became angry. After the meeting, Khrushchev notified

[360] HQ Air Force, "Development Directive 411" (Andrews AFB MD, 12 October 1960).

[361] HQ Air Force, "AFDAP-78950," TWX to HQ AFSC (Andrews AFB MD, 16 June, 1961); HQ AFSC, "SCLDA-8-1-2-E," TWX to HQ ASD (Wright-Patterson AFB OH, 8 January 1962).

Myasishchev that OKB-23 would become branch number 1 of OKB-52.[362] Khrushchev did not appreciate Myasishchev's retort to one of Khrushchev's favorites.

Khrushchev--like Stalin in 1953--eventually abandoned the promise of boost-glider technology as a follow-on to manned strategic jet bomber systems or as a means of space-based reconnaissance. For political and propaganda reasons, Khrushchev agreed to a less technologically demanding solution to the problem of placing the first man into orbit. He agreed to the ballistic configuration of the *Vostok* over the more expensive and time consuming configurations of Korolev/Tsybin's Sandal and the VKA-23. OKB-256, like OKB-23, would be absorbed into another bureau, OKB-1. Chief designer Tsybin would become Korolev's deputy designer, making considerable contributions to a modified *Vostok* spacecraft, the *Soyuz, Soyuz T,* and numerous unmanned spacecraft. V. K. Myasishchev would become the head of TsAGI, the Central Aerohydrodynamics Institute.[363] No one outside the Soviet Union knew it canceled its boost-glide efforts in favor of a ballistic approach. Nor could American intelligence experts agree on the nature of many of Khrushchev's space exploits. Which were only for show and how many represented threats?

Not surprisingly, Soviet space achievements since *Sputnik* became a central issue in the 1960 presidential campaign. In his campaign for the presidency, Senator

---

[362]Petrakov, "Two Projects," p. 355.

[363]Valentin Bobkov, "Unknown Spacecraft," in *History of the Soviet Space Program*, in *What's New in Life, Science, and Technology: Space Program and Astronomy Series*, ed. I. B. Afanasyev (Moscow: JRPS-USP-92-003, 13 December, 1991), pp. 48-49.

Kennedy ticked off one Soviet achievement after another to support his contentions of inactivity and complacency by the Republican administration. Eisenhower and his party could be blamed for losing the space race with the Soviets.[364] To Kennedy, *Sputnik I* made the Cold War a "total war" by attacking the domestic tranquility of Americans. It signaled imminent strategic parity for the Soviets and a new credibility for Soviet propaganda, especially in the "Third World." These blows to American prestige helped unite Democratic Cold Warriors and social liberals beneath the banner of vastly increased federal activity in all areas, not just to close the missile gap but to construct an American society to match its preferred image of affluence and justice.[365] While Eisenhower kept America at peace for eight years, he sacrificed all his major goals on the altar of an ambitious Kennedy/Johnson ticket. Ultimately, his concerns about the compromises of increased technology fell on deaf ears as the Kennedy administration embraced a new technological order and its intellectual elite.[366]

As this new order gained prominence, individuals with the academic background to analyze national defense issues made significant contributions to Kennedy's campaign and presidency. Taking the opportunity offered by the defense debates, his campaign strategists made the "missile gap," a sagging defense posture,

---

[364]Senator John F. Kennedy, *Missiles and Rockets*, 10 October 1960, p. 10.

[365]Fred Kaplan, *The Wizards of Armageddon* (New York: Simon and Schuster, 1983), p. 248; Allen Nevins, *Kennedy, The Strategy for Peace* (New York: New York Publishing, 1960), p. 34-35.

[366]McDougall, *The Heavens and the Earth*, Chapters 17 and 22.

and eight years of a seemingly complacent Republican administration the dominant campaign issues. With the aid of these intellectuals, Kennedy embraced the missile gap phenomenon, aligning himself with the advocates who championed increased military expenditures.[367] From his articles and speeches, Kennedy seemed familiar with the issues. He opposed massive retaliation, favored the build-up of "limited war" forces, recognized the dangers of SAC's vulnerability and lamented the accompanying missile gap. Indeed, the defense community felt vindicated by Kennedy's pronouncements. With renewed hopes, they looked forward to a Kennedy administration.[368] After the election, the intellectuals who helped Kennedy become president found themselves in a position to influence defense policy directly through the new Secretary of Defense, Robert S. McNamara, and through many of Eisenhower's defense advisors who remained with the Kennedy administration.

During World War II McNamara worked in the Statistical Control Office of the Army Air Forces. Although it was not a combat role, it was an important support role. He figured out the logistical requirements and schedules for the Eighth Air Force, calculating how to mesh the right number of men with the right amount and types of equipment at the right time.[369] After the war, McNamara and nine others from the

---

[367]Kaplan, *The Wizards,* p. 248.

[368]Ibid., pp. 251-55.

[369]Robert S. McNamara, *In Retrospect* (New York: Random House, 1995), pp.4-27; Deborah Shapley, *Promise and Power: The Life and Times of Robert McNamara* (Boston: Little, Brown, and Company, 1993), pp. 20-75.

Statistical Control Office sold themselves as a consulting group to a manufacturing firm. Ford Motor Company hired these "whiz kids" as a team to turn its manufacturing practices around. McNamara became the central figure. He believed he could tackle any situation more quickly and proficiently than the traditional "experts," whether they constituted auto executives or Air Force generals. McNamara approached problems brusquely, determined to keep emotional influences out of the "inputs" and "cognitive" processes that made up his judgments and decisions.[370] All the whiz kids who came with McNamara to the White House angered the military with their young, book-smart, Ivy League, think-tank attitudes. They compared Air Force bombers and ICBMs to Navy submarines and SLBMs, attempting to optimize a master equation of cost-benefits and cost-effectiveness for thermonuclear war. Lacking an extensive military background or any combat-hardened experience on which to base his decisions, McNamara used what he knew best--statistical analysis--as the foundation for his decisions. McNamara's whiz kids, only weeks into their occupancy of the Pentagon, started attacking the Air Force's strategic missile and bomber projects in favor of the Navy Polaris submarines and the Army's conventional forces.[371] The whiz kids knew of their low popularity among military officers and relished their reputations, seeking battle with the Joint Chiefs of Staff whenever they considered it appropriate. What was important to the whiz kids was getting an answer quickly, then

---

[370]Shapely, *Promise and Power*, pp. 163-247.

[371]Ibid., pp. 77-112; ; McNamara, *In Retrospect*, pp. 4-27; Kaplan, *The Wizards*, p. 257.

moving on without wasting any more precious time on the subject.[372] Such a management style definitely affected Dyna-Soar.

Considering a New Booster for Dyna-Soar Step I

In the April 1960 development plan, the Dyna-Soar office proposed the employment of Titan I as the Step I booster. The first stage of this system used the LRS7-AJ-3 engine. It could develop 300,000 pounds of thrust; while the second stage, an LR91-AJ-3 engine, could produce 80,000 pounds of thrust. This booster would be able to propel the 10,000-pound Dyna-Soar to a velocity of 19,000 feet per second on a suborbital flight from Cape Canaveral to Fortaleza, Brazil. Yet the Titan I's reliability rate, 60 percent in the first ten flights, had not been good. Assistant Secretary Perkins considered this booster marginal for Step I flights. On 28 November 1960, he asked the Air Force to examine the feasibility of employing Titan II for Step I. Afterwards, a combination Titan II first stage and a Centaur-derivative upper stage might work well for the Step II and III.[373] The Titan II was a two-stage liquid rocket and, unlike the Titan I, employed hypergolic storable propellants. The first stage consisted of an XLE87-AJ-5 engine, capable of producing 430,000 pounds of thrust, while the second stage consisted of an XLR91-AJ-5 unit, capable of delivering 100,000 pounds of thrust.

---

[372]Gerald M. Steinberg, *Satellite Reconnaissance: The Role of Informal Bargaining* (New York: Praeger Press, 1983), pp. 25-28; Shapley, *Promise and Power,* pp. 203-24.

[373] HQ Air Force, "AFDSD-66668," TWX to HQ ARDC (Andrews AFB MD, 5 December 1960).

Late in December 1960, Mr. R. C. Johnston of the Dyna-Soar office and Major G. S. Halvorsen of BMD presented the advantages of Titan II to HQ ARDC. The proposal received the endorsement of Gen. Schriever. A presentation to HQ Air Force followed. Perkins appeared satisfied with the recommendation but stated DOD approval would probably not be given unless the Air Force could couple a booster change with an anticipated funding level of $70 million for FY 1962, instead of the requested $150 million.[374]

Conclusion

Within weeks after his narrow victory, President-elect Kennedy appointed Dr. Jerome Wiesner of MIT to head a special nine-man ad hoc committee to review the nation's space program. Wiesner had been one of the members of Killian's original PSAC and a close associate of both Killian and Kistiakowsky, Killian's successor. As these scientific advisors of Eisenhower stayed on with the Kennedy administration, the term "missile gap" soon disappeared from the administration's lexicon. The continuing flow of intelligence information provided by the NRO's operational reconnaissance satellites confirmed that the Soviets did not seem to be translating their lead in ICBM development into a corresponding lead in missile deployment. Another twist in the election rhetoric then followed. Despite the common expectations of many both in and out of Air Force circles, the changeover in administrations reflected continuity and consolidation in the scientific, technical, and defense oriented agencies. Many of the

---

[374]R. C. Johnston, Chairman, "Trip Report to HQ Air Force" (Wright-Patterson AFB OH, 9-11 January 1961).

same people who played the principal roles in formulating the defense policies under Eisenhower continued to do so in the new Kennedy administration.

McNamara invited all five of the R&D officials at the presidential-appointee level to stay. Four of them did: York, Charyk, Dr. James Wakelin, Jr., Assistant Secretary for the Navy, R&D, and Richard S. Morse, Director of R&D for the Army. By 1 May, York had been replaced by his good friend, Dr. Harold Brown, maintaining the mental, if not physical continuity.[375]

Much the same would occur in the White House science positions. Wiesner became Kennedy's Special Assistant for Science and Technology. PSAC membership remained the same except for a very few of its seventeen members. Wiesner became chairman. When Kennedy created a new agency, the Office of Science and Technology, Wiesner became its director. Some of Eisenhower's special assistant staff became members of this new agency. Because of this continuity of people and ideology, no revolutionary changes in strategic weapons development programs occurred.

York's position that DOD had no interest in spaceflight and exploration as ends in themselves but rather in the application of flight into space to the defense of the United States and its allies carried over into the Kennedy administration. DOD space programs would be considered as integral parts of the total defense effort. Accordingly, administration officials believed it would not be logical to formulate long-

[375]York, *The Advisors,* pp. 147-49.

range military space plans or programs, separate and distinct from the overall defense plans and programs. While the Air Force believed Dyna-Soar represented the only avenue for exploring the usefulness of manned military space missions, the best hope, technologically, would be for developing maneuverable, reusable, space vehicles. Officials within the OSD did not embrace this entire vision, however. They shared a portion of it, but even that small part was not in focus. How could a state-of-the-art, long-term program survive when the officials charged with sustaining it refused to support long-term space programs or plans? Air Staff officers followed the administration's lead by emphasizing the suborbital, research aspects of Step I. Subsequently, they gained approval to study the military configurations of Steps II and III. The administration gave its approval for orbital flight in Step II. It approved the funding for Step II and III military studies and approved the substitution of Titan II, a booster with greater orbital potential, for Step I. Yet gaining approval for the development of Step II, much less Step III, was becoming extremely hard. Indeed, it seemed that the closer the administration came to publicly committing itself to a program dedicated to putting a military man in space, the harder the administration pushed to delay it. Unquestionably, these small steps did not mean the OSD believed Dyna-Soar would surpass existing, or planned, reconnaissance, ICBM, or ASAT programs. It meant only that the Air Force had managed to inspire a degree of technological confidence and fiscal support for their hypersonic research on a boost-glide weapon system. For proponents of Dyna-Soar, this was a tenuous existence but better than none at all.

CHAPTER 6

MANNED MILITARY SPACE PROGRAMS: INTERAGENCY RIVALRY, JANUARY 1961-JUNE 1962

> Apparently Dyna-Soar, the SAINT II program and the SSD Advanced Re-entry Technology Program contain serious duplications. General Wilson evidently thinks so since he sent a message to General Schriever requesting a briefing to assure him they did not conflict. General Schriever evidently thinks so since he has indicated a necessity for the correlation of the programs. The SPO is outclassed against a united SSD effort (plus extensive Aerospace [Corporation] push) which appears to already have been marshaled.
>
> Colonel Walter L. Moore, Program Director,
> Dyna-Soar System Program Office (SPO),
> 28 June 1961.[376]

The interagency strife between ASD and SSD marked an escalating effort within the Office of the Secretary of Defense (OSD) to maximize cost effectiveness by minimizing duplication, whether real or perceived. Secretary of Defense McNamara could afford to be cost conscious. By September 1961, the administration knew the Soviets were acting out of strategic weakness. For years Khrushchev had skillfully used the heroic efforts of Soviet space scientists, as well as the ambitions of Kennedy

[376]Geiger, *History of the X-20 Dyna-Soar*, pp. 80-81; Colonel William L. Moore, Program Director, "Dyna-Soar, SSD Advanced Re-entry Technology Program and SAINT II Proposed Conflict," Letter to Brigadier General A. T. Culbertson, Director, Directorate of Systems Management, ASD (Wright-Patterson AFB OH, 28 June 1961).

to show the international community how Soviet technology equaled or surpassed anything the Americans possessed. Despite Soviet propaganda to the contrary, the end of the "missile gap" began in August 1960. After twelve failures, the United States successfully launched and recovered its first spy satellite, Discoverer 13. Although Discoverer 13 did not contain a film canister, by January 1961, the film canisters recovered from other Discoverer flights revealed no missiles, silos, and factories at the locations Khrushchev boasted about.[377] During the summer of 1961, additional satellite reconnaissance enabled the NRO to conclude that the Soviets had only a few primitive ICBMs , perhaps four 100-ton SS-6s. The administration also knew the Soviets kept these missiles on an extremely low alert status, and that they stored the missile's warheads separately from the delivery vehicles. This meant it would take three hours to fuel each missile. Finally, all the missiles stood at the same Siberian test site--Plesetsk. The missile gap did not exist. American ICBMs were better, and the United States had more than the Soviets.[378]

Aside from their ICBMs, the Soviets maintained 200 bombers capable of carrying nuclear weapons, but their probability of reaching targets in the United States remained low. They also employed 78 missiles on board submarines. These submarines would need to bring their nuclear weapons within 150 miles of American shores to have any chance of hitting the coastal cities. Yet, these submarines were

---

[377]John Ranelagh, *The Agency: The Rise and Decline of the CIA from Wild Bill Donovan to William Casey* (New York: Simon and Schuster, 1986), pp. 323-27.

[378]McNamara, *In Retrospect*, p. 21.

rarely at sea. Instead, they stayed in the sanctuary of their Soviet ports. On the other hand, Soviet hypersonic research began to bear fruit. Chelomey's OKB-52 benefited from the years of conceptual work done by Myasishchev's OKB-23, before its consolidation with OKB-52. In December, OKB-52 launched a full scale mock-up of their spaceplane--Mp-1.[379]

That same month, the United States continued to debate the merits of a new booster and various design approaches to hypersonic flight. Still, America retained 185 ICBMs and more than 3,400 nuclear warheads on submarines and bombers capable of striking deep within the Soviet Union. With the exception of hypersonic development, the United States had overwhelming superiority. Yet, in the game of nuclear chess, there could be no guarantees. Soviet missiles might hit American targets, even if the United States launched a first strike. Kennedy needed to make sure Khrushchev knew the American president knew the Soviet leader had been bluffing about the Soviet Union's nuclear strength. To accomplish the task, he changed the tone of American defense reporting. Kennedy began to emphasize the "new" strength of America's strategic military forces, even though there were no new weapon systems in the inventory and began retiring strategic bombers like the B-47.[380] Because the United States was militarily stronger than the Soviet Union, the administration restrained the

---

[379]Kirpil and Okara, "Designer of Space Planes," pp. 14.

[380]Richard Reeves, *President Kennedy: Profile of Power* (New York: Simon and Schuster, 1993), pp. 229-30; Prados, *The Soviet Estimate*.

development of hypersonic flight and other means of achieving manned military space operations.

The New Frontier

Kennedy initiated and presided over one of the largest military build-ups of all time. He knew it could not be directly attributed to a real Soviet threat. It resulted from "runaway American politics, exaggerated threats of communism, misunderstood intelligence reports, inflated campaign rhetoric, a few lies here and there, and his own determination never to be vulnerable to charges of being 'soft on communism.'"[381] The Republicans had regularly used these charges to discredit Democrats. In 1961, Kennedy explicitly challenged the Soviets to an escalating arms race, doubling the production of American Polaris missile submarines from 10 to 20, increasing the number of SAC nuclear-armed bombers on alert from 33 percent to 50 percent, and signing off on 1,000 new Minuteman ICBMs (each with a warhead 80 times more powerful than the atomic bomb dropped on Hiroshima). In addition to the administration's new focus on a "triad" of nuclear capabilities, created by reducing the nation's reliance on the Air Force's ICBM and bomber forces, Kennedy began to shift his military strategy away from Eisenhower's "massive retaliation" to his own strategy of "flexible response," by strengthening the military and political alternatives between inaction and nuclear war.[382] Another contrast to the Eisenhower administration came

---

[381]Reeves, *President Kennedy*, pp. 230-31.

[382]Prados, *Soviet Estimate*, Chapters 7-8; Deborah Shapley, *Promise and Power*, pp. 94-111.

with Kennedy's ideas about publicizing reconnaissance satellite programs and their launches. Eisenhower, against the wishes of his science advisor James Killian, made it a point to stress the openness of American space efforts. Attempts to limit access to launch operations and information on launches would run counter to the openness the United States sought to exploit with its "space-for-peace" policy. The Kennedy administration was more receptive to Killian's views. Immediately upon taking office, the administration sought to limit the publicity given to reconnaissance satellite activities while continuing to champion a "space-for-peace" policy. In January 1961, McGeorge Bundy, Kennedy's national security advisor, and Secretary of Defense McNamara initiated a review of the existing public relations policies regarding SAMOS launches.[383] As a result, a restrictive "blackout" of information began. While this policy did not initially prevent Air Force personnel from continuing open discussions of reconnaissance satellite programs, the president bitterly resented public efforts to highlight the importance of the Air Force's burgeoning military space programs. Ultimately, the president barred military officers, particularly in the Air Force, from mentioning NRO programs by name or mission without prior approval.[384] By mid-November, the SAMOS and MIDAS programs ceased to exist publicly. Shortly afterwards, the administration extended the blackout to Discoverer. Finally, in order

---

[383]Steinberg, *Satellite Reconnaissance*, pp. 42-43.

[384]General Bernard A. Schriever, *New York Times,* 8 October 1961; General Thomas S. Power, Commander, *New York Times*, 11 October 1961, p. 21; *New York Times,* 14 October 1961.

to make reconnaissance satellite launches indistinguishable from all other military launches, all military launches became classified by registry letter and dates.[385] This blackout remained for 17 years. Without knowing what type of reconnaissance systems it had to compete with, Dyna-Soar proponents found it much harder to sell their system to OSD.

McNamara fully supported the president's blackout policy and his hatred for the "rigidity" of the military's highest officers.[386] Their unwillingness to replace their intuitive judgments with rational decision-making processes made Kennedy furious. McNamara's expertise in statistics, production planning, finance, and management accustomed him to basing budgetary decisions on close analyses of numerical data rather than the combat-hardened intuition military personnel had gained through years of experience. As such, he long regarded the Pentagon as a particularly fascinating challenge and informed the president that he intended to be active in office, undertaking the responsibility in his own unique way. Without compromising presidential authority, Kennedy acknowledged McNamara would be a policy maker as well as a manager with broad authority for individual initiative. Empowered with the president's blessings, McNamara instituted a new approach to analyzing, synthesizing, and centralizing defense planning, devoid of the intuitive judgments of the professional

---

[385]Philip J. Klass, *Secret Sentries in Space* (New York: Random House, 1971), pp. 109-11.

[386]Reeves, *Profile of Power*, pp. 226-35.

military.[387] "Commonality" within the services would be the key to efficiency and productivity, just as it had been when he managed automobile production at Ford. In *Promise and Power*, Debra Shapley suggests McNamara was a statistically minded executive who lacked any feel for the physical problems of advanced engineering. He was personally suspicious of "frills," and of revolutionary technological change. Innovation introduced instability.[388] Evolutionary incremental technological change increased efficiency and decreased production costs. In this sense, his faith in technology was very strong. While he successfully spearheaded an increase in the Air Force's military lift capabilities through the development of the Lockheed C-5 transport, established the "triad" nuclear strategic strategy, and presided over the institution of "flexible response," his faith in evolutionary technology and his failure to understand the "intangibles" of human nature resulted in the TFX debacle and contributed to America's defeat in Vietnam.[389] For Dyna-Soar, McNamara's systems management approach to defense planning meant a redirection from the suborbital flights of the three-step development plan to orbital flights in a new, more cost-effective development plan. Technologically, it reduced the difficulty of modifying multiple boosters for manned spaceflight. Additionally, WADD's radiative approach

---

[387]George M. Watson, *The Office of the Secretary of the Air Force, 1947-1965* (Washington, D.C.: GPO, 1993), pp. 205-12.

[388]Shapley, *Promise and Power*, pp. 201-22.

[389]McNamara, *In Retrospect*, pp. 15-37.

to heat protection would once again be scrutinized because it still seemed more radical than the "proven" ablative approach proposed by BMD.

Substituting One Titan for Another

On 5 January 1961, the Dyna-Soar program office protested the imposition of a $70 million funding ceiling, insisting it would result in serious delays. Regardless of the previous fiscal arrangements, the office urged approval of Titan II as Dyna-Soar's primary Step I booster.[390] Colonel Kiessling, HQ ARDC, concurred with this position and appealed to HQ Air Force. Even with the proposed funding level, employment of the Titan II promised a substantially improved Dyna-Soar program and Kiessling believed this booster change should be immediately approved.[391]

R. C. Johnston, chairman of the Booster Branch, Dyna-Soar WSPO, again went to brief HQ Air Force. After receiving the approval of Major General M. C. Demler, Director of Aerospace Systems, the Dyna-Soar representatives informed the Air Staff's Strategic Air Panel of the attributes of Titan II. Their discussion centered on the availability of the new booster for Step I flights, limitations of the combination Titan II and Centaur-derivative for the orbital booster, and the inadequate funding level for FY 1962. In spite of some doubts about Titan II, the panel approved the proposed booster

---

[390] HQ WADD, "WWZR-5-11081," TWX to HQ ARDC (Wright Patterson AFB OH, 5 January 1961).

[391]Geiger, *The History of the X-20 Dyna-Soar,* p. 65.

for Dyna-Soar Step I and further recommended the allocation of approximately $150 million for FY 1962.[392]

At the request of Assistant Secretary of the Air Force, C. D. Perkins, Gen. Demler summarized the advantages of Titan II over Titan I. The Director of Aerospace Systems insisted that Titan I would barely be sufficient for achieving the Step I objectives, and it could not be modified to provide orbital velocities. Fiscally, Demler estimated that the total booster cost for Step I and II employing the Titan I, then a Titan I Centaur combination, would be $320.3 million. If Titan II were immediately used for Step I, the booster total cost would be $324.3 million. Thus, the additional cost for using the more powerful booster in the first phase of the Dyna-Soar program amounted to $4.2 million. The conclusion seemed obvious. However, Gen. Demler refrained from making recommendations.[393]

Following the briefing to the Strategic Air Panel, Mr. Johnston and Major Halvorsen gave the Titan II presentation to the Air Staff's Weapons Board. The members were familiar with the logic of General Demler's summary. While expressing their interest in the early attainment of orbital flight, they endorsed the change to Titan II. The board further recommended that HQ Air Force immediately

---

[392]R. C. Johnston, Chairman, "Titan II Booster Presentation," Trip Report to HQ Air Force, 9-11 January (Washington, D.C., 12 January 1961).

[393]Major General M. C. Demler, Director, "System 620A, Dyna-Soar Step I Booster," Report (Washington, D.C., 9 January 1961).

instruct ARDC to adopt the new booster.[394] Major General V. R. Haugen and Colonel B. H. Ferer, both in the Office of the Deputy Chief of Staff, Development, decided, however, to seek the approval of OSD. Accordingly, the Titan II presentation went before John H. Rubel, Deputy DDR&E. While repeating the necessity of a $70 million budget Rubel agreed to the technical merits of Titan II. On 12 January 1961, HQ Air Force announced OSD's approval for substituting the Titan II booster for Step I flights.[395]

Reviewing the National Space Program

Two days after HQ Air Force announced the approval for the substitution of Titan II for Titan I, Jerome Wiesner, appointed by president-elect Kennedy to head a nine-man ad hoc committee to review the nation's space program, voiced serious criticisms of the existing United States space effort. Specifically, neither the new NASA, the dispersed military space programs, nor the NASC adequately met the military or political challenges posed by the Soviet Union's space program. Wiesner's committee believed that the Air Force, already the largest provider of space hardware and support expertise, should be assigned the responsibility of all military space developments. This would enable the Secretary of Defense to maintain control of the scope and direction of the program and allowed the NASC to settle conflicts between

---

[394]Johnston, "Titan II."

[395] HQ Air Force, "AFDSD-76644," TWX to HQ ARDC (Washington, D.C., 12 January 1961).

DOD and NASA.[396] Soon after taking office as Secretary of Defense, McNamara ordered his staff to reexamine DOD's role in light of the Wiesner committee criticisms. Completed in late February, this order led to a DOD directive in March.

While the OSD fielded criticisms about the past administration's managerial practices regarding the military space program, Dyna-Soar officials began to believe DOD planned to limit FY 1962 funding to $70 million. This restriction was confirmed on 3 February, when HQ Air Force directed the Dyna-Soar office to reorient their Step I program to conform to the lower funding level.[397] By the end of the month, the Dyna-Soar project office and its contractors completed their evaluations of the reduced program. One thing was clear: flight schedules would have to be set back almost one year.[398]

In February 1961, the Soviets placed a large spacecraft (over 14,000 pounds) into orbit to serve as a launch platform for a Venus planetary explorer. This action focused American concerns over the growing Soviet ability to launch weapons from space against Earth and space targets.[399] Worried about the Soviet Union's ability to

---

[396]Berger, *The Air Force in Space Fiscal Year 1961*, pp. 3-4; *Washington Post,* 11 January 1961; *New York Times,* 12 January 1961.

[397] HQ Air Force, "AFDSD-82107," TWX to HQ ARDC (Washington, D.C., 3 February 1961).

[398] Directorate of Systems Management, "Daily Activity Reports" (Wright-Patterson AFB, 3 March 1961).

[399]Walter R. Dornberger, "Arms in Space: Something Else to Worry About," *U.S. News & World Report*, 9 October 1961, p. 76.

realize its military space potential, Kennedy's State Department officials advocated a continued reliance on Eisenhower's "space-for-peace" through a policy of open disclosure of American launch activities. The state department sought unilaterally to develop a climate for international acceptance of observation satellites. Additionally, the department wanted to pressure the Soviets into relinquishing their inherent military space advantages.[400] While the political embarrassment of the U-2 incident of 1960 represented a classic case of the consequences of nonsanctioned territorial overflight, some administration officials disagreed with the state department's policy, preferring to stick to the "blackout" policy. The Kennedy administration vacillated over the legitimacy issue during the first half of 1961 while it sustained a "blackout" of reconnaissance satellite information to the public. In the fall, confronted with the issue of Berlin, Kennedy again realized the critical importance of reconnaissance satellites.

As the administration reacted to Soviet initiatives, in March 1961 ARDC submitted its "stand-by" plan for achieving orbital flight with the Step I glider, hoping higher headquarters might approve the action. Because the Air Staff's 12 October 1960 development directive concurrently authorized ARDC to begin aggressively detailing studies of military applications for Dyna-Soar's Step I glider, the Dyna-Soar WSPO believed that an approval for orbital flight--by merging Step I and Step II into continuous development--would sanction military applications. By using either a Titan/Centaur combination or NASA's Saturn C-1 booster for both the Step I suborbital

---

[400]Steinberg, *Satellite Reconnaissance*, p. 47.

and the Step II orbital flights, manned orbital flight could be accelerated by as much as 17 months. Equally important, overall costs for the Step I-II program could be reduced further.[401]

On 6 March 1961, after giving "careful consideration" to the comments the JCS made about his directive on the centralization of space system development within DOD, McNamara announced his decision to assign space development programs to the Air Force, except under unusual circumstances.[402] Still, to foster the best common solution to any mission, each service could conduct preliminary research on new ways of using space technology to perform its assigned missions. Any research, however, required the approval of DDR&E.[403]

ARDC Reorganizes

The directive triggered a major Air Force reorganization. For some time Air Force officials contemplated the functional realignment of ARDC and AMC. Now, in order to centralize direction of ballistic missile and space programs they announced sweeping command changes. By combining both commands, they created the Air Force Systems Command (AFSC), which was to be responsible for the development and acquisition of all aerospace and missile systems. This reorganization was

---

[401]Berger, *The Air Force in Space Fiscal Year 1961*, p. 55.

[402] U.S. Congress, House, *Report to the House Committee on Science and Astronautics*, DOD Directive 5160.32, 87th Congress, 1st Session (Washington, D.C.: GPO, 1962).

[403]Berger, *The Air Force in Space Fiscal Year 1961* pp. 9-10.

completed by 1 July 1961. In establishing the AFSC, the Air Staff created four major subordinate elements: the Space Systems Division (SSD), composed of the space elements of BMD and BMC; the Ballistic Systems Division (BSD), composed of the missile elements of BMD and BMC; the Ballistic Missile Construction Office of the Army Corps of Engineers; the Aeronautical Systems Division (ASD), composed of the WADD and ASC; and the Electronic Systems Division. The Air Force believed that the reorganization would facilitate decisions and accelerate actions on their system programs. In turn, the centralization would ensure efficient, responsible management of its recently assigned space development mission. To help redirect the R&D efforts of the new commands, Gen. Schriever asked Trevor Gardner, the man who had championed the crash program for the ICBM, to form a committee, similar to von Kármán's committee, to create a new *Where We Stand* summary.[404]

On 20 March 1961, Trevor Gardner submitted his committee's report to Gen. Schriever. The report provided assessments of the Soviet space threat, recommendations on Air Force organization, and requirements for Air Force space activities. The committee believed the Air Force viewed its role in space too narrowly. In fact, a dogma prevailed within the Air Force suggesting technical developments, particularly those involving any substantial application of resources, must be justified by a specific weapon system tied to a specific military requirement. By committing itself to systems development, the committee believed the Air Force treated space

---

[404]Berger, *The Air Force in Space Fiscal Year 1961* pp. 10-11; McDougall, *The Heavens and the Earth*, pp. 312-14.

systems requirements just as if it knew the framework of strategy and space technical boundary conditions in the future. The development of urgently needed capabilities such as boosters, rendezvous, maneuverability, and communications would be essential to the speedy attainment of effective military use of space. The premature initiation of systems was producing inefficiencies and could in the future limit or even foreclose the opportunity for the full development of fundamental capabilities.[405] Just as the Lewis and Clark expedition combined military and civilian resources for the betterment of the nation, the bulk of the space effort should be devoted to constructing a firm technological foundation for both NASA and DOD.

This would not contradict national policy, because these generic capabilities did not constitute inherently military or peaceful qualities. Indeed, the Gardner committee concluded the Air Force should participate in a broadened American moon program: a step-by-step project to land a man on the moon sometime between 1967 and 1970. Such a project would yield tremendous benefits for both civilian and military capabilities.[406]

Dyna-Soar and National Prestige

In a special message to Congress on 28 March 1961, two months before his lunar landing speech, Kennedy asked for an additional $144 million to speed up development of MIDAS, Dyna-Soar, Discoverer, SAMOS, and several other space-

---

[405]Futrell, *Ideas, Concepts, Doctrine*, p. 430.

[406]Berger, *The Air Force in Space Fiscal Year 1961* pp. 11,14.

oriented military projects. As a result, DOD officials relented on their earlier fiscal restrictions. HQ Air Force announced that the FY 1962 budget for Dyna-Soar would be $100 million. The following day, Colonel W. L. Moore, Dyna-Soar director, and his Deputy Director for Development, William E. Lamar, reported on the status of the program to HQ Air Force. Despite the new funding level, both Charyk and Haugen directed Moore and Lamar to keep the program on a "reasonable" level. Colonel Moore noted how neither official offered to define the term.[407]

As Colonel Moore wrestled with funding issues, ARDC officially became the Air Force Systems Command (AFSC), acquiring the procurement and production functions from the AMC on 1 April 1961. As part of the reorganization, at Wright-Patterson AFB, WADD combined with the ASC to become the Aeronautical Systems Division (ASD). By 4 April, HQ AFSC officially instructed the Dyna-Soar program office to redirect boost-glider R&D to a $100 million level for FY 1962.[408] Equally important, HQ Air Force received ARDC's recommendations for a "stand-by" plan to accelerate Steps I and II development.

Shortly after congressional hearings started on Kennedy's revisions to the last Eisenhower budget, the Soviet Union once again did something dramatic to energize the American space program. On 12 April 1961, Air Force Major Yuri Gagarin

---

[407]Colonel William L. Moore, Chairman, "Presentation on Status of Dyna-Soar Program," Trip Report to Brigadier General A, T. Culbertson, Director, Systems Management, WADD (Wright-Patterson AFB, 31 March 1961).

[408] HQ AFSC, "SCRAS-3-4-2," TWX to HQ ASD (Washington, D.C., 4 April 1961).

the American space program. On 12 April 1961, Air Force Major Yuri Gagarin successfully orbited the Earth in a five-ton *Vostok* spacecraft, becoming the first man to fly in space. While the event did not deliver as crushing a blow as the *Sputnik* launch, it generated considerable frustration, excitement, and gloom in the United States.[409] The chairman of the House subcommittee on DOD appropriations, Representative George H. Mahon, criticized NASA's Mercury program. He noted how everyone remembers Lindbergh's solo, nonstop crossing of the Atlantic, but no one remembers the second man to accomplish the feat. Mahon suggested there might be little political advantage in continuing to pursue the Mercury program. In turn, he asked Under Secretary of the Air Force Charyk and Gen. Roscoe Wilson, Deputy Chief of Staff, Development, whether the orbiting of a man in a maneuverable glider might not be considered a greater achievement.[410] While both officials emphasized the importance of controlled, maneuverable space vehicles, General Wilson specifically expressed a firm conviction regarding Dyna-Soar. He believed that Dyna-Soar represented the most important program in the Air Force. Indeed, America would not be a true spacefaring nation until it demonstrated the ability to take off and return the vehicle to a conventional landing under the pilot's control. Dyna-Soar, in his opinion, would be the genesis of such a program--the first time humans would truly "fly" in space.

---

[409]Berger, *The Air Force in Space Fiscal Year 1961* pp. 16-17.

[410]U.S. Congress, House, Hearings Before the House Subcommittee on DOD Appropriations, *DOD Appropriations for 1962*, 87th Congress, 1st Session (Washington, D.C.: GPO, 1961), pp. 510-12.

The following day, McNamara met with Air Force Secretary Zuckert and DDR&E York to ask them to study independently the recently published Gardner committee report. Additionally, they should reexamine the national space program from the viewpoint of DOD requirements. Their efforts would form the basis of a sweeping review of the DOD's space programs. Secondly, they would aid Vice-President Johnson in responding to the president's request for a *Where We Stand*-style document on American space efforts. To coordinate the Air Force's inputs, an SSD special task force was created under the direction of Major General Joseph R. Holzapple, formerly the WADD commander. With a former WADD commander leading the task force, Dyna-Soar's role might be defended more than if someone within SSD chaired the task force.

As the SSD task force began to prepare its report in early April 1961, Lt. Gen. Wilson appeared concerned about the way HQ Air Force managed the Dyna-Soar program. Although the Air Staff devoted considerable attention to this program, its ability to persuade OSD left something to be desired. General Wilson believed the situation could be alleviated if the Air Staff placed the program under the management of the Air Force Ballistic Missile and Space Committee.[411] This could prove difficult. Historically, OSD had given reluctant support, if any, to Dyna-Soar's military missions.

---

[411]Geiger, *The History of the X-20 Dyna-Soar,* pp. 84-85.

Revising the Program Plan

By 26 April 1961, the Dyna-Soar office had completed a new program plan, one that elaborated on the familiar three-step approach. Step I would involve suborbital missions of a Dyna-Soar glider boosted by a Titan II. For the R&D of this program, $100 million would be required for FY 1962, $143.3 million for 1963, $114.6 million for 1964, $70.7 million for 1965, $51.1 million for 1966, and $9.2 million for 1967.[412] If they received these funds, the first B-52 air-drop would take place in January 1964, the first unmanned launch in August 1964, and the first manned launch in April 1965.

The objective of Step IIA would be to demonstrate orbital flight, with Dyna-Soar flying missions from Cape Canaveral to Edwards Air Force Base. On these flights, the SPO proposed to test various military subsystems, such as weapon delivery and reconnaissance. Because of the high cost, it did not recommend the evaluation of a space maneuvering engine, space-to-Earth missiles, or space-to-space weapons during Step IIA flights. For FYs 1963 through 1968, the program office estimated this phase of Step II would total $467.8 million and, assuming the selection of the orbital booster by the beginning of FY 1962, reasoned that the first manned orbital flight could be conducted in April 1966.[413]

---

[412]Directorate of Systems Management Dyna-Soar SPO, ASD, "System Package Program, System 620A" (Wright-Patterson AFB, 26 April, 1961), pp. 42, 411, 446-47, 454.

[413]Ibid., pp. 460-74, 486-90.

In Step IIB, the Dyna-Soar was to provide an interim operational system capable of fulfilling reconnaissance, satellite interception, space logistics, and bombardment missions. With the exception of $300,000 necessary for an additional Step IIB study, the Dyna-Soar office did not detail the financial requirements for this phase. Based on Step IIA data, however, it thought a Step IIB vehicle could be operating by October 1967. The program office looked farther into the future, maintaining $250,000 would be necessary for each FY, through 1964, for studies on a Step III weapon system. A Step IIB Dyna-Soar could be available by late 1971.[414]

Concurrently, Maj. Gen. Holzapple submitted his task force's report to Secretary Zuckert. While the proposal suggested the broadening and acceleration of various military goals and programs to fulfill those goals, at the heart of the proposal was a plea for a dramatic national objective to focus the nation sharply on a goal, a clear-cut assignment of responsibility. Even though the development of large boosters to launch heavier and more sophisticated payloads, the development of advanced recovery, reentry, and rendezvous techniques, and the introduction of manned spaceflight might satisfy military requirements in the near-term, a feat worthy of the nation's technological potential and one capable of capturing the imagination of the world, would be required. Holzapple suggested a manned expedition to the moon sometime between 1967 and 1970. Such a clear decision would have tremendous international and national significance. It would also gain the funding required to

[414]Ibid, pp. 502-22.

provide better ways to accomplish the national defense mission.[415] Air Force officials knew they had little chance of being selected to head the expedition. Still, SSD officials fully expected to play a major role, particularly in the development of a powerful "going-to-the-moon" booster, which had been the sole responsibility of NASA since it acquired the ABMA team in October 1959. If the Air Force could garner a manned program along the way, all the better. Zuckert incorporated the task force's report into his briefing to McNamara in April. McNamara then used the report in compiling his thoughts into a joint report with NASA administrator James E. Webb for presentation to the vice-president.

Support Testing for Dyna-Soar

While Secretary McNamara and NASA administrator Webb compared notes for their report to Vice-President Johnson, the Dyna-Soar office outlined an extensive test program, consisting of structural, environmental, design, and aerothermodynamic studies. All of these would be necessary for the development of the glider. To verify information obtained from these laboratory tests, the SPO recommended participation in another test program (SSD's 609A) to place Dyna-Soar models in a hypersonic free-flight trajectory.[416] Unfortunately, HQ ARDC refused to release funds for even

[415]Berger, *The Air Force in Space Fiscal Year 1961* pp. 19-20.

[416]Dyna-Soar SPO, "System Package Program," p. 187.

two research flights. Subsequently, Colonel Moore canceled Dyna-Soar participation in 609A.[417]

HQ Air Force felt concerned about the cancellation. The absence of a free-flight test program for Dyna-Soar failed to carry out the assurances that HQ Air Force's previously gave to the DOD.[418] NASA had another approach. Dyna-Soar models constructed by both NASA and the Air Force would be placed on RVX-2A reentry vehicles. These vehicles could then be boosted to hypersonic velocities by Atlas or Titan systems.[419]

In May 1961, Major General W. A. Davis, ASD Commander, emphasized the requirements for RVX-2A tests to HQ AFSC : funds and space on Titan II launches. After two more appeals by the program office, Major General M. F. Cooper, Deputy Chief of Staff for Research and Engineering, summarized the SPO-HQ AFSC position. Placing Dyna-Soar reentry models on a Titan II would impose several limitations on the test schedule of the booster, requiring several modifications to the airframe and the launch facilities. Additionally, Cooper believed that HQ Air Force would need to approve the $10 million NASA officials estimated it would cost for the Air Force's

---

[417]Geiger, *The History of the X-20 Dyna-Soar,* p. 70.

[418] HQ Air Force, "AFDSD-AS/O-93477," TWX to HQ ARDC (Washington, D.C., 13 October 1961).

[419]William E. Lamar, Deputy Director, "Conference at NASA Regarding RVX-2 Test for Dyna-Soar" (Wright-Patterson AFB OH, 1961); NASA, "The Atlas RVX-2 and Communications Experiments Proposed by NASA" (4 November 1961); HQ WADD, "WWDR-7-11-2," TWX to HQ ARDC (Wright-Patterson AFB OH, 8 November 1961).

portion of the RVX-2A program. Consequently, Cooper intended to incorporate this test program into a future Dyna-Soar development plan. Indeed, the RVX-2A proposal was included in a 7 October 1961 plan for the development of a Dyna-Soar weapon system. This program plan did not, however, receive HQ Air Force approval. Subsequently, neither did the RVX-2A tests.[420] This also ended any attempt by the Dyna-Soar office to provide a specific program for free-flight verification of its laboratory test data.

Symbol of Technological Superiority

As the Dyna-Soar SPO attempted to gain free-flight verification of its laboratory data, the successful suborbital flight of Commander Alan B. Shepard on 5 May gave Congress and the president the "green light" to shift into a higher gear with the space program. Air Force Chief of Staff White approved Gen. Wilson's suggestion for improving Dyna-Soar's exposure to DOD officials by assigning it to the Air Force Ballistic Missile and Space Committee to be reorganized as the Designated System Management Group, or DSMG, on 25 July 1961. General LeMay asked the Office of the Secretary of the Air Force to assign the project to the committee. The under secretary disagreed. Regardless of the positive political and military implications inherent to the program, Charyk considered the current phase of Dyna-Soar's development primarily oriented to applied research. As such, it should be deferred until the program reached a point where serious consideration would be given to a

[420]Directorate of Systems Management Dyna-Soar SPO, "Abbreviated Development Plan, System 620A" (Wright-Patterson AFB OH, 7 October 1961), p. 64.

follow-on effort. As the director of NRO, Charyk was not sympathetic to congressional wishes for Dyna-Soar. The existing ability to gather critical intelligence information routinely with reconnaissance satellites represented the true line of military demarcation in the struggle for a military space mission and NASA's manned spaceflight program represented the political line of demarcation in the struggle for international prestige. Accordingly, he did not consider Dyna-Soar as a symbol of America's technological superiority.

While Charyk debated the technological merits of Dyna-Soar with the Air Staff, President Kennedy briefed Democratic congressional leaders on the substance of his forthcoming second "State-of-the-Union" message dealing with space, which he wanted to deliver to a joint session of Congress on 25 May. For the first time since *Sputnik*, the United States accepted the Soviet challenge for the preeminence in space, Kennedy said. The race to the moon was on.[421]

The immediate effect of Kennedy's lunar-landing speech on the Air Force was small, but significant. The Air Force was to receive only $77 million of the $500 million Apollo program to begin development of an upper-stage booster and a large solid-fuel booster to compete with NASA's liquid-fueled engine for its Nova booster. The two-year embargo on the Air Force's efforts to develop a "super-booster" had been lifted. Optimistically, the Air Staff expected the Air Force to become a major participant in the enlarged space effort. It believed the new capabilities and techniques

[421] *New York Times,* 26 May, 1961.

acquired in this extended effort would serve as building-blocks for its efforts to meet the space-oriented requirements of the military services.[422]

Why Suborbital Flight?

Following the president's announcement, the Air Staff began to question the need for suborbital flights listed in Dyna-Soar's April program plan. In the April 1961 system package, the Dyna-Soar SPO reduced the number of unmanned launches to two instead of the previously-planned four. On the first flight, the Titan II would accelerate the glider to a velocity of 16,000 feet per second, reaching Santa Lucia in the Leeward Islands. During the second launch, the vehicle would attain a velocity of 21,000 feet per second and land near Fortaleza, Brazil. Twelve manned flights were then planned with velocities ranging from 16,900 to 22,000 feet per second. The Dyna-Soar SPO made these changes to the April program package because it believed, that if the two additional vehicles for unmanned launches were not used, additional piloted suborbital flights could be substituted.[423]

The scheduling of flights to Fortaleza, however, were becoming moot. As early as June 1960, HQ Air Force notified HQ ARDC of the state department's concern over renewing an agreement with Brazil for use of its territory to conduct military operations.[424] This subject reappeared in May 1961. The acting DDR&E, John Rubel,

---

[422]Berger, *The Air Force in Space Fiscal Year 1961* pp. 23-25.

[423]Dyna-Soar SPO, "Abbreviated Development Plan," pp. 306-07.

[424] HQ ARDC, "RDROF-9-6-4," TWX to HQ WADD (Andrews AFB MD, 9 June 1960).

informed the Department of the Air Force about the state department's discussion about the difficulty, if not the impossibility, of obtaining a landing site for Dyna-Soar in Brazil.[425] Unless HQ Air Force tolerated increased costs, reduced flight test objectives, or employment of a new booster, the Dyna-Soar office thought a landing field in Brazil would be essential. Employment of alternative landing sites would seriously affect the conduct of the test flights and would prevent attainment of several important research objectives. Although Dr. Brockway McMillan, Assistant Secretary of the Air Force for R&D, reiterated this position to OSD, the subject of a Fortaleza landing site did not assume any greater significance because the Air Staff was already seriously considering going straight to orbital flight by merging Step I and II objectives.[426]

From January 1960 through April 1961, the Dyna-Soar program office defined Dyna-Soar in terms of a three-step program, implementing a suborbital phase in Step I. While HQ Air Force previously approved the April 1960 development plan, it did not sanction the more detailed three-step approach outlined in the April 1961 system package program. Consequently, because the Dyna-Soar office was engaged in a study to eliminate suborbital flight and accelerate the date for the first manned orbital launch by merging Steps I and II, HQ Air Force felt no compulsion to sanction the April 1961 development plan.

---

[425]Geiger, *The History of the X-20 Dyna-Soar,* p. 72.

[426]Ibid., p. 71.

The redirection actually began when Brigadier General M. B. Adams, Deputy Director of Systems Development in HQ Air Force, forwarded Development Directive 411 in October 1960. He instructed the ARDC to formulate a "stand-by" plan for achieving orbital flight with the Step I glider at the earliest possible date.[427] In December, the Dyna-Soar office was ready with a proposal. By merging Steps I and IIA into a continuous development, and employing an orbital booster for both suborbital and orbital flight, the time for the first manned orbital launch could be accelerated by as much as 17 months over the three-step schedules.[428]

Depending on either a March 1961 or a November 1961 approval date Dyna-Soar officials estimated that a Titan II/Centaur combination would cost either $726 million or $748 million. If they used a Saturn C-1, the figures would be $892 million or $899 million. The total for a separate suborbital Step I and an orbital Step IIA , however, would be approximately $982.6 million. The Dyna-Soar office recommended that HQ ARDC immediately approve the “stand-by” program plan.[429] Command headquarters disagreed. It believed that OSD would only approve the

---

[427]Brigadier General M. B. Adams, Deputy Director, "Development Directive 411," Letter to Commander ARDC (Washington, D.C., 12 October 1960).

[428]Colonel William L. Moore, Program Director, “Preliminary Results of Dyna-Soar ‘Stand-By’ Program Study,” Letter to Commander ARDC (Wright-Patterson AFB OH, 23 February 1961).

[429]Ibid; Dyna-Soar SPO, “Abbreviated Development Plan,” pp. 411, 487a.

stand-by plan when the international situation necessitated a higher priority--and subsequently additional funds--for Dyna-Soar.[430]

The logic of employing the same booster for Steps I and IIA led to another conclusion. On 4 May 1961, Boeing officials proposed yet another plan for acceleration. Its "streamlined" approach encompassed the elimination of suborbital flight, temporary employment of available subsystems, and the use of Saturn C-1. Assuming a June 1961 approval date, Boeing representatives anticipated that the first unmanned orbital flight could occur in April 1963, instead of August 1964 as scheduled in the April 1961 three-step approach.[431]

Again the Dyna-Soar SPO disagreed. It felt that temporary subsystems would only decrease system reliability. Consequently, it rejected Boeing's proposal. The key to accelerating the orbital flight date would not only be booster availability, but also the time required to develop the various glider subsystems. If it could get a funding increase for FY 1962, it might be possible to accelerate the various glider subsystem schedules and advance the orbital flight date.[432] There was merit to Boeing's plan, the SPO conceded, but the plan needed refinement.

---

[430]Colonel William L. Moore, Program Director, "'Stand-By' Program," Memo (Wright-Patterson AFB OH, 20 March 1961).

[431]Geiger, *The History of the X-20 Dyna-Soar,* p. 79.

[432]Ibid., p. 80.

The Roots of Interagency Rivalry

A month after Boeing presented its streamlined proposal, DDR&E Brown reviewed SSD's SAINT (unmanned satellite intercepter) program for the Senate Committee on Aeronautical and Space Sciences. SAINT should be developed because the OSD believed the capability to determine the characteristics, performance, and intentions of foreign satellites through direct inspection represented an important military requirement. This could be done with unmanned satellites capable of maneuvering to intercept unidentified spacecraft. Additionally, the results of the planned test flights would enable the OSD to determine the overall feasibility of the current SAINT approach. Indeed, a manned inspection system might be necessary rather than an unmanned system.[433] If SSD convinced OSD of the superiority of its manned SAINT over Dyna-Soar, then it might gain a manned military mission at Dyna-Soar's expense.

On 29 May 1961, while the Dyna-Soar office considered ways to accelerate the orbital flight date of its glider, SSD completed two development plans for demonstrating orbital flight with a lifting-body. Essentially, the objective of its Advanced Reentry Technology (ART) program was to determine whether SSD's ablative or ASD's radiative heat protection would prove most feasible for a reentry vehicle. SSD's second plan initiated an extension of its SAINT. As suggested by

---

[433]Berger, *The Air Force in Space Fiscal Year 1961*, p. 72.

DDR&E Brown, SSD submitted a development plan for a manned satellite inspector to be known as SAINT II.[434]

SAINT II was to be capable of precise orbital rendezvous and space logistic missions. Like Dyna-Soar, SAINT II was to maneuver during reentry and accomplish a conventional landing at a preselected site. Officials of the space division listed several reasons why Dyna-Soar's configuration could not, in their opinion, accomplish SAINT II missions. Dyna-Soar's reentry velocity could not be increased significantly because it could not be adapted for ablative heat protection. Furthermore, winged configurations did not permit sufficient payload weights and imposed structural penalties on the booster--a fact SSD knew from its Titan II research for Dyna-Soar. Finally, SSD believed rendezvous and logistics missions would require major modifications to the Dyna-Soar glider. The proposed SAINT II demonstration vehicle was to be a two-man, lifting-body launched by a Titan II/Chariot using the new Chariot upper stage, which employed fluorine and hydrazine propellants and produced 35,000 pounds of thrust. The vehicle would initially be limited to 12,000 pounds; but, with approval of the new Air Force space launch system (what would become the Titan IIIC), the weight could be increased to 20,000 pounds. The plan called for 12 orbital demonstration launches, with the first unmanned flight occurring early in 1964 and the initial manned launch taking place later that year. From FY 1962 through 1965 this

---

[434] HQ SSD, "Proposed Development Plan for an Advanced Reentry Technology Program" (Los Angeles, 29 May 1961), pp. 1-5.

program would need $413.9 million.[435] Both the SSD proposals and Dyna-Soar's streamlined plan were sent to the commander, AFSC, for review.

After examining all program proposals, General Schriever deferred any decision on Dyna-Soar until the relationship between its streamline plan and SAINT II could be clarified. Moreover, further analysis of an orbital booster for Dyna-Soar would have to be accomplished.[436]

The Quest for "Commonality"

At the same time this was going on inside the Air Force, NASA administrator James Webb and Secretary of Defense Robert McNamara signed a report enumerating McNamara's desires to control R&D in the DOD. To implement his plans for commonality and cost-accounting reforms, McNamara defined each military program detail by detail in an attempt to make them fiscally competitive.[437] This was a difficult job, at best, because these R&D projects were created on the premise of their ability to combat enemy weapon systems not yet in existence. In the name of commonality between DOD and NASA space programs, McNamara envisioned several program cuts for the DOD--and for the Air Force in particular. Such cuts would adversely affect the aerospace industry and the administration's economic plans. Yet, if NASA gained a

---

[435] HQ SSD, "System Program Package, Expanded SAINT" (Los Angeles CA, 29 May, 1961), 1-8, V-63, VII-2; Geiger, *The History of the X-20 Dyna-Soar,* p. 80.

[436] Moore, "Stand-By."

[437] U.S. Congress, House, Hearings Before the Committee on Science and Astronautics, *Space Posture*, 87th Congress, 1st Session (Washington, D.C.: GPO, 1961), pp. 174-75.

national commitment for a large space program, as they soon would for Apollo, then its growth would offset DOD space program cuts. The aerospace industry would flourish, the administration's economic policy would not be damaged by the cuts, Congress would have a "peaceful" space program to battle the Soviets for prestige, and the Air Force's management of R&D for space operations would be controlled.[438]

As McNamara began to put his push for commonality into motion, a Dyna-Soar technical evaluation board--composed of representatives from the Air Force Systems Command, the Air Force Logistics Command (AFLC), and NASA--considered 13 proposals for orbital boosters. Of the 13, the evaluation board decided that the Martin C proposal was the most feasible. The first-stage of this liquid-fueled booster consisted of an LR87-AJ-5 engine, capable of producing 430,000 pounds of thrust, while the second-stage, with a J-2 engine, could deliver 200,000 pounds of thrust.[439]

In June 1961, as the Dyna-Soar technical evaluation board forwarded its results to HQ AFSC, congressional support for an accelerated program materialized. The House Committee on Appropriations endorsed the advantages of an operational, manned, military space vehicle by declaring that Dyna-Soar represented the quickest and best means of attaining this objective. Furthermore, the committee thought that previous Dyna-Soar planning lacked boldness and imagination. The costs of such

---

[438]Shapley, *Promise and Power*, pp. 187-246.

[439]Geiger, *The History of the X-20 Dyna-Soar,* p. 81.

programs, when pursued at less than optimum pace, mounted.[440] Because an accelerated program promised lower costs and early orbital flight, the committee voted to increase the Dyna-Soar appropriation to $185.8 million for FY 1962--$85 million more than Kennedy had requested in March. Justifying this kind of support, the committee said Dyna-Soar would not compete with the moon program. Dyna-Soar's objectives were military, some of which were vital, because for the remainder of the decade low Earth orbit (LEO) missions would be of greater interest to military planners than trips to or around the moon.[441]

By the end of June, the Dyna-Soar program office completed its refinement of Boeing's original plan. Like the April 1961 three-step program plan, the first phase of the streamline plan involved the development of an orbital research vehicle. In the second phase, military subsystems would be developed and tested. In the final phase, an operational weapon system would be developed. To attain orbital flight, either a modified Saturn booster, a Titan II with a hydrogen-oxygen second-stage, or a Titan II augmented by solid propellant engines (what would become a Titan IIIC), would be acceptable. This modified plan would cost a total of $967.6 million with the first unmanned orbital flight occurring in November 1963.[442]

---

[440] U.S. Congress, House, Hearings Before the House Subcommittee on DOD Appropriations, *DOD Appropriation Bill, 1962*,, 87th Congress, 1st Session (Washington, D.C.: GPO, 1961), pp. 61-62.

[441]Ibid.

[442]Directorate of Systems Management Dyna-Soar SPO, ASD, "System Program Package, 620A" (Wright-Patterson AFB OH, 26 June, 1961), pp. 395-99.

Before a Senate subcommittee in July, General Schriever discussed the consequences of the Kennedy administration's continuance of the "space-for-peace" policy begun by Eisenhower. When asked whether the military space program was adequately and properly supported, Schriever replied that it was not. He specifically argued that the "space-for-peace" policy had been inhibiting military space programs--so much so that an arbitrary division between the DOD and NASA had been created.[443] On the basis of this answer, the committee asked Schriever for a written statement summarizing the situation.

As Gen. Schriever debated the consequences of "space-for-peace," the Dyna-Soar directorate of SSD, having the responsibility for developing boosters for System 620A, also made a recommendation for orbital propulsion. On 11 July, Colonel Joseph Pellegrini informed the Dyna-Soar office that his directorate favored employment of the projected Space Launch System A388. An outgrowth of an SSD study on the Phoenix series of various combinations of solid and liquid boosters, Phoenix A388 was to have a solid-fuel first-stage (producing 750,000 pounds of thrust) and a liquid propellant second-stage using the J-2 engine.[444]

As SSD made its booster proposal, the Dyna-Soar program gained a higher management profile when it came under the jurisdiction of the designated management group on 1 August. Two days later, Colonel Moore brought the streamlined proposal

---

[443]Carl Berger, *The Air Force in Space, Fiscal Year 1962* (Washington, D.C.: USAF Historical Division Liaison Office, 1966), p. 5.

[444] HQ SSD, "SSVS-10-7-3," TWX to HQ ASD (11 July, 1961).

before the Strategic Air Panel, the Systems Review Board, and the Vice Chief of Staff. By eliminating suborbital flight, the first air-drop would occur in mid-1963; the first unmanned orbital flight in 1964; and the first piloted orbital launch in early 1965. In comparison, the first piloted Step IIA flight had been scheduled for January 1967. Not only would the orbital flight date have to be accelerated but considerable financial savings would also accrue. Colonel Moore now estimated that the combined cost of Steps I and IIA was $1.201 billion, while the figure for the streamlined proposal amounted to $1.026 billion. The director concluded by emphasizing how Dyna-Soar was the most effective way to achieve an Air Force manned space program and how the streamlined plan would be the most expeditious approach to piloted orbital flight.[445]

Officials from SSD and the Aerospace Corporation (formerly the Space Technology Laboratories, now a nonprofit civil contractor) presented their considerations for a booster to accommodate the streamlined plan.[446] At this point in the briefing, SSD's position became clear. It incorporated its previous evaluations for a Step IIA booster into its analysis for the streamlined proposal. Once again, its first choice was its own Phoenix space launch system. Assuming a November 1961 approval date, Phoenix A388 allowed the first, unmanned launch to occur in July 1964. Based on an 18-flight Dyna-Soar program, the cost for Phoenix development from FY 1962 through 1966 would total $183.3 million. SSD's second option was the Soltan,

---

[445]Colonel William L. Moore, Program Director, "Project Streamline," Presentation to the Strategic Air Panel (Washington, D.C., 3 August 1961).

[446]Watson, *Secretary of the Air Force,* p. 224.

which would be derived by attaching two 100-inch-diameter solid-propellant engines to the Titan II. The projected Soltan schedule permitted the same launch date as the Phoenix, but the cost was estimated at $325.4 million. Although the Saturn C-1 allowed an unmanned launch date in November 1963 (the cost would total $267.2 million), SSD and Aerospace officials ranked this booster last, largely because they deemed it less reliable. The space division representatives concluded their part of the presentation by discussing the inherent merits of ART and SAINT II.[447]

The Assistant Secretary of the Air Force for R&D, Dr. Brockway McMillan, was enthusiastic about the Phoenix system. While he did not recommend using the Saturn, McMillan thought the Air Force should seriously consider the merits of obtaining an early launch date by using NASA's big booster. The assistant secretary, however, believed an Atlas-Centaur combination would be the most feasible booster for 10,000-pound payloads through 1965. Until then, McMillan favored Soltan.[448]

Pushing Harder

While the Dyna-Soar SPO sparred with SSD and Aerospace representatives over the merits of their proposals, Congress debated Kennedy's ambitious proposal to go to the moon. Some 10 weeks after Kennedy's remarkable announcement, on 6 August, the Soviets launched their second cosmonaut, Air Force Major Gherman S. Titov, successfully recovering him 25 hours and 18 minutes into his flight. He completed 17

---

[447]Moore, "Project Streamline."

[448]Geiger, *The History of the X-20 Dyna-Soar,* p. 83.

orbits. Gen. Schriever was still drafting his reply for Senator Stennis's subcommittee when Titov's 6 August flight reaffirmed the Soviet Union's superiority in space technology and underscored Air Force contentions regarding the nation's inferior state of readiness. The chairman of the Senate Armed Services Committee, Richard B. Russell (D., Georgia), agreed, believing a satellite the size of Titov's spacecraft could be used as a weapon. The chairman of the House Committee on Science and Astronautics, Representative Overton Brooks (D., Louisiana), also felt the Soviets clearly possessed the capability to launch manned satellites carrying nuclear weapons.[449] The Gagarin-Titov flights formed the public background for the Air Force's renewed campaign to win a larger role in the space program. While the Air Staff achieved some success in the previous fiscal year, it remained disappointed and frustrated by its inability to overcome two main obstacles: the continuing commitment of the Kennedy administration to Eisenhower's "space-for-peace" policy and the continuing skepticism of key defense officials toward many Air Force space proposals.[450] In FY 1961, NASA's budget surpassed DOD's space budget for the first time. By 1963, the NASA budget was $3.62 billion while DOD's space budget was $1.57 billion. Indeed, between the two space policies, "space-for-peace" continued to

---

[449]*New York Times,* 7 August 1961.

[450]Berger, *The Air Force in Space Fiscal Year 1962* p. 2.

enjoy the lion's share of the administration's fiscal support in spite of Air Force efforts.[451]

In its attempts to work around the second obstacle, the Air Staff repeatedly tried to convince OSD officials of the necessity for a military man-in-space program. Not until February 1962 would the Secretary of Defense reluctantly acknowledge the national importance of investigating the role of a military man-in-space. Even then he insisted that the investigation must seek commonality with the NASA-DOD national space program.[452] Deputy DDR&E Rubel, bluntly stated the OSD could not conceptualize a mission for a military man-in-space.[453] Nor did it seem even to define a role.

A Manned Military Space Capabilities Vehicle Study

Before these briefings, Gen. Schriever had become convinced of the need to accelerate Dyna-Soar. Furthermore, he believed the best booster would be the Phoenix A388.[454] On 11 August, he informed ASD, SSD, and his Deputy Commander for Aerospace Systems, Lieutenant General H. M. Estes, Jr., of HQ AFSC's approval of the streamlined plan. In fact, it must be "vigorously supported" by all elements of

---

[451]Ibid., pp. 2-3.

[452]Robert S. McNamara,"The Air Force Manned Military Space Program," Memo to Secretary of the Air Force Eugene M. Zuckert (Washington, D.C., 23 February 1962).

[453]John H. Rubel, Deputy Director of DDR&E, *Missiles and Rockets*, 5 March 1962.

[454]Geiger, *The History of the X-20 Dyna-Soar,* p. 84.

the command. Yet the acceleration of Dyna-Soar would not be simple. Schriever was still concerned over the duplication in SSD's SAINT proposal and ASD's orbital Dyna-Soar. These plans constituted complex and conflicting approaches to military spaceflight. Until reconciled, they could not be presented to HQ Air Force. Consequently, Schriever directed a Manned Military Space Capability Vehicle study to be completed by September. This study would consist of the plan to streamline Dyna-Soar and a Phase Beta investigation to determine vehicle configuration, boosters, military subsystems, and missions for an operational system to follow Dyna-Soar. Schriever also directed the review of AFSC's applied research program to assure it made contributions to Dyna-Soar and the far-Earth to geosynchronous orbital flights envisioned for the follow-on operational system.[455]

During an August 1961 meeting of the Designated Systems Management Group, the Secretary of the Air Force, Eugene M. Zuckert, commented on the question of Dyna-Soar's acceleration. He directed the three-step approach to continue until the position of Dyna-Soar in a manned military space program could be determined. Within the confines of the $100 million FY 1962 budget, the secretary believed action could be taken to facilitate the future transition from a Step I to a streamlined program. Finally, he requested his own staff study on various approaches to manned military orbital flight.[456]

---

[455] HQ AFSC, "SCGV-11-8-18," TWX to Deputy Commander, Aerospace Systems (Wright-Patterson AFB OH, 11 August 1961).

[456] Geiger, *The History of the X-20 Dyna-Soar,* pp. 84-85.

With the Titov flight still fresh in everyone's mind, Schriever's statement on the preparedness of the nation's military space program--approved for immediate release by Air Force Secretary Zuckert--reached the chairman of the Senate Preparedness Investigating Subcommittee, Senator John Stennis (D., Mississippi).[457] Schriever believed current Soviet capabilities demonstrated an impending space threat, endangering America's international prestige and security. He cited the frequency and payload size of the Soviet space launches. While America's space program continued to expand, past efforts to introduce military space programs "suffered under an unnecessary self-imposed restriction" of the artificial division into "space-for-peace" and "space for military use" concepts when no technical distinction actually existed. Indeed, when the Soviet Union orbited two officers of the Soviet Air Force, Gagarin and Titov, it did not feel compelled to proclaim the peaceful nature of their journeys. Equally important, many in the United States dismissed these flights as having no military significance when, in fact, a five-ton spacecraft could deliver a considerable military payload. Citing recent SAB recommendations, Schriever suggested eliminating the artificial division between the civilian and military space programs. By refocusing the existing sense of urgency into manned military space programs, the United States could surpass the Soviet Union within the decade.[458]

---

[457]Berger, *The Air Force in Space Fiscal Year 1962,* p. 5.

[458]Berger, *The Air Force in Space Fiscal Year 1962,* pp. 5-6.

Senator Stennis agreed. Embracing Schriever's views, he delivered a speech to the Senate on 26 September, repeating Schriever's statement and warning of the impending danger from the expanding Soviet threat. His staff would soon undertake a detached and exhaustive study of the military role in space, Stennis said, to determine whether the division of the civilian and military programs was proper in light of international developments.[459]

Although important congressional leaders were receptive to Stennis's pro-Air Force views, Kennedy vigorously reasserted the "space-for-peace" theme. On 25 September 1961, in an address to the United Nations general assembly, the president proposed an extension of the U.N. charter, which in discussing the limits of man's exploration of the universe, reserved outer space for peaceful purposes. Kennedy wanted to prohibit weapons of mass destruction in space or on celestial bodies, to open the mysteries and benefits of space to every nation, and to extend the rule of law to man's new domain--outer space.[460]

Interagency Rivalry Flares Again

Gen. H. M. Estes formed a committee in mid-August 1961 with representation from the Air Force Systems Command, RAND, MITRE, and the Scientific Advisory Board to formulate a manned military space plan. The plan was to be ready by the end of September. One of the working groups, chaired by a representative from the

---

[459]*Congressional Record*, Volume 107, Part 17 (Washington, D.C.: GPO, 1961), p. 21252 .

[460]*New York Times,* 26 September 1961.

Aerospace Corporation, favored terminating the Dyna-Soar program and redirecting Boeing's efforts to the development of a lifting-body at a cost of $2 billion. A second alternative was to accelerate a suborbital Dyna-Soar program, cancel the orbital phase, and initiate studies for far-Earth, orbital flights. This proposal would total $2.6 billion. The least feasible approach in this group's opinion would be to implement the streamlined proposal and initiate a Phase Beta to examine a follow-on operational system. Such a program would be the most expensive, totaling $2.8 billion.[461]

Scientific Advisory Board members, chaired by Professor C. D. Perkins, took the opposite position and strongly supported the last option offered by the Aerospace group. The SAB thought that the military applications of a lifting-body approach did not offer any more promise than Dyna-Soar. To emphasize this point, the board questioned the safety of the slow-speed flight characteristics inherent to Aerospace's lifting-body design. For one thing, it made conventional landings extremely hazardous. The group further argued for using the streamlined plan to refine military space objectives. Additionally, it insisted that a Phase Beta study and an applied research program should be undertaken to ensure the methodology of an advanced vehicle based on Dyna-Soar.[462]

---

[461]Lieutenant General H. M. Estes, Jr., "Manned, Military, Space, Capability, Vehicle Study," Letter to General Schriever (Wright-Patterson AFB OH, 28 September 1961).

[462]Geiger, *The History of the X-20 Dyna-Soar,* p. 86.

Gen. Estes reached his own conclusions about a manned military space study. The streamlined plan should receive Air Force approval; however, it should have unquestionable military applications, namely satellite inspection and interception missions. In turn, the deputy commander doubted that Dyna-Soar's current configuration could accomplish far-Earth orbital flights and survive the resulting reentry velocity--ranging from 35,000 to 37,000 feet per second--by using its radiative heat protection. He believed a lifting-body protected by ablative material would be necessary for these far-Earth orbital missions. Consequently, a Phase Beta study, conducted by Boeing, would be necessary to determine a super-orbital design for Dyna-Soar.[463]

McNamara also made a pronouncement at this time on Dyna-Soar. After hearing ASD's presentations on the program and the SSD's proposal, the Secretary of Defense seriously questioned whether Dyna-Soar represented the best expenditure of the nation's resources.[464] From this encounter with the defense department, the Air Staff derived a concept that would dominate the ebb and flow of the Dyna-Soar program from that time on. Before any military applications would be considered, the Air Force would need to perform a manned orbital flight and safe recovery--in essence, complete a research phase.[465]

---

[463]Estes, "Manned, Military, Space Capability."

[464]Geiger, *The History of the X-20 Dyna-Soar,* p. 87.

[465] HQ Air Force, "AFSDC-67166," TWX to HQ AFSC (Washington, D.C., 3 October 1961).

During a meeting of the Designated Systems Management Group in early October 1961, the group diverted from McNamara's observations, clearly in favor of the Air Force's proposal for a streamlined approach. The management group criticized SAINT II severely, insisting that the projected number of flight tests and the proposed funding levels represented an unrealistic projection and a subterfuge to undermine ASD's Dyna-Soar and gain a manned space program. As a result of this review, the Air Force prohibited further use of the SAINT designation.[466]

Continuing to Push

While the Air Force restricted the use of the SAINT designation, it did not feel compelled to refrain from speaking out for an expanded military space program, despite the president's reaffirmation of the "space-for-peace" policy before the U.N. during the previous month. In an address to the American Ordnance Association in Detroit on 26 October, Gen. LeMay, the new Air Force Chief of Staff following White's retirement on 30 June 1961, warned of the striking parallel between space power in the 1960s and airpower during the First World War. He believed that the nation with maneuverable space vehicles and revolutionary armaments could control space, just as the ability to deny an enemy from performing reconnaissance missions in World War I led to the development of fighter aircraft to control the high ground over the Western Front.[467]

---

[466] HQ Air Force, "AFSDC-S-67777," TWX to HQ AFSC (Washington, D.C., 5 October 1961).

[467] Berger, *The Air Force in Space Fiscal Year 1962,* p. 7-8.

Arguments such as these, advanced at a time when the Soviet Union monopolized manned orbital flight, won adherents among top administration officials. Vice-President Johnson, chairman of the NASC, began to believe the arbitrary distinctions made between the civilian and military space efforts did not serve the best interests of the United States. Even Kennedy seemed to express a more positive attitude toward a military role in space.[468] Still, concrete evidence of change would not come until December, when the Air Force received authorization to accelerate Dyna-Soar.

Meanwhile, to maintain a closer inspection of the Soviet Union's growing R&D, and its strategic implications, American reconnaissance satellites assumed greater and greater importance. In conjunction with their offensive nuclear potential, Soviet ASAT capabilities represented a direct threat to American intelligence gathering and decision making capabilities. How could the administration protect the nation's valuable reconnaissance assets? LeMay side-stepped the international agreement issue and argued for enforcing the peace through military capabilities and preparedness. To implement his initiatives, Air Force leaders converted the final development phase of Dyna-Soar from orbital bombardment to satellite inspection.[469]

---

[468]Ibid., pp. 8-9.

[469] U.S. Congress, House, Hearings Before the Committee on Armed Services, *Military Posture Briefings*, 87th Congress, 2nd Session (Washington, D.C.: GPO, 1962).

Faced with Soviet threats, the Kennedy administration, in an attempt to undermine Khrushchev's veiled verbal threats and to deflate the arguments of domestic proponents who advocated such defensive antisatellite programs as Dyna-Soar, revealed the details of American estimates of Soviet nuclear and antisatellite capabilities.[470] The administration did not make this decision without careful consideration; nevertheless, the Soviets quickly realized the implications of America's satellite intelligence breakthroughs and reacted as expected by increasing the intensity of their efforts to gain an operational ASAT.[471] In an additional response to Kennedy's politically embarrassing revelations, the Soviets matched American initiatives by agreeing to establish a permanent U.N. Committee on the Peaceful Uses of Outer Space.[472] The Soviets intended to use the U.N. politically as a platform to oppose various American space programs and deny the United States the use of its technological advantage.[473]

The Implications of McNamara's Management Policy

In the winter of 1961, as the United States and the Soviet Union debated international overflight rights, Secretary McNamara investigated alternatives to Dyna-Soar with the intention of cutting spiraling Defense Department costs. NASA's newly

---

[470]Steinberg, *Satellite Reconnaissance*, pp. 49.

[471]Roger Hilsman, *To Move a Nation* (New York, 1964), p. 164.

[472]Lincoln Bloomfield, "Prospects for Law and Order," in *Outer Space, Prospects for Man and Society* (Englewood Cliffs, NJ, 1962); *Red Star*, July 1961, as quoted in Bloomfield.

[473]*New York Times*, 23 October 1961; U.S. Arms Control and Disarmament Agency, *Documents and Disarmament 1961* (Washington, D.C.: GPO, 1962), pp. 738.

approved Gemini program offered to promote commonality between the two agencies and eliminate his concerns over any possible duplication between Dyna-Soar and Gemini.[474] In addition, McNamara's civilian experts initiated the Planning-Programming-Budget System (PPBS) of management and created five-year plans for R&D, weapons development, and cost reduction. Combined with the five-year plans, PPBS ensured each of these factors, as well as force requirements, military strategy, and foreign policy, remained in balance.[475] Consequently, in every functional pyramid of the DOD, new layers of centralized civilian bureaucracy radiated from the OSD.[476] With this depth of civilian control at every level of decision making, McNamara believed Air Force leaders could not possibly control their programs without his direction.

A Two-step Program for Dyna-Soar

On 7 October, Dyna-Soar officials completed an abbreviated development plan for a manned military space capability program. The plan consisted of the streamlined proposal, a Phase Beta study to determine approaches to the design of a far-Earth orbital Dyna-Soar, supporting test programs, and an applied research program. This

---

[474] U.S. Congress, Senate, Hearings Before the Permanent Subcommittee on Investigations of the Committee on Government Operations, *TFX Contract Investigation*, 88th Congress, 1st Session (Washington D.C.: GPO, 1962), pp. 756-758, 1030-34, Pt. 3-1063.

[475]Robert S. McNamara, *The Essence of Security: Reflections in Office* (London, 1968), pp. 93-96; Alain Enthoven and K. Wayne Smith, *How Much is Enough? Shaping the Defense Program, 1961-1969* (New York, 1971), pp. 30-36.

[476]McNamara, *The Essence of Security*, pp. 96-101.

plan would provide a technological basis for manned, maneuverable orbital systems and would help determine the optimum configuration for far-Earth orbital mission; it would also demonstrate the military capability of both orbital and far-Earth orbital vehicles. The Dyna-Soar program office considered the Phoenix booster system acceptable. On the other hand, it believed a new booster, based on the employment of Titan IIIC (which differed from Soltan by using two 120-inch diameter solid-propellant engines) would enable it to create a two-step program. While Dyna-Soar Step I would encompass the streamlined proposal, Dyna-Soar Step II would involve the development of a far-Earth orbital vehicle. Essentially, the SPO merged elements of all three former steps from the April 1961 program plan into a new two-step, totally orbital, program for a military weapon system.[477]

The program office anticipated the first unmanned orbital flight in November 1964, and the first piloted flight in May 1966. The next five flights would be piloted multiorbital missions. The ninth flight test, occurring in June 1966, would be an unmanned mission at far-Earth orbital velocities. The remaining nine flight tests would be piloted, with the purpose of demonstrating military missions of satellite interception and reconnaissance. The flight test program was to terminate by December 1967.

To accomplish this program, the Dyna-Soar office thought that it needed $162.5 million in FY 1962, $211.7 million for 1963, $167.4 million for 1964, $168.6 million

---

[477]Directorate of Systems Management Dyna-Soar SPO, ASD, "Abbreviated Development Plan, System 620A" (Wright-Patterson AFB OH, 7 October, 1961), pp. 1-2, 6-8, 17-25, 41-43.

for 1965, $99.0 million for 1966, $21.0 million for 1967, and $2.4 million for 1968. With $88.2 million already spent before FY 1962, the total cost for the development of a manned military Dyna-Soar vehicle amounted to $921 million.[478]

On 15 October 1961, Col. B. H. Ferer from the Dyna-Soar system staff office, HQ Air Force, asked W. E. Lamar, Deputy Director, Development, Dyna-Soar SPO, to brief Dr. Brockway McMillan, then a member of the military manned spacecraft panel. For the first briefing, Lamar presented a comprehensive narrative of Dyna-Soar's history and its current status. While McMillan approved the briefing for presentation to the spacecraft panel, he believed Lamar should *not* emphasize the program's military applications. Following the briefing to the panel, McMillan scheduled Lamar to brief Dr. L. L. Kavanau, Special Assistant on Space, OSD. Kavanau appeared interested in the various alternatives to accelerating Dyna-Soar and felt going directly to orbital flight was sensible.[479]

Based on the October proposal, Gen. Estes prepared another development plan for Dyna-Soar. This plan was presented in a series of briefings to AFSC, the Air Staff, and, on 14 November, to the Designated Systems Management Group. The central objectives of the two-step program were to be the development of a manned maneuverable vehicle capable of obtaining basic research data, demonstrating reentry at various speeds, testing subsystems, and exploring man's military function in space.

---

[478]Ibid.

[479]Geiger, *The History of the X-20 Dyna-Soar,* p. 89.

These objectives would be achieved by adapting the Dyna-Soar glider to a Titan IIIC booster. While accepting the concept of standard space launch for all DOD payloads of a certain weight, DOD decided against SSD's Phoenix system. On 13 October, OSD informed McMillan that the Titan IIIC would be the Air Force's new space booster and would be used to launch Dyna-Soar.[480]

To accomplish the task, the Dyna-Soar office considered two alternate funding plans. Plan A adhered to the established $100 million ceiling for FY 1962, $156 million for 1963, and required $305.7 million from 1964 through 1967. Total development funds would amount to $653.4 million and would permit the first unmanned launch by November 1964. Plan B followed the ceilings of $100 million for FY 1962 and $125 million for FY 1963. Under this approach, $420.2 million would be required from 1964 through 1968, totaling $736.9 million. This latter plan established April 1965 as the earliest date for the first unmanned launch. Regardless of which approach was taken, the proposed program would substantially expedite the first manned orbital flight, moving it up from 1967 to 1965.[481]

On 11 December 1961, HQ Air Force informed AFSC of the Secretary of the Air Force's approval. Dyna-Soar would in fact be accelerated. The suborbital phase of the old three-step program would be eliminated with the central objective the early attainment of orbital flight, with a Titan IIIC booster. The costs of Plan B in the

---

[480]Ibid., p. 90.

[481]Directorate of Systems Management Dyna-Soar SPO, ASD, "Development Plan, Dyna-Soar" (Wright-Patterson AFB OH, 16 November 1961), pp. 7-21, 44-54.

November 1961 development plan were accepted. Finally, the Air Staff instructed the Dyna-Soar office to present a new system package program to HQ Air Force by early March 1962.[482]

Col. Moore set the following tentative target dates for reorienting the program: the first air-launch would be in July 1964; the first unmanned orbital launch in February 1965; and the first manned orbital launch in August 1965. Indeed, Moore felt the advancement of the program to an orbital status represented a large step toward meeting the overall objectives of Dyna-Soar.[483]

The program office then issued instructions to its contractors, Boeing, Honeywell, and RCA. The tentative dates offered by Moore would be used as guidelines for establishing attainable schedules. From its first flight, the Dyna-Soar glider would be capable of completing one orbit. All flights would be end at Edwards Air Force Base, California. Equally important, OSD sanctioned only Step I of the two-step program. Because McMillan did not allow Lamar to brief Dyna-Soar's military applications to Kavanau, in the minds of some OSD officials no requirements existed for maneuvering in space nor for the development of military subsystems. On the other hand, the Air Staff never relinquished its goal for a hypersonic manned military space program. Once Dyna-Soar demonstrated the feasibility of manned maneuverable

---

[482] HQ Air Force, "AFSDC-85-081," TWX to HQ AFSC (Washington, D.C., 11 December 1961).

[483] Geiger, *The History of the X-20 Dyna-Soar,* p. 91.

reentry from orbital flight to a preselected landing site, an operational military system would follow.

Still, the SPO informed the contractors to make only a minimum number of changes to the glider and the transition section. Only those changes necessary to adapt the airframe to the Titan IIIC should be accomplished. To conform to the Plan B budget, a serious reduction in program scope would be necessary. Certain wind-tunnel tests would have to be suspended. The air-launch program would consist of only 15 drops from a B-52 and would be terminated in April 1965. The first two ground-launches would be unmanned and the remaining eight would be piloted.[484]

On 27 December 1961, Major General Joseph R. Holzapple, Deputy Chief of Staff, Systems and Logistics, HQ Air Force, issued Systems Program Directive 4, repeating the program objectives announced in the November 1961 development plan. Holzapple reemphasized the Air Force view: that military man-in-space was essential to national security. The Dyna-Soar program would provide an economical and flexible means for a military spacecraft to return to a specific landing site. Consequently, Dyna-Soar would fulfill a vital military need not covered in the national space program, or at least in the publicly recognized space program. While only a few officials within OSD knew about them, NRO's highly classified unmanned reconnaissance satellites were fulfilling the military requirement to gather information, even if they could not make conventional landings. The directive specified that the

---

[484]Ibid., p. 92.

Titan IIIC would be the booster. Only single-orbit missions were contemplated for each launch.[485]

The Soviet Hypersonic Threat

Concurrently, V. N. Chelomey, head of OKB-52, successfully launched the first of his group's unmanned hypersonic test vehicles, the MP-1.[486] Boosted into orbit on top of an R-12 from Soviet Air Force test site No. 1 at Kapustin Yar, the vehicle reentered the atmosphere forty minutes later. Descending from its apogee of 405 kilometers at 3,800 meters per second, the spaceplane maneuvered through the atmosphere by using an aft-mounted adjustable braking panel. It landed safely following the deployment of its parachute. The following day, with individuals from the State Commission, engineers examined the vehicle. To their surprise, almost all of the heat shielding remained intact. Additionally, all the onboard instrumentation still worked perfectly. After only a year, the project reached the point of experimental launches of the full-size models.[487] Since the merger with V. K. Myasishchev's OKB-23 in 1960, OKB-52 had solved the problems of complex gas dynamics, systems mockups, wind-tunnel tests, development of cosmonaut spacesuits, catapult tests, and the crew rescue system, all in preparation for the first full-size model. But to be ready

---

[485]Dyna-Soar SPO, pp. 7-25, 40-55; HQ Air Force, "Systems Program Directive 4" (Washington, D.C., 27 December, 1961).

[486]Kirpil and Okara, "Designer of Space Planes," pp. 14-16.

[487]Mikhail Rudenko, "Star Wars: History of the 'Death' of a Unique Spaceplane," *JPRS-USP-93-005*, 5 October 1993, pp. 32-34.

for launch within a year required sacrifices. OKB-23's previous work allowed OKB-52 to forego any further conceptual development; instead, they went directly to hardware development. The success of MP-1 led to the launch of a second full-size M-12 in March 1963.

McNamara's Nuclear Defense Strategy

As the Soviets continued to develop their hypersonic boost-glider successfully, economic and managerial concerns occupied McNamara's thoughts. His nuclear defense strategy would slice into Air Force desires for manned military space operations. In January 1962, McNamara introduced the no-cities (this is often referred to as the "Ann Arbor Strategy" because he announced it to the public in a commencement address at the University of Michigan),"counter-force," strategy to Congress.[488] Because this strategy called for a nuclear force second to none, it did not get past the Cuban missile crisis of October 1962 before McNamara replaced it with "assured destruction."[489] Under the strategy of assured destruction, Air Force reconnaissance satellites emerged as proven, low risk technology, politically stabilizing, and, therefore, cost effective assets to national defense. To McNamara, tampering with national security by deploying unproven, high-risk, politically destabilizing, and expensive manned space defense systems, such as Dyna-Soar, was

---

[488]William W. Kaufman, *The McNamara Strategy* (New York, 1971), 114-21; Shapley, pp. 139-46, 187-89, 196-200.

[489]Henry L. Trewhitt, *McNamara: His Ordeal in the Pentagon* (New York, 1971), 114-16; Shapley, *Promise and Power*, pp. 165-89.

imprudent.[490] McNamara continued to believe that close cooperation with NASA offered the best answer to U.S. space policy.

As McNamara balanced existing military space capabilities with the capabilities of NASA's space programs, the Air Staff rushed sought to develop Dyna-Soar as quickly as possible. Although HQ Air Force chose the low funding level of Plan B ($100 million for FY 1962 and $115 million for 1963), it also insisted on the accelerated flight dates of Plan A. The flight schedule of Plan A stipulated April 1964 for the air-launch program, November 1964 for the unmanned ground-launch, and May 1965 for the manned ground-launch. Maj. Gen. Holzapple would accept later flight dates only if an examination by AFSC revealed the impossibility of achieving such a schedule. Lastly, a new system package program had to be completed by March 1962.[491]

Major General W. A. Davis, ASD commander, protested the March 1962 date as an arbitrary limitation, saying that it did not allow the Dyna-Soar system office enough time to reshape the program. HQ Air Force tentatively agreed. On 2 February 1962, Holzapple issued an amendment to the system program directive of 27 December 1961, extending the completion date of a new system package program to mid-May 1962.[492]

---

[490]McDougall, *The Heavens and the Earth*, p. 339.

[491]HQ Air Force, "AFSDC-85-081."

[492]Major General Joseph R. Holzapple, deputy Chief of Staff, "Amendment 1 to Systems Program Directive 4" (Washington, D.C., 2 February 1962).

Dyna-Soar's Symbolism is Lost

Eighteen days after Holzapple issued his amendment, NASA astronaut Lt. Col. John Glenn rode a Mercury capsule to a successful orbital flight, ending the Soviet Union's monopoly of manned orbital spaceflight and dissipating the Air Force's dream of a greater role in space. The Glenn flight produced a huge feeling of relief and euphoria. A vast outpouring of international acclaim and goodwill flowed to the United States. This sentiment was not only for the achievement, but for the public manner in which it was conducted. As the Glenn flight reduced pressure on NASA, it undermined the Air Force's chances of using Dyna-Soar as a symbol of international prestige.[493]

The day after the sensational orbit of John Glenn, Major General W.B. Keese, Deputy Chief of Staff, Research and Technology, HQ Air Force, attempted to give further legal sanction to the redirected program by issuing an amendment to the development directive of 21 July 1960. Previously designated as System Development Requirement 19, the amendment deleted references to suborbital flights. Equally important, it deleted references to the development of military subsystems. While HQ Air Force stated that a reliable method for routine recovery of space vehicles would make military missions practical, the official elimination of Dyna-Soar's military subsystems from the program plan in truth weakened the Air Force's rationale for using Dyna-Soar as a weapon system. The amendment further stipulated that the

[493]Berger, *The Air Force in Space Fiscal Year 1962,* pp. 8-9.

program would be reoriented to single-orbit flights, with the first unmanned ground-launch occurring in November 1964.[494] Although the Air Staff believed eliminating overt references to military subsystems might help Dyna-Soar compete with future Mercury program flights for routine access to space within the administration's space-for-peace policy, the official elimination of military subsystems from the program in 1961 set the stage for OSD to criticize the program in 1963 for *not* having a military mission.

Two days after HQ Air Force issued Keese's amendment, McNamara issued a memorandum officially endorsing the redirection of the Dyna-Soar program. He directed the termination of the suborbital program, the attainment of orbital flight, and the employment of the Titan IIIC booster (the booster's first assigned payload). Funding would be limited to $100 million in FY 1962 and $115 million in 1963. Finally, McNamara insisted on redesigning Dyna-Soar to a nomenclature more suitable for a "research vehicle": a research vehicle whose program plan no longer contained its original military objectives.[495]

To ensure close coordination between the military and civilian space programs, Secretary McNamara issued a policy directive on 24 February 1962 assigning the Secretary of the Air Force the responsibility to support, to "the extent compatible with its primary mission," specific NASA projects and programs arising from joint

---

[494]Major General W. B. Keese, Deputy Chief of Staff, "Amendment 1 to ADO 19" (Washington, D.C., 21 February 1962).

[495]McNamara, "Manned Military Space Program."

NASA/DOD agreements.[496] By the end of 1962, approximately 50 arrangements and agreements between NASA and the DOD existed while the DOD performed more than $550 million worth of work for NASA.[497] Still, McNamara felt that the DOD should increase its utilization of NASA assets. Believing two national manned space programs would develop out of Dyna-Soar and Gemini, McNamara and administrator James Webb signed another letter of agreement on 21 January 1963. It stated the two agencies would ensure the most effective use of the Gemini in the national interest. Specifically, Gemini experiments were to be directed at requirements of both agencies. It concluded by saying, "DOD and NASA will initiate major new programs or projects in the field of manned spaceflight aimed chiefly at the attainment of experimental or other capabilities in near-Earth orbit only on mutual agreement."[498] To facilitate these arrangements, McNamara and Webb established a Gemini planning board, co-chaired by the associate administrator of NASA and the assistant secretary of the Air Force for R&D. McNamara considered this precedent a major step forward and supported DOD's relationship to NASA within the administration's space-for-peace policy. He believed DOD and NASA could work effectively within the existing organizational

---

[496]Robert S. McNamara,"DOD Support of NASA," DOD Directive (Washington, D.C., 24 February 1962).

[497] U.S. Congress, House, Hearings Before a Subcommittee of the Committee on Appropriations, *DOD Appropriations for 1964*, 88th Congress, 1st Session (Washington, D.C.: GPO, 1963).

[498]U.S. Congress, Senate, "TFX Contract," Part 9, p. 2412.

structure.[499] These domestic political events directly shaped Dyna-Soar's destiny.

By the end of February, a draft version of the Dyna-Soar system package program was completed. In the middle of March, the program office offered the preliminary outlines to AFSC and HQ Air Force. If the $115 million FY 1963 ceiling was maintained, the attainment of desired system reliability would be endangered and the flight profile of the glider would be limited. As a result of these presentations, HQ Air Force instructed the systems command to prepare their briefing for the DOD.[500]

On 17 April, officials from the Dyna-Soar office made a presentation to the DDR&E, Dr. Harold Brown. The program office wanted approval of a $12.2 million increase for FY 1963 and an additional $16.7 million to pay for the expenditures to make an unmanned ground-launch by May 1965. Brown offered to give both proposals further consideration. Additionally, he requested alternative funding levels for a May or July 1965 unmanned launch date.[501]

By 23 April 1962, a new program plan was ready. This time the Dyna-Soar SPO asserted its intentions for future military subsystems. While Dyna-Soar would be an R&D program, it would be R&D for a *future* military system. Dyna-Soar would

---

[499]Ibid., Part 3, p. 698.

[500]Directorate of Systems Management Dyna-Soar SPO, ASD, "Program Summary, 620A," Daily Activity Report (Wright-Patterson AFB OH, 19 March 1962).

[501]Directorate of Systems Management Dyna-Soar SPO, ASD, Daily Activity Report (wright-Patterson AFB OH, 19 April 1962); Major General W. a. Davis, Commander ASD, "System 620A Package Program," Letter to Major General M. F. Cooper, Deputy Chief of Staff, Systems, HQ Air Force (Wright-Patterson AFB OH, 25 April 1962).

explore and demonstrate maneuverable reentry of a piloted orbital glider capable of conventional landings at a preselected site. These demonstrations would lay the foundation for Step II, a military vehicle. For the SPO officials, the new program represented a fundamental step towards their original goal of attaining piloted military spaceflight--a view not shared by OSD. While SSD lost its initial bids to attain a hypersonic manned military system, it gained other leverage. Before redirection in December 1961, the Dyna-Soar SPO had final authority over the Step I booster being developed by the space division. Under the new program, a critical difference emerged--Dyna-Soar would only be one of the payloads for the standard space launch system, designated 624A.[502]

The new Titan IIIC standard launch vehicle contained a Titan IIIA as its core. Essentially a modified Titan II with a transtage composed of an additional propulsive unit and a control module, the Titan IIIA could place 7,000 pounds into an orbit of 100 nautical miles. The Dyna-Soar boost-glider, however, would ride the Titan IIIC booster. In addition to the Titan IIIA core, the Titan IIIC had two four-segment solid-rocket motors, capable of delivering a total of 1,760,000 pounds of thrust attached to its first stage. Liquid fuel propulsive units comprised the second and third stages, producing 474,000 and 100,000 pounds of thrust, respectively. Titan IIIC could place

[502]Directorate of Systems Management Dyna-Soar SPO, ASD, "System Program Package, 620A" (Wright-Patterson AFB OH, 14 May 1962), sections 1-1, 2-21, 5-3, 5-5, 6-10.

a maximum of 25,000 pounds in LEO. For Dyna-Soar's particular trajectory and conditions, however, the payload capability would be 21,000 pounds.[503]

In late May 1962, the consequences of the change in management became apparent. At SSD's request, Assistant Secretary McMillan asked the Dyna-Soar office to investigate the impact of a Titan IIIC using five-segment solid rocket boosters (SRBs) in the program. The additional segment would increase the booster's payload capabilities. Although this change would necessitate glider modifications amounting to $5.4 million, the program office recommended the five-segment configuration be selected for Dyna-Soar. The additional payload capability would be useful for future military missions. HQ AFSC concurred on 25 July.[504]

The new development plan defined the flight test program in three phases. One Dyna-Soar glider would now make 20 air-launches from a B-52C aircraft to determine slow-speed approach and landing characteristics, obtain data on lift-to-drag ratios, and accumulate information on the operation of the glider's subsystems. On four of the air-launches, the acceleration rocket would power the glider to a speed of Mach 1.4 and a height of 70,000 feet to gain data on flight characteristics at low supersonic velocities.[505]

---

[503]Geiger, *History of the X-20 Dyna-Soar,* p. 95.

[504] HQ AFSC, "LSCSAD-23-7-18," TWX to HQ ASD (Andrews AFB MD, 25 July 1962).

[505]Dyna-Soar SPO, "System Program Package."

Following the air-launch programs, two unmanned orbital launches would occur. These would verify the booster-glider system for piloted flight and demonstrate the feasibility of the glider's design at hypersonic velocities. The Titan IIIC would propel the glider to a velocity of 24,490 feet per second. After fulfilling its single-orbit mission, the vehicle would land at Edwards Air Force Base. Eight piloted single-orbit flights would follow, further exploring and defining the Dyna-Soar flight profile. According to the reasoning of the Dyna-Soar office, the first air-launch would occur in September 1964, with the final drop taking place in July 1965. The first unmanned ground-launch would be conducted in May 1965. The second unmanned flight would occur in August 1965. The first piloted flight was scheduled for November 1965 while the last manned orbital mission would be in the beginning of 1967. The Dyna-Soar office believed that this schedule represented the earliest possible launch dates while still remaining within the $115 million FY 1963 ceiling set by HQ Air Force on 27 December 1961.[506]

On 25 April 1962, General Davis forwarded the system plan to HQ AFSC for approval. In line with Brown's request for alternative funding proposals, the Dyna-Soar office submitted a more realistic funding schedule. To meet a May 1965 schedule for the first unmanned launch, $144.8 million would be required for FY 1963

---

[506]Ibid., section 6-10.

and $133.1 million for 1964. If the first unmanned launch was to occur in July 1965, then $127.2 million would be needed for FY 1963 and $133.1 million for 1964.[507]

Davis also felt that the $100 million financial requirement issued by the Pacific Missile Range, Department of the Navy, for the construction of four vessels for employment in the Dyna-Soar program was too much of a burden for the Dyna-Soar program, especially because other space programs would eventually use these facilities. Consequently, this cost should not be fully attributed to System 620A. Eventually, Pacific range officials lowered the requirement to three new ships and modification of an existing vessel, totaling $69 million. By the middle of May, Navy officials conceded that only ship costs of $36 million and a total range requirement of $49 million needed to be directly attributed to the Dyna-Soar program. Because of subsequent revisions in the program, range officials would later submit an increased estimate of $69 million for both the 10 October 1962 and the 11 January 1963 system package programs. The Dyna-Soar office would not accept this figure. By May 1963 total range costs relating to System 620A was finally established at $48.8 million.[508]

Having forwarded the program plan to HQ ASD, Dyna-Soar officials made presentations to HQ AFSC, HQ Air Force, and the DOD. If it remained within the $115 million FY 1963 ceiling, the development test program would be reduced. The reduction would decrease the reliability of the glider system, limiting the scope of the

---

[507]Davis, "System 620A."

[508]Geiger, *The History of the X-20 Dyna-Soar,* pp. 104-05.

flight test program. During one of the briefings to the OSD, Brown recommended significant changes to the Dyna-Soar program. Additional funds closer to the realistic funding schedule would be allotted for further development testing. Equally important, Dyna-Soar would fulfill multiorbit missions.[509] Dr. Brown's decision renewed the old debate regarding the capabilities of ASD's boost-glider and SSD's lifting-body. Because Aerospace officials enjoyed easy access and close relationships with Brown, Dyna-Soar officials would once again need to begin preparing a defense.

DDR&E Introduces Multi-Orbit Missions

On 14 May, the program office completed a revision to its system plan, they expanded the wind-tunnel program, adding glider and glider panel flutter tests, and contemplating more work on the heat-resistant ability of certain sections of the glider. Refinements to the glider design and dynamic analysis of the air vehicle vibration were also necessary. Furthermore, the program office scheduled additional testing of the glider's reaction control, environmental control, and guidance systems. A more comprehensive reliability program for the glider, communication and tracking systems, and analysis to reduce the weight of the glider's subsystems were also inaugurated.[510]

For the Dyna-Soar office, multiorbital missions seemed a logical and relatively inexpensive addition to the basic program. They would probably be scheduled for the fifth or sixth ground-launch. Such a demonstration, in the opinion of the SPO, would

---

[509]Ibid., p. 105.

[510]Dyna-Soar SPO, "System Program Package," sections 6-1, 6-54, 6-55.

be a prerequisite to more extensive exploration of the military function of piloted spaceflight. Multiorbital missions, however, would require a modification of the guidance system, an increase in the reliability of all subsystems, and an additional deorbiting unit. Previously, a single-orbit Dyna-Soar mission did not require a deorbiting system, largely because the flight profile was actually a ballistic trajectory.[511]

The Dyna-Soar office considered two alternatives for equipping the glider for deorbiting. One possibility was to place a system in the transition section (the adapter section from the glider to the booster) of the glider. Another approach, eventually chosen, would be to employ the transtage of the Titan IIIC vehicle. This fourth stage would permit accurate orbital injection of the glider and would remain attached to the transition section to provide deorbiting propulsion. It could also be used in orbital plane changes on military missions.

Along with these additions to the system package program, the Dyna-Soar office submitted a new funding schedule. This involved $152.6 million for FY 1963, $145.2 million for 1964, $113.7 million for 1965, $78.3 million for 1966, and $17.7 million for 1967. The proposal set the total cost for the Dyna-Soar program at $682.1 million.[512]

---

[511]Ibid.

[512]Ibid.

Before the DOD acted on these revisions, the system office and HQ Air Force determined a new designation for Dyna-Soar that reflected the experimental nature of the first step of the program. In his February memorandum, McNamara directed Secretary Zuckert to replace the name Dyna-Soar with a numerical designation, such as the X-1, X-15, and so forth. J. B. Trenholm, Jr., assistant director of the program office, asked his director for program control to come up with a number for Dyna-Soar while retaining Dyna-Soar as the popular name. Whatever the designation, HQ Air Force wanted it by April.[513]

Following Air Force regulations, the director for program control reluctantly submitted ARDC form 81A, offering the designation, XJN-1 but asking to keep the name "Dyna-Soar." Colonel Ferer, HQ Air Force, did not like the XJN-1 label. In its place he offered XMS-1 to designate it as an experimental-manned-spacecraft. Other elements in HQ Air Force and in the DOD objected to both designations. Finally, on 19 June 1962, HQ Air Force approved the designation, X-20. On 26 June, a DOD news release explained how this new designation described the experimental character of the program--and did so without mentioning a military follow-on in Step II.[514] By the middle of July, HQ Air Force allowed "Dyna-Soar" to stand with X-20.[515]

---

[513]Geiger, *The History of the X-20 Dyna-Soar,* p. 107.

[514] DOD, "Dyna-Soar Designated X-20," News Release (Washington, D.C., 26 June 1962).

[515]Geiger, *The History of the X-20 Dyna-Soar,* p. 107.

International Intrigue Over Reconnaissance Satellites

In addition to Dyna-Soar's redesignation, arguments concerning satellite overflights frequently occurred throughout 1962 at international meetings, conferences, and in the media. The Soviet position suggested that America's satellites represented aggressive actions; therefore, a Soviet military response would be a legitimate act of self-defense. The Soviet Union's technological capabilities for space operations made the option of space reconnaissance becoming illegal a possibility. If this occurred, the Soviets could justify shooting down American satellites just as they shot down the U-2 in May 1960.[516] The outlawing of reconnaissance satellites would force the United States to limit severely, maybe even end, its satellite programs. In turn, such a space law would hamper America's ability to monitor Soviet military developments and make the United States vulnerable to surprise attack.[517] For this reason, America could not allow an interruption in the flow of information provided by its reconnaissance satellite network.[518]

Meanwhile, state department discussions in the U.N. increased awareness of the potential arms-control benefits of reconnaissance satellites and reasserted the American

---

[516]U.S. Congress, House, *DOD Appropriations for 1964*, pp. 589-93.

[517]Steinberg, *Satellite Reconnaissance*, p. 56.

[518]*Missiles and Rockets*, 7 January 1962, p. 9; U.S. Congress, House, Armed Services Committee, Hearings on Military Posture, *House Report 9751*, 87th Congress, 1st Session (Washington, D.C.: GPO, 1961), pp. 3179, 3184.

position: peaceful uses of outer space included Earth observation.[519] But the actual similarity between military and civilian uses of space, coupled with the administration's continued desire to pursue a "space-for-peace" policy, kept military programs under close scrutiny in mid-1962, especially controversial programs like Dyna-Soar. When the Soviets launched their own reconnaissance satellite--*Cosmos* 4 on 26 April 1962, mutual intelligence gathering capabilities warmed East-West relations. Now both nations could watch the strategic arms developments of the other from the high ground of space. From these developments the State Department considered correspondence between Khrushchev and Kennedy as an indication that the Soviets would respond favorably to American restraint in defensive military space operations.[520] The implications of American restraint coincided with Brown's views. The DDR&E felt ambivalent about a military role in space because, according to Brown, military requirements for manned systems like Dyna-Soar did not exist.[521] Instead, a "building-block" approach should be implemented to meet any possible contingency. Such an incremental approach would provide "insurance" should a need for defensive military space weapons be justified. In addition to identifying specific requirements, these

---

[519]U.S. Congress, House, Armed Services Committee, p. 3709.

[520]Ibid.; U.S. Arms Control and Disarmament Agency, *Documents and Disarmament 1962* (Washington, D.C.: GPO, 1963), p. 1121.

[521] U.S. Congress, Senate, Hearings Before the Committee on Aeronautical and Space Sciences, *NASA Authorizations for FY 1963*, 87th Congress, 1st Session (Washington, D.C.: GPO, 1962), p. 343.

efforts would shorten any time lag in full-scale development.[522] This policy again restricted Dyna-Soar to a research role. Equally important, Congress, delighted by the success of Glenn's February flight and later by Commander Scott Carpenter's 24 May flight, lost interest in pursuing a vigorous reexamination of the separation of roles and missions between NASA's and DOD's space programs.

Conclusion

Thus, the situation reverted to what it had been before the Air Force attempted to push for a reexamination of the civilian-military relationship. The Air Force would not be getting a larger portion of the nation's space program. Mirroring these sentiments, Deputy Secretary of Defense Roswell L. Gilpatric told a Senate committee in 1962 that the DOD would remain conscious of the need to ensure the United States technological parity, or superiority, with the Soviet Union's military space capability. DOD would accomplish this task by continuing to support the national objective of "space-for-peace."[523] Additionally, Brown made it clear that OSD fully supported the language and intent of the Space Act and would not preempt areas designated for NASA. In fact, he observed, DOD's planned space efforts for the following year would be much smaller than NASA's.[524]

---

[522]Ibid., p. 335.

[523]Roswell L. Gilpatric, Deputy Secretary of Defense, *NASA Authorization for FY 1963*, Statement made during Senate hearings before the Committee on Aeronautical and Space Sciences, 87th Congress, 2nd Session (Washington, D.C.: GPO, 1962).

[524]Harold Brown, DDR&E, *NASA Authorization for FY 1963*, Statement made during hearings before the Committee on Aeronautical and Space Sciences, 87th

On 14 June 1962, the president also commented on the civilian-military space issue. Responding to a correspondent's question, Kennedy said the existing mix between civilian and military space efforts--with NASA as the primary player--should continue. As a result, the Air Force's efforts to win a larger role in space and to modify the "space-for-peace" policy came to an end, at least temporarily.[525] With Glenn's orbital flight eliminating the international "prestige" factor as a justification for Dyna-Soar, political support to use the program as part of an expanding Air Force sponsored military space program eroded as well. Once again, officials within the OSD viewed the program solely as a research project, denying its military utility by refusing to fund its military phase.

In February 1962, McNamara finally identified the purposes of a manned military space initiative. It would establish the technology and experience necessary for manned space missions, rendezvous with uncooperative targets, demonstrate maneuverability during orbital flight and reentry, achieve precise recovery, and ensure the reusability of these vehicles with minimum refurbishment. In order to achieve these objectives McNamara offered to support three programs. The orbital, research, Dyna-Soar program would provide the technological basis for maneuverability on-orbit, reentry, and accomplishing a precision recovery. A cooperative effort with NASA's Gemini program would provide commonality between the agencies while yielding

---

Congress, 2nd Session (Washington, D.C.: GPO, 1962).

[525] *New York Times*, 15 June 1962.

additional rendezvous experience and on-orbit maneuverability. Finally, a manned space laboratory to conduct sustained tests of military systems would be useful.[526] From April 1959, when former DDR&E York altered the military objectives of the 1957 development plan through the December 1961 redirection, the DOD had been placing major emphasis on the development of a suborbital research vehicle. In spite of intensive comparative studies with SAINT II and Gemini vehicles, the central purpose, from DOD's perspective, remained unchanged. Indeed, by February 1962, McNamara had officially requested the new X-20 nomenclature to emphasize Dyna-Soar's experimental, rather than military, nature. Conceivably the redirected program could appear as a reversal of the research-oriented three-step approach defined by York in favor of a new program centered on the orbital Step II military objectives. While the three-step program defined military objectives for Steps II and III, the "real" Dyna-Soar program, under York's guidance, consisted of a experimental glider for suborbital flight. Similarly, although McNamara's sanction of orbital flight marked an advance over the three-step approach, inasmuch as orbital and multiorbital flights became established objectives of the first step, DOD officials refused to embrace the military objectives offered by the Dyna-Soar program office. To McNamara and other OSD officials, the "real" program remained centered on a research vehicle. Only through a building-block approach where a research vehicle represented the first block could Dyna-Soar proponents gain an opportunity to explore military missions.

---

[526]McNamara, "Manned Military Space Program."

Although Air Force officials selected ASD's glider rather than SSD's lifting-body as the beginning building-block, the interagency battle between the two agencies slowed the development of hypersonic flight. Yet the acrimony between them did not end with the Air Force's decision to go with Dyna-Soar. SSD was responsible for Dyna-Soar's booster, the new Titan IIIC. As OSD placed more importance on the Titan IIIC's ability to launch a large payload, Dyna-Soar's value as the booster's first payload was superseded. OSD subordinated Dyna-Soar to the Titan IIIC by refusing to modify the booster to meet the needs of Dyna-Soar and by coupling Dyna-Soar's development schedule to the Titan IIIC's. Being able to launch a heavier, more sophisticated, second-generation reconnaissance satellite for the NRO would come before ASD's need to modify the booster for Dyna-Soar or advance its development schedule.

Knowing the military capabilities of NRO's reconnaissance satellites, the ability of NASA to place a man in orbit, and the burgeoning promise of NASA's Gemini program to perform military requirements in space, OSD officials began to question the need for a separate Air Force-sponsored manned spaceflight program. To these officials, the Air Force's vision of space requirements was inverted. The Air Force wanted routine access to space before it proved what a man could do in space that a machine could not. The Air Force faced a "Catch-22." How could it demonstrate a military need for a man-in-space before it placed one in space to prove his capabilities? Ultimately, Dyna-Soar proponents would have to prove their point by quantifying and qualifying Dyna-Soar against space systems they knew little, if anything, about.

CHAPTER 7

THE DYNA-SOAR CANCELLATION

McNAMARA: What can the X-20 do that SAMOS can't do?
LAMAR: I don't know. I'm not cleared for the program.
McNAMARA: Well, you should be.

Conversation between Secretary of Defense McNamara
and Director, Dyna-Soar Engineering, William E. Lamar,
23 October 1963 at Denver, Colorado[527]

William Lamar could not have known anything about the operational details of NRO's SAMOS reconnaissance satellite unless someone in OSD told him. As a highly classified "black" program, it "did not exist" after the administration initiated its black-out policy in 1961, except for those who had a "need-to-know." OSD officials had not informed Lamar or any of the Dyna-Soar management because OSD did not believe they had a need-to-know even though SAMOS reconnaissance capabilities directly competed with Dyna-Soar's for the same mission. If Dyna-Soar management had known about the capabilities and limitations of the NRO's reconnaissance satellites, they could have used that information to highlight Dyna-Soar's unique abilities to use

---

[527]Colonel William L. Moore, Program Director, "X-20 Status Report to Secretary McNamara," Memo (Wright-Patterson AFB OH, 24 October 1963); Colonel William L. Moore, Program Director, "Record Memorandum of the X-20 Presentation to Secretary of Defense McNamara, 23 October 1963, and Pertinent Background," Memo (Wright-Patterson AFB OH, 30 October 1963).

the same quality of reconnaissance equipment. Instead, the secrecy surrounding reconnaissance satellites handicapped Lamar's ability to place Dyna-Soar properly within the administration's space-for-peace or military space policy.

Sustained by the largest space-oriented budget in its history but restrained by the strictest of OSD-imposed constraints, the SSD succeeded in attaining some of its long-term space objectives during FY 1963, particularly with its Titan IIIC booster and interim antisatellite capability. Meanwhile, the NRO's highly classified first-generation reconnaissance satellites, notably SAMOS, began to provide critical strategic information to the Kennedy administration, making more sophisticated--second-generation--reconnaissance satellites even more desirable. OSD's rejection and redirection of the Air Force's space proposals for manned military space operations offset these achievements, however. Secretary McNamara continued to control funding strictly, insisting on absolute program definitions in support of his arguments for commonality between DOD and NASA manned space programs. Because McNamara could quantify and qualify the America's strategic superiority over the Soviet Union, his concerns about manned military spaceflight centered more on obtaining the most efficient and economical use of the nation's space resources rather than spending whatever it took to develop a military space program to meet a high priority threat. Additionally, as in the past, the self-imposed restraints of the administration's "space-for-peace" policy adversely affected the development of Dyna-Soar. While the public knew about Dyna-Soar's development, they did not know the administration continued to give the NRO's unmanned reconnaissance satellites the highest development priority.

Nor would the public, or Dyna-Soar proponents, soon learn about the NRO's programs because OSD continued to restrict the flow of information about these national assets. Consequently, it would be difficult for proponents of a publicized program like Dyna-Soar to compete with these programs for a military space requirement.

As a result, the Air Force limited its roles in space to two: its mission to deter and, if necessary, wage war, and its responsibility of observing and analyzing Soviet intentions based on the reconnaissance of its space capabilities. Air Force Chief of Staff LeMay and his predecessor, General White, made public statements about the Soviet threat in space, emphasizing America's need for inspecting and, if necessary, eliminating Soviet satellites--manned or unmanned. LeMay believed that the Soviets would deploy military space systems when they found them feasible and advantageous. The Soviets might orbit a nuclear weapon and detonate it in space or direct it to a target on Earth. Based on this forecast, the Air Force believed that the Soviets could soon intercept and possibly damage an American satellite by using space tracking systems and surface-to-surface missiles. Nevertheless, the Air Force also believed that the Soviet Union--while continuing to exploit space for political and psychological purposes--would not acquire an effective offensive weapon system before 1970.[528]

Air Force leadership also realized that 1970 would be too late to prepare for this sort of Soviet threat. The United States needed to develop the capability to counter the

[528] U.S. Congress, House, Hearings Before a Subcommittee of the Committee on Appropriations, *DOD Appropriations for 1964*, 88th Congress, 1st Session (Washington, D.C.: GPO, 1963), Pt. 2, pp. 436-37.

anticipated threat of the 1970s now. Secretary of the Air Force Zuckert believed that the Air Force could redeem the R&D promises of the 1950s. Over the past few years, the Air Force had laid a solid foundation for the space defense systems of the future. Still, the service had a long way to go in developing those systems. The window of time to move from a developmental to an operational level could not be lost. Ready capabilities--not a technology base--constituted deterrence, which meant that the Air Force had to convert its space technology base at once.[529] The blueprint for those conversions was already in the service's proposed five-year space plan.

Because McNamara had previously suggested such a step be taken, LeMay directed Lt. Gen. James Ferguson, Deputy Chief of Staff, R&D, to draft a five-year space plan on 26 June 1962. While the five-year plan crystallized practical ways for the Air Force to achieve its space objectives, McNamara ignored the document he helped to create. Taking his lead from McNamara, Deputy DDR&E John Rubel echoed a similarly negative response, assuring the SAB that had been convened to review the five-year plan that it would receive little OSD support. As far as OSD was concerned, the plan failed to justify the requirements for the programs it outlined. Rubel made it quite clear: a national space program existed, not an Air Force space program. All Air Force space activities would be conducted within the framework of an overall DOD space program. Consequently it was inappropriate for the Air Force

[529]Ibid., p. Pt 2, p. 421.

to be pursuing space objectives on its own.[530] Moreover, OSD did not believe that the Soviet threat in space warranted the Air Force's five-year plan. DOD's building-block approach to program development was adequate, even at its current level, a judgment based on information from the "black" world of NRO's spy satellites like SAMOS.[531] All the while, the Soviets were proceeding nicely with their hypersonic boost-glide research. In March 1963, they launched the second full-scale mockup of their hypersonic glider.[532]

While final DOD approval of Dyna-Soar's system development plan was still pending in the middle of 1963, the effect of the December 1961 redirection was significant. The first Dyna-Soar development plan of October 1957 had defined specific military objectives, in terms of both orbital reconnaissance and bombardment vehicles. In April 1959, Herbert York, then DDR&E, altered these goals by placing major emphasis on the development of a suborbital research vehicle. In the years following, despite intensive comparative studies with SSD's manned lifting-body--SAINT II--and NASA's Gemini spacecraft, the central purpose did not change. Even though Secretary McNamara's memorandum of February 1962 elevated Dyna-Soar to an orbital vehicle, the glider was still officially described by OSD as an experimental system.

---

[530]Gerald T. Cantwell, *The Air Force in Space Fiscal Year 1963* (USAF Historical Division Liaison Office: GPO, 1966), pp. 4-8.

[531]Futrell, *Ideas, Concepts, Doctrine*, pp. 426, 434-36.

[532]Rudenko, "Star Wars," p. 32.

Even though it knew what military missions the Air Force planned for Dyna-Soar, OSD considered the program a means of obtaining research data on maneuverable hypersonic reentry while demonstrating the ability to make a conventional landing at a preselected site.[533] McNamara had his own agenda for a national military space program. He considered the establishment of a technology and experience base for manned space missions as the immediate building-block. Dyna-Soar would provide an initial technological and experience base. Only with a space station would the Air Force obtain an operational military system.[534] The Air Force felt Dyna-Soar offered more than just research opportunities. It saw DOD's sanction of the new program as an advancement over the three-step approach inasmuch as orbital, and even multi-orbital, flights--operational functions of the reconnaissance-based mission of Step II in the older development plan--became established objectives. In fact, the Air Force believed Dyna-Soar could operate as a ferry vehicle in a larger military space system based on the concept of routine access to a military space station. But as the Air Force considered McNamara's preference for a military space station, it ran the risk of seeming to select a space station over Dyna-Soar.

In 1963, the DOD would again question the need for Dyna-Soar. Ironically, the Air Force was told to direct its hypersonic program towards its originally planned

---

[533] HQ Air Force, "AFSDC-85-081," TWX to HQ AFSC (Washington, D.C., 11 December 1961).

[534] Robert S. McNamara, "The Air Force Manned Military Space Program," Memo to Secretary of the Air Force Eugene M. Zuckert (Washington, D.C., 23 February 1962).

military goals or terminate it in lieu of another approach to a manned military space system. During the Phase Alpha studies of 1960 and the Manned Military Space Capability Vehicle studies of 1961, the maneuverable reentry approach of the hypersonic glider had been compared with other reentry proposals and systems. On these two occasions, both the Air Force and DOD had deemed the Dyna-Soar as the most feasible, although DOD had continued to emphasize the Step I research phase of the program while restricting Air Force efforts to develop the military systems of Steps II and III. In the 1963 evaluations, the X-20 program would not be as fortunate.

In January 1963, McNamara took another significant step in defining the manned military space program: he directed a comparison between the Dyna-Soar and Gemini programs in order to determine the one with the greatest military value.[535] Gemini became even more important a few days later when DOD completed an agreement with NASA for Air Force participation. Following a Dyna-Soar program review in March 1963, McNamara further clarified his redirection of manned military space operations in light of the Gemini/X-20 comparison. He stated that the Air Force had been placing too much emphasis on controlled reentry to a selected landing site and not enough on the missions Dyna-Soar would perform on orbit, that is, satellite inspection, reconnaissance, defense of space vehicles, and the introduction of offensive weapons in space. He told the Air Force to take as long as six months to determine the most practicable test vehicle for these military space missions. In truth, however,

---

[535]Robert S. McNamara, "Gemini and Dyna-Soar," Memo to DDR&E (Washington, D.C., 18 January 1963).

McNamara already believed that a space station serviced by a lifting-body ferry vehicle was the most feasible approach.[536] Nevertheless, HQ Air Force directed AFSC to organize studies concerning X-20 and Gemini contributions to these four on-orbit missions.[537]

Alternatives to Dyna-Soar

On 6 July 1962, Deputy Secretary of Defense Roswell L. Gilpatric advised the Dyna-Soar SPO that it would be limited to $135 million and that the Air Force should make every effort to maintain future funding at that level. Reemphasizing OSD's view of the program as solely a research project, Gilpatric made it clear that, should the restricted funding force technological choices, the Air Force should emphasize research data rather than push for an early launch date. Six days later, the Air Force Chief of Staff approved a Military Orbital Development System (MODS) system development plan previously prepared by AFSC and the Air Staff in June 1962.[538]

At the same time, Gilpatric initiated a program definition study and created a System Program Office (SPO) within AFSC. Furthermore, he directed the Air Staff to

---

[536]McMillan Brockway, Assistant Secretary of the Air Force R&D, "Secretary McNamara's Trip to Seattle," Memo to Secretary of the Air Force (Washington, D.C., 15 March 1963).

[537]McMillan Brockway, Assistant Secretary of the Air Force, R&D, "Dyna-Soar Briefing to Secretary McNamara," Memo to Secretary of the Air Force (Washington, D.C., 18 March 1963).

[538] Space Systems Division, *Partial System Package Plan, Military Orbital Development System (MODS), System Number 648C* (Los Angeles CA: Space Systems Division, 1962), section 1-1.

seek $14.7 million in emergency DOD funds to support FY 1963 efforts.[539] A program change proposal justifying the expenditures called for the acquisition of an orbital station system to assess the capability of men, material, and techniques of performing military space missions. The proposed MODS would have three major elements: a station module, a logistics support vehicle, and a launch vehicle.[540] The station module, containing a work area of 1,100 cubic feet, would be placed into near-Earth orbit by a Titan IIIC booster. A Titan IIIC would also be used to boost the logistical support vehicle into orbit, a modified Gemini capsule with a payload of 2,500-5,000 pounds and a paraglide capability (Rogallo Wing) for precision landings.[541] The spacecraft would also provide a means for crew rotation and resupply. To accomplish military objectives, the Air Force planned four launches of the station module and 12 of the logistical support vehicles. Crew rotations would be every 15 to 30 days, gradually extending to year-long rotations. By March 1967, the station would begin operations. Its cost would be approximately $733 million.[542]

On 13 July 1962, HQ Air Force informed AFSC of the Secretary of Defense's conditional approval of the 14 May revision to its Dyna-Soar system development plan. Instead of the requested $152.6 million for FY 1963, McNamara authorized $135

---

[539]Ibid.; Futrell, *Ideas, Concepts, Doctrine*, p. 389.

[540]Space Systems Division, *MODS*, sections 1-1, 3-1, 5-1, 6-1, 11-1, 12-1, 14-1.

[541]Hansen, *Spaceflight Revolution*, pp. 380-84, 387.

[542]Space Systems Division, *MODS*, sections 1-1, 3-1, 5-1, 6-1, 11-1, 12-1, 14-1.

million, insisting that future funding would not exceed this level. He further stipulated that Dyna-Soar's schedules would have to be compatible with Titan IIIC milestones. Additionally, he repeated that gaining technical confidence and data acquisition were higher priorities than flight schedules. HQ Air Force directed the program office to make appropriate changes to its development plan.[543]

Air Force Participation in Gemini

Although the Air Force's man-in-space planning centered on Dyna-Soar and MODS, these plans became complicated in the fall when the Air Force proposed its participation in the Gemini project. On 13 August 1962, Colonel Wilton H. Earle, Deputy Director, Development Planning, HQ Air Force, directed AFSC to expand its earlier proposal for Air Force participation in Gemini by incorporating it as a preliminary phase of MODS. Colonel Earle dubbed this proposed phase of MODS "Blue Gemini."[544] Earle described Blue Gemini as an early opportunity to advance manned military spaceflight by taking advantage of NASA experience and hardware. Blue Gemini would allow Air Force personnel to obtain operational experience, undertake specific orbital experiments, and make preliminary assessments of manned military space operations. This series of proposed Blue Gemini flights would produce a cadre of engineering officers, astronauts, and contractors who would understand the problems of launching a manned vehicle on something resembling a military time

---

[543] HQ Air Force, "AFSDC-5-9-65922," TWX to HQ AFSC (Washington, D.C., 13 July 1962).

[544] Futrell, *Ideas, Concepts, Doctrine*, pp. 388, 432-33.

schedule, operating it in space, then returning it to a landing site selected by the astronaut. Such results could be directly applied to MODS.[545]

The Air Force planned to use the basic Gemini capsule modified to a military configuration. It contemplated a series of six launches beginning in May 1965. In the first four flights, the Air Force would investigate and evaluate manned spaceflight techniques and subsystems planned for MODS or other future space operations. It would attempt to rendezvous and dock with an Agena target, inspect an Agena in orbit, perform post-docking maneuvers, and accomplish a precise recovery. The other two flights would concentrate on mission subsystem testing. Each Blue Gemini pilot would first ride as a copilot on a NASA Gemini to gain familiarity. Because of existing NASA experience and facilities, the Air Staff believed Blue Gemini would be inexpensive, about $273.8 million over a four-year period.[546]

Blue Gemini would never progress beyond the proposal stage, partially because a unified DOD-NASA position for it did not develop and partially because other developments overshadowed it. The fundamental difficulty would be Dyna-Soar. Some Air Force officials such as Lt. Gen. Ferguson preferred Blue Gemini, as did McNamara, because it would fly two years before the X-20. While Dyna-Soar remained the next logical step in the minds of most Air Staff officers, its first manned

---

[545] Space Systems Division, *Partial System Package Plan, Program 287, Supplement I (Blue Gemini)* (Los Angeles CA: Space Systems Division, 1962), sections 1-1, 2-1, 3-1, 6-1, 11-1, 12-1.

[546] Ibid.; Futrell, *Ideas, Concepts, Doctrine*, pp. 432-33.

ground launch would not take place until mid-1966, approximately the same time period for the proposed MODS initial operational capability.

Rather than wait two years, key Air Force R&D officials, like Assistant Secretary for R&D, Brockway McMillan, agreed that the Air Force should take advantage of Gemini technology, pending arrival of Dyna-Soar, MODS, or something like the aerospace plane.[547] Yet Gemini posed problems for the Air Force. How far could it go with Gemini technology before it jeopardized the X-20 or subordinated Air Force identity to NASA? While Gemini participation could give the Air Force significant experience in space during 1963-1966, it might also weaken the Air Force's case for having Dyna-Soar later on, when Gemini would still be trying to perfect its controlled paraglide landings using a controllable wedge-shaped parachute.[548] NASA would abandon this idea for Gemini in 1964, temporarily considered it for Apollo, and then mostly forgot about it.[549]

Meshing Dyna-Soar and the Titan IIIC

While the Air Force contemplated the virtues of Gemini, a problem arose as a result of OSD's decision to launch Titan II with a five--rather than four--segment solid-fuel motor. This combination, tentatively approved, would create excessive maximum dynamic pressure for the X-20 during the boost phase. Although other alternatives

---

[547]Futrell, *Ideas, Concepts, Doctrine,* p. 388.

[548]Space Systems Division, *MODS*; Space Systems Division, *Blue Gemini.*

[549]Hansen, *Spaceflight Revolution*, pp. 380-87.

presented themselves, SSD refused to compromise its development schedule by altering the booster. Consequently, ASD was, once again, forced to compromise Dyna-Soar's design to accommodate SSD. The X-20 would be reinforced to withstand the increased dynamic pressure. Naturally, this would slow Dyna-Soar's development, cost approximately $5.4 million, and increase the glider's weight by about 500 pounds.[550]

By 20 August 1962, DDR&E Brown had informed Air Force Chief of Staff LeMay that the Air Force's FY budget for space activities would not be increased. Defense priorities for R&D, testing, and evaluation programs would be based on the following three criteria: clearly defined military needs, technical feasibility, and relative cost effectiveness. On such a basis, it would be difficult to justify any increase in funding for space. In spite of OSD's redirection of Dyna-Soar in 1962, it still had not approved or funded System 624A, Titan IIIC. Because the X-20 would ride the fourth development launch of Titan IIIC, flight dates for Dyna-Soar could not be determined. On 31 August 1962, SSD informed the X-20 SPO that it could not furnish launch dates for the booster until OSD released funding. This should occur in November, with program development beginning in December 1962. Accordingly, the first Titan IIIC launch would occur 29 months later, and the fourth launch (the first

[550]Systems and Logistics Deputy Chief of Staff, "Dyna-Soar Adaptation to Titan Booster," Letter to Secretary of the Air Force (Washington, D.C., 3 August 1962).

unmanned Dyna-Soar launch) would take place 36 months after OSD gave the "go-ahead."[551]

Based on this tentative Titan IIIC schedule, the X-20 system office completed, on 10 October, another system development plan. Still containing some passing references to the military aspects of the program, the plan described Dyna-Soar as a manned R&D program of an orbital military test system capable of demonstrating hypersonic maneuverable reentry and completing a conventional landing at a selected site. Twenty air-drop tests would be conducted from January through October 1965. Two unmanned orbital launches would occur in November 1965 and February 1966. The first of eight piloted flights would take place m May 1966, with a possible multi-orbit launch occurring in November 1967. These X-20 schedules proved compatible with the Titan IIIC schedules. Therefore, on 15 October 1962, HQ Air Force issued System Program Directive 9, initiating R&D of the space booster on 1 December 1962. Total booster funding was to be $745.5 million from FY 1962 through FY 1966. The Dyna-Soar SPO felt $135 million would be required in FY 1963, $135 million in 1964, $102.78 million in 1965, $107.51 million in 1966, 66.74 million in 1967, and $10 million in 1968. For the development of the orbital X-20, the program would require a total of $766.23 million.[552]

---

[551] HQ SSD, "SSBT-31-8-26," TWX to HQ ASD (Los Angeles CA, 31 August 1962).

[552] Directorate of Systems Management Dyna-Soar SPO, ASD, "System Package Program, System 620A" (Wright-Patterson AFB OH, 10 October 1962), pp. 2-6, 11-5.

By late September, Dyna-Soar/Titan IIIC interface problems and ASD/SSD management problems produced a change in the ground rules. McNamara's February 1962 guidance called for minimum changes in the X-20 with additional costs borne by SSD's Titan IIIC office. The plan to go with the five-segment solid rocket motor, however, forced a departure from McNamara's instructions. Additionally, SSD's elimination of the Titan IIIC's fins--with the change supported by its contracted research associates in the Aerospace Corporation--also caused difficulties. Boeing flatly rejected SSD's decision, made without the coordination or concurrence of either the X-20 SPO or Boeing--the X-20 contractor. Boeing did not believe SSD/Aerospace Corporation assumptions that the Titan IIIC's would not to distort structurally in flight. Basing their opinion on hours of wind-tunnel tests that showed the Titan II distorted with the Dyna-Soar glider as a payload, Boeing engineers believed the Titan IIIC would also distort. Consequently, like the Titan II, the Titan IIIC would need fins. In the absence of fins, stabilization would depend entirely on the booster's flight control system, a modified version of the Titan II guidance system. Boeing did not believe that this would be sufficient. OSD, however, overruled Boeing's argument. These modifications caused unacceptable slippage in the Titan IIIC's development schedule. As a result, Dyna-Soar's December 1962 development plan described a hypersonic glider system completely responsive to the dictates of SSD's Titan IIIC development, rather than the reverse.[553]

---

[553]William E. Lamar, Deputy Director, "History of Dyna-Soar to Present," Presentation to HQ ARDC (Wright-Patterson AFB OH, 20 February, 1963), pp.

Shifting Power from ASD

Major General R. G. Ruegg, ASD commander, submitted this system development plan to HQ AFSC on 12 October 1962. It never received command endorsement. While the X-20 office concerned itself with Titan IIIC schedules and obtaining the approval of a new package program, HQ AFSC directed a change in the organization of ASD. On 28 September 1962, the AFSC transferred all the functions of the ASD Field Test Office at Patrick Air Force Base, Florida, to the 6555th Aerospace Test Wing of the Ballistic Systems Division.[554]

Previously, HQ ARDC had established a general policy for test procedures that placed firm control of system testing in the hands of various project offices rather than the test centers.[555] Consequently, the Dyna-Soar office appointed a test director for the entire test program and directed the Air Force Flight Test Center to provide a Deputy Director for Air-Launch while the WADD Field Test Office at Patrick Air Force Base provided a Deputy Director for Ground-Launch.[556] However, the test centers objected to giving the project offices full authority, largely because such a policy did not fully use their abilities to conduct flight test programs.

47-58.

[554] ASD Field Test Office, "ASFP-5-10-1," TWX to HQ ASD (Patrick AFB FL, 5 October 1962).

[555]Geiger, *History of the X-20 Dyna-Soar*, p. 109.

[556] HQ ARDC, "RDRA-30-9-43," TWX to HQ WADD (Andrews AFB MD, 30 September, 1960).

As a result, on 31 January 1962, General Schriever rescinded the August 1960 policy while directing the centers and test wings to prepare, then implement, the test plans. They would also appoint local test directors.[557] While Schriever believed this new policy would give the test centers more authority over the test programs, it did not result in any significant changes to the structure of the Dyna-Soar test force. Under this new arrangement, the program office appointed a Deputy System Program Director for Test, while the flight test center provided the Air-Launch Test Force Director and the Patrick field office, the Ground-Launch Test Force Director.[558]

Throughout these changes in the Dyna-Soar test structure, the 6555th Aerospace Test Wing of the Ballistic Systems Division held authority only during the operation of the booster. With the transfer of the functions of the ASD field office to this test group, the aerospace wing became, in effect, the director of the orbital flight tests. This test group would be responsible to the commander of BSD. In turn, the commander would, when conflicts occurred, determine priorities for the operations of his test wing.[559]

While these structural changes occurred, the Air Force attached tremendous importance to MODS. As the Air Staff formally approved the plan on 9 November

---

[557]Geiger, *History of the X-20 Dyna-Soar*, p. 110.

[558]Directorate of Systems Management Dyna-Soar SPO, ASD, "System Package Program, 620A" (Wright-Patterson AFB OH, 14 May 1962), pp. 5-15, 5-19.

[559]Major General W. A. Davis, Commander BSD, "Support of Test Programs by the 6555 ATW, Patrick AFB, FL," Memo to Commander ASD (Patrick AFB FL, 16 October 1962).

1962, Secretary Zuckert identified it as one of the four major space efforts for which he sought special funding from the Secretary of Defense, in spite of DDR&E's specific rejection of LeMay's 20 August request for additional Air Force space program funding.

Specifically, Zuckert sought an additional $363 million in FY 1964 funding for four projects: MODS, Blue Gemini, MIDAS, and the unmanned SAINT. In requesting $75 million for the orbital system in 1964, when nothing had been originally authorized, Zuckert argued that MODS would provide distinct advances beyond Dyna-Soar and Gemini, allowing DOD to resolve many of the uncertainties concerning manned military applications in space. In asking $102 million for Blue Gemini, also originally unauthorized, the secretary argued it would be an essential steppingstone to achieving an orbital system. While NASA's Gemini operations would be useful, they could not substitute for actual Air Force experience with its own vehicles. For the other two systems, Zuckert argued for increased funding to speed their development. OSD would approve only one of these requests, authorizing funds for Blue Gemini. It would not, however, be the same Blue Gemini program outlined by the Air Force but rather a DOD program conforming to McNamara's definition of commonality. A fundamental criterion for any future DOD space program would be its ability to mesh with NASA's efforts.[560]

---

[560] U.S. Congress, Senate, Hearings Before the Committee on Military Procurement, *Military Procurement Authorization 1964*, 88th Congress, 1st Session (Washington, D.C.: GPO, 1963), p. 242; Cantwell, *The Air Force in Space Fiscal Year 1963*, p. 10; Futrell, *Ideas, Concepts, Doctrine*, pp. 388, 432-33.

Following Zuckert's lead, Lt. Gen. Ferguson, Deputy Chief of Staff, R&D, told the Aviation Writers Association convention in Dallas, Texas, that "only MODS could give the Air Force the promise--indeed, the confidence--of overcoming the outstanding technical problems associated with manned spaceflight within a single program."[561] Such a program would be a national rather than departmental effort, carried out under DOD management and DOD funding with the experience and technical knowledge within NASA. This could, in fact, follow McNamara's desires for commonality, giving nation an opportunity to explore manned lunar landing while also advancing manned near-Earth explorations.

Reconsidering the Hypersonic Approach

In November 1962, as its commonality strategy began to take shape, OSD considered restricting Dyna-Soar's FY 1963 and 1964 funds to $130 million and $125 million instead of the previously stipulated level of $135 million for both years.[562] Colonel Moore told HQ AFSC that only through aggressive efforts would $135 million be sufficient for FY 1963. If anyone proposed further reductions, those reductions would be based on their lack of understanding for Dyna-Soar's requirements. Furthermore, an increase in FY 1964 funds would be necessary, raising the figure to

---

[561]Cantwell, *The Air Force in Space Fiscal Year 1963*, p. 26.

[562]Major General M. F. Cooper, Deputy Chief of Staff, "X-20 System Package Program," Letter to Lieutenant General H. M. Estes, Jr., Vice Commander, ASD (Andrews AFB MD, 16 November 1962).

$147.652 million.[563] Later, the SPO informed Gen. LeMay that Dyna-Soar's schedules could not be maintained if funding fell below these levels. Additionally, $135 million and $145 million would be required for FYs 1963 and 1964.[564] In an effort to conserve program funds, the X-20 office formulated a flight test program called "Westward-Ho," which eliminated the need for the construction of several control centers and multiple flight simulators. Previous planning had located a flight control center at Edwards Air Force Base for the conduct of the air-launch tests. The ground-launch program required a launch center and a flight control center, both at Cape Canaveral, in addition to a recovery center at Edwards Air Force Base. Westward-Ho called for the consolidation of the flight control centers for both the air-drop and ground-launch tests at Edwards, leaving only a launch control center at the Cape. The Air Force Flight Test Center would provide a test director for both the air-drop and orbital flight tests . The director would be responsible to the X-20 program office. By establishing one flight control center and employing only one flight simulator, the Dyna-Soar office estimated a savings of at least $3 million.[565]

As the Dyna-Soar SPO attempted gain additional funding through flight test center consolidations, Congressman Albert Gore, Sr. (D. Tennessee), replied to a

---

[563]Geiger, *The History of the X-20 Dyna-Soar,* p. 117.

[564]Air Force Chief of Staff, "AFRAE-69512," TWX to HQ AFSC (Washington, D.C., 18 January, 1963); HQ AFSC, "SCSAS-28-1-59," TWX to Chief of Staff, Air Force (Andrews AFB MD, 28 January 1963).

[565]Geiger, *The History of the X-20 Dyna-Soar,* pp. 110-11.

Soviet U.N. resolution attacking United States reconnaissance satellites on 3 December 1962 (this was two months after the Kennedy administration successfully avoided a nuclear war over Cuba). In his address Gore stated that the United States would take whatever steps were "necessary and consistent to avoid an arms race in outer space."[566] DOD took the first of these steps by canceling one of its defensive space programs, SAINT. With this initiative from DOD, Air Force officials felt other such defensive weapons might meet a similar fate. Still, they did not believe arms control agreements would eliminate the need for all defensive weapons systems. Confident in its estimates of military necessity and the administration's understanding of the dual nature of the program, the Air Staff felt Dyna-Soar would survive, if sufficient funding could be maintained.

As OSD canceled SAINT, AFSC failed to see the logic of Westward-Ho. On 19 December, AFSC vice-commander, Lieutenant General Estes, directed the establishment of a manned spaceflight review committee to examine all aspects of the X-20 test program, including its relationships to various AFSC agencies. Brigadier General 0. J. Glasser of the Electronic Systems Division (ESD) was to be its chairman. The review committee contained representatives from HQ AFSC, ASD, SSD, the missile test center, and the missile development center.[567] Interestingly, Col. Moore

---

[566] U.S. Arms Control and Disarmament Agency, *Documents and Disarmament 1962* (Washington, D.C.: GPO, 1963), p. 1123.

[567] HQ AFSC, "SCSS-19-21-1," TWX to HQ ASD (Andrews AFB MD, 19 December 1962).

noted how the Air Force Flight Test Center--the key agency in Westward-Ho--did not have a representative at this review. Furthermore, when he offered to familiarize the committee about Dyna-Soar's test requirement, the committee rejected the proposal.[568] Consequently, the Dyna-Soar SPO manager did not see the significance of the coming review.

Gen. Glasser's committee formally convened on 3 and 23 January and 5 February 1963. While they made no formal decisions at these meetings, the members discussed several critical points of the Dyna-Soar program. Although the Test Support Panel seemed to favor the location of a single flight control center at Edwards Air Force Base, it became quite clear how much Westward-Ho impinged on the organizational interests of the Air Force Missile Development Centers, SSD, and the Air Force Missile Test Center. Additionally, General Glasser emphasized another central problem confronting the Dyna-Soar program: the open conflict between SSD and ASD for control of the only Air Force manned space program.[569]

The Organization and Management Panel offered some solutions to this problem. First, management of the program by HQ AFSC would have to be altered. Like the Titan IIIC program, the Dyna-Soar system should be placed under the guidance of the deputy to the Commander for Manned Spaceflight instead of the

---

[568]Colonel William L. Moore, Program Director, "Manned Spaceflight Review Group," Letter to Major General Ruegg, ASD Commander (Wright-Patterson AFB OH, 2 January 1963).

[569]Geiger, *The History of the X-20 Dyna-Soar,* p. 112.

Deputy Chief of Staff, Systems. Equally important, the panel strongly recommended reassigning the entire program to SSD. General Glasser did not favor such a radical solution. Instead, he thought a single AFSC division should be made the arbiter for both the Titan IIIC and X-20 programs.[570]

While designating his deputy for manned spaceflight as a headquarters point of contact for Dyna-Soar, Gen. Schriever on 9 May 1963 altered the structure of the X-20 test force by directing SSD to name the director for X-20 orbital flights. The flight control center would be located at the Satellite Test Center, Sunnyvale, California. The AFSC commander, however, did emphasize ASD's responsibility to development of the X-20. At the end of July, Schriever also assigned responsibility for the air-launch program and pilot training to SSD.[571]

Stressing Commonality

Although the Air Force had undertaken a manned military space study in 1961, OSD did not give its blessing to a military space mission--or a particular program to fulfill the mission--for the Air Force. While the 1961 study compared the Dyna-Soar glider with a SAINT II lifting-body, Secretary McNamara was interested also in the military potentialities of NASA's two-man Gemini spacecraft. In his 23 February 1962 memorandum, the Secretary of Defense expressed his interest in this program. Gemini

---

[570]Ibid.

[571]General Bernard A. Schriever, Commander, "X-20 Program Management," Letter to Commander, SSD (Andrews AFB MD, 9 May, 1963); General Bernard A. Schriever, Commander, "X-20 Program," Letter to Commander, ASD (Andrews AFB MD, 31 July 1963).

could be used to demonstrate manned rendezvous of other spacecraft, an essential element of future ASAT operations.[572]

With this perception of Gemini's potential in mind, in January 1963 McNamara ordered another review of Dyna-Soar, particularly its relationship to NASA's Gemini spacecraft. He wanted to know to if the X-20 would provide a more valuable military capability than Gemini. He also asked for a comparison of the Titan IIIC to various alternative launch vehicles.[573]

McNamara stressed the importance of economics through this kind of commonality. He felt concerned about the nation spending $800 million each on two comparable, although admittedly not identical , programs. The secretary considered it a real danger. Because Gemini promised to put two men in space about two years earlier than the X-20 would orbit one man, the future of the X-20 program was questionable. Neither the unique capabilities of Dyna-Soar nor its contributions to research hypersonic flight really mattered.[574] This reasoning led McNamara to seek an agreement with NASA to allow more Air Force participation in its Gemini program. On 17 January, DOD completed an agreement with NASA. DOD would not only

---

[572]McNamara, "Manned Military Space Program."

[573]McNamara; Dr. Harold Brown, DDR&E, "Rationale for RDT&E Program Adjustments by OSD," Memo (Washington, D.C., 19 January 1963); Robert S. McNamara, "Review of Titan IIIC," Memo to DDR&E (Washington, D.C., 19 January 1963).

[574] U.S. Congress, Senate, Hearings Before the Committee on Armed Services, *McNamara Testimony*, 88th Congress, 1st Session (Washington, D.C.: GPO, 1963).

participate in the program but would also financially assist in the attainment of Gemini objectives.[575] While he could foresee no clear military need for either spacecraft, McNamara did concede the possibility of a military requirement for operations in near-Earth orbit. Therefore, he became anxious for either the X-20 or Gemini, whichever came first, to fulfill this contingency.[576]

Under this agreement, several DOD experiments planned for Dyna-Soar were to be carried out on Gemini flights (Gemini V represented the height of Defense Department participation). To facilitate these endeavors, McNamara and Webb established a Gemini Program Planning Board (GPPB), co-chaired by the associate administrator of NASA and the assistant secretary of the Air Force, R&D.[577] The GPPB would identify DOD-NASA scientific and technological requirements while monitoring the Gemini program to ensure that maximum benefits accrued to both agencies. In their joint announcement, McNamara and Webb characterized Gemini as a great national resource. They were determined to use it as a national asset, thus

---

[575]Robert S. McNamara, Secretary of Defense and James E. Webb, NASA Administrator, "DOD-NASA Agreement," Memo (Washington, D.C., 21 January 1963).

[576] U.S. Congress, Senate, *TFX Contract Investigation*, Hearings Before the Permanent Subcommittee on Investigations of the Committee on Government Operations, 88th Congress, 1st Session (Washington D.C.: GPO, 1962), Part 9, p. 2412.

[577]Futrell, *Ideas, Concepts, Doctrine,* p. 388.

avoiding unnecessary duplication.[578] Based on this pronouncement, McNamara came to the conclusion that the Air Force's Blue Gemini was an "unnecessary duplication." Furthermore, for any future program, McNamara and Webb concluded that neither agency would initiate new manned spaceflight programs or projects--aimed chiefly at attaining experimental or other capabilities in near-Earth orbit--without the mutual agreement of the other agency.[579]

For their part, Air Force planners considered the civilian-scientific orientation of NASA's Gemini technology, and the similar technology generated from its follow-on program, Apollo, incapable of providing the depth and breadth of information offered by Dyna-Soar. These programs were not slated to develop the military technology required for future manned military operations in space. Accordingly, the Air Staff proposed a $177 million allocation of the FY 1964 DOD budget for at least two additional programs: the Blue Gemini and MODS. McNamara considered these new military space programs a duplication of NASA's Gemini program and excluded them from the department's January 1963 budget requests submitted to Congress.[580]

---

[578] DOD, "DOD-NASA Agreement," News Release (Washington, D.C., 22 January 1963).

[579] U.S. Congress, House, Hearings Before the Subcommittee on Manned Spaceflight of the Committee on Science and Astronautics, *Agreement Between the NASA and the DOD Concerning the Gemini Program, January 1963*, 88th Congress, 1st Session (Washington, D.C.: GPO, 1963).

[580] Ibid.; Pt 6, pp. 521-24, 579-80; U.S. Congress, House, *DOD Appropriations for 1964*, Part 1, pp. 479-80; U.S. Congress, House, Hearings Before the Committee on Science and Astronautics, *Space Posture*, 88th Congress, 1st Session (Washington, D.C.: GPO, 1963), pp. 224-30.

At the end of January, Major General 0. J. Ritland, Deputy to the Commander for Manned Spaceflight, told the commanders of ASD and SSD of McNamara's intentions to focus on the X-20, Gemini, and Titan IIIC programs with his ultimate objective being the development of a manned military space system. General Ritland warned the feuding commanders: once a decision was made, it would be difficult for the Air Force to alter it. Consequently, HQ AFSC, SSD, and ASD would need to prepare a comprehensive response to the secretary's request. General Ritland then gave the SSD the responsibility for providing statements of the Air Force's manned space mission and for defining space system requirements, tests, and operations.[581]

The Consequences of Gemini Participation

By the end of February 1963, HQ AFSC compiled a position paper on the X-20 program to be forwarded to the Air Staff. They offered six alternative positions: maintain the present Dyna-Soar program, reorient to a lower budget through FY 1964, accelerate the flight test programs, reinstate a suborbital phase, expand the program further--exploring technological and military objectives--and, finally, terminate the X-20 program. HQ AFSC recommended continuation of the present X-20 and Titan IIIC programs.[582]

---

[581]Major General O. J. Ritland, Deputy to the Commander for Manned Spaceflight, "Gemini-Dyna-Soar Task Groups," Letter to Commander, SSD (Andrews AFB MD, 31 January 1963).

[582]Geiger, *History of the X-20 Dyna-Soar,* p. 114.

After reviewing AFSC's input and the inputs of several Air Staff agencies, the Air Staff Board began its recommendation with a strong statement for Dyna-Soar, which in everyone's opinion was the single most important Air Force program. The board believed that Dyna-Soar development could be fully justified on its research alone. It would expand the nation's reservoir of hypersonic knowledge and, as such, did not compete with NASA's Gemini. Indeed, it was a logical extension of the X-15 research vehicle. Additionally, the Titan IIIC should proceed as planned. The board felt that the Air Force should make maximum use of any results Gemini might provide in the future.

If the Air Force needed to compromise, the Air Staff would recommend a series of alternatives, partially based on AFSC's suggestions. First, the Air Force could retain the Dyna-Soar unchanged. Second, it might retain Dyna-Soar and reduce its participation in Gemini. Third, the Air Force could retain Dyna-Soar and cease its participation in Gemini. Fourth, it might stretch out Dyna-Soar and cease Gemini participation with Air Force resources. Finally, the Air Staff proposed that NASA could take the lead role in Dyna-Soar with the Air Force as a lesser partner. The Air Staff suggested that the Air Force should resort to the last alternative only to avoid complete cancellation of Dyna-Soar.

Early in March, General LeMay began to have second thoughts about the Air Force's participation in Gemini. He believed part of the difficulties in this latest Dyna-Soar crisis stemmed from the Air Force's enthusiasm for a role in Gemini. With this in mind, he urged Secretary Zuckert to clarify this issue with McNamara, on the chance that the Air Force had inadvertently given McNamara the impression that Gemini offered a better approach to manned military space operations than Dyna-Soar. The Air Force's interests in Gemini were strictly in addition to the X-20, even then, only to the extent that it could be supported by existing funding. While he believed Titan IIIC development should continue, the current X-20 program should definitely proceed as well. Dyna-Soar's hypersonic reusable technology would provide major extensions to the development of future military systems. Consequently, the Air Force should not be forced to consider its termination or delay it for an alternative space program.

In defense of the X-20, the Air Force received welcome support from some NASA officials. Drs. Raymond L. Bisplinghoff, the Director of NASA's Advanced Research and Technology Office and Milton E. Ames, Chief of its Space Vehicle Division, and Dr. John V. Becker, Chief of Langley's Aero-Physics Division, were among the NASA engineers who helped prepare a joint Air Force-NASA review with Assistant Secretary for R&D, McMillan. Essentially, NASA believed if the Air Force did not develop the X-20 someone else would have to pursue it, or something similar. From its inception, NASA felt Dyna-Soar held the promise of advancing the state-of-the-art in maneuverable hypersonic reentry vehicles. Even though its influential participation was gradually reduced throughout 1961, culminating in a low point with McNamara's December 1961 decision to eliminate suborbital flights and go directly to orbital flights, NASA continued, as Becker states, "as a largely inactive nominal partner, completing the tests to which we were committed."[583] Because NASA's hypersonic research interests in Dyna-Soar did not include a multiorbit capability, the capability would not affect NASA's evaluation of the X-20. NASA considered Dyna-Soar as a tool for advanced hypersonic research--a role they considered the backbone of the program.

Redirecting Manned Military Space Operations

In forwarding Gen. LeMay's 2 March letter and the Air Staff's X-20 review paper to McNamara on 11 March, the Secretary of the Air Force did not echo the chief of staff's vigorous defense of Dyna-Soar. Indeed, he remained completely neutral. On the other hand, he repeated his earlier belief, one that McNamara staunchly supported: that the Air Force should seek the maximum possible benefits from Gemini. Additionally, he concurred with McNamara's wish to review the whole man-in-space area.[584]

Concurrently, Deputy DDR&E Rubel conducted a companion review of the X-20, probably the most incisive and influential analysis in its history. It went to

---

[583]John V. Becker, "The Development of Winged Reentry Vehicles: An Essay from the NACA-NASA Perspective, 1952-1963," as cited in Hallion, *Hypersonic Revolution*, pp.434-40. Becker feels it was not a coincidence that NASA participation began to decline when Gen. Schriever became the AFSC commander in April 1961. He recalls William Lamar's telephone conversation during the fall of 1961 when Lamar apologetically informed him about Dyna-Soar's forthcoming redirection to orbital flight. The redirection was accomplished without any participation or consultation with NASA and eliminated what Becker calls the "research airplane" exploration of hypersonic flight down the Atlantic missile range that was of prime interest to NASA.

[584]Futrell, *Ideas, Concepts, Doctrine*, pp. 432-33, 437-40.

McNamara on 13 March. In the document, Rubel considered the principal objectives and characteristics of the X-20 and how the related to other programs, especially Gemini. In asking how important the X-20 objectives were and what it would be worth to attain them, he also contemplated what would be lost if the program ceased to exist and its objectives went unattained. Rubel's document dwelt extensively on the single distinguishable feature of the X-20: its hypersonic maneuverability upon reentry. Of the two basic capabilities flowing from this feature, Rubel wrote off the capability of flexible reentry and conventional landing at a number of pilot-selected sites as not immediately important, operationally or fiscally. He attributed greater importance to the capability of exploring hypersonic flight, where he found a historic pattern to the extension of knowledge and flight capabilities. Rubel viewed the X-20, as NASA viewed the X-20, as part of a long continuum of exploratory advances in high-speed flight and as the latest, most expensive, program.[585]

Rubel recommended four options to McNamara. First, continue X-20 development at a level of $125-$135 million annually for the next few years. Second, increase 1963 and 1964 funding to permit multiorbital flights at the earliest possible date. Third, return to the suborbital hypersonic research objectives. Finally, terminate Dyna-Soar but continue R&D on materials, configurations, automatic controls, and other components as appropriate. In discussing these alternatives, Rubel suggested that any funding level below $125 million, even with scheduling stretch-outs, would mean

---

[585]Ibid., pp. 434-37.

the X-20 should be canceled. Ultimately, Rubel believed that OSD should consider whether it wanted to invest large sums of money, time, plus the labor of thousands of scientists and engineers, to explore hypersonic flight or whether it wanted to use these resources some other way.[586]

With the Air Force and DDR&E positions in hand, McNamara began an on-site review. In mid-March, he visited several AFSC stations, plus the Martin and Boeing plants. The Boeing visit, on 14 and 15 March, made quite an impression, opening his mind to another way of perceiving Dyna-Soar, not as a research vehicle but as a space vehicle. It crystallized his thinking on the subject. He would now extend his review of Dyna-Soar and Gemini to include their application to several specific missions. In typical fashion, on the return trip to Washington, he stated how he believed the Air Force had been placing too much emphasis on controlled reentry when it did not have any real objectives for orbital flight. Rather, the sequence should be identifying the missions that could be performed in orbit, the methods to accomplish them, and only then the most feasible approach to reentry. Conversely, Brown pointed out, the Air Force could not detail orbital missions unless it could perform controlled reentry. What was the Air Force to do inquired Brown? Use a Gemini spacecraft to land a military mission in the ocean like NASA? The Air Force did not have its own fleet of ships and the associated costs would make such a practice ridiculously expensive for routine military missions. Dyna-Soar would be reusable and would not need to rely on

---

[586]Ibid.

a large ocean-based recovery support structure. As the DDR&E stated, the widest lateral mobility, such as possessed by the X-20, would allow reentry “on-demand,” a prerequisite for performing military missions. The Soviets would not know where the boost-glider would land once it began reentry. While McNamara did not favor immediate termination of the X-20 program, he did request another investigation.[587] McNamara wanted a further comparison between Dyna-Soar and Gemini in the light of their ability to perform four military missions: satellite inspection, satellite defense, reconnaissance in space, and the orbiting of offensive weapon systems.[588]

Also during March 1963, the X-20 office prepared four funding alternatives. General Estes submitted them to HQ Air Force at the end of the month. The most reasonable approach was to maintain the program schedules as offered in the 10 October 1962 system development plan by increasing the funding. The X-20 office estimated that $135 million was required for FY 1963, $145 million for 1964, and $114 million for 1965, which combined with previous years funding gave a total program cost of $795 million. The second alternative was to authorize a ceiling of $792 million, with $135 million allotted for FY 1963, $135 million for 1964, and $120 million for 1965. This reduction could be accomplished by deferring the multiorbit flight date by six months. The third option required $130 million for FY 1963, $135 million for 1964, and $130 million for 1965 with a program total of $807 million.

---

[587]McMillan, “Dyna-Soar Briefing.”

[588]Robert S. McNamara, "X-20, Gemini, and Military Missions," Memo to Secretary of the Air Force (Washington, D.C., 15 March 1963).

Such a funding arrangement would delay the entire program by two months and defer the multiorbit flight from the fifth to the seventh ground-launch. The least desirable approach would be to delay the entire program six months by authorizing $130 million for FY 1963, $125 million for 1964, and $125 million for 1965. Under this alternative, the program would total $828 million.[589]

On 12 April 1963, HQ Air Force accepted the third alternative. It established a funding level of $130 million for FY 1963 and directed the SPO to plan for $135 million in 1964. Headquarters then stipulated program schedules could not be delayed by more than two months. Additionally, two new system development plans had to be submitted by 20 May.[590]

On 27 April 1963, McNamara discussed his desires for commonality, cooperation, and the national space program with NASA administrator Webb. Both agreed that neither would explore the field of near-Earth orbit, not even studies, without the consent and cooperation of the other. Indeed, a DOD-NASA planning group under the Aeronautics and Astronautics Coordinating Board (AACB) existed to monitor DOD-NASA studies in the area. As Webb pointed out, the AACB's Manned

---

[589]Lieutenant General H. M. Estes, Jr., "X-20 Program," Letter to HQ Air Force (Andrews AFB MD, 30 March 1963).

[590] HQ Air Force, "AFRDC-92965," TWX to HQ AFSC (Washington, D.C., 12 April 1963).

Spaceflight Panel was currently investigating the best method of developing a coordinated manned orbital space station effort.[591]

The Soviet Threat

Tests of the Soviet Union's second full-size model of their boost-glider--M-12--occurred in March as well. M-12 resembled its predecessor, the MP-1, in virtually every aspect except one: aerodynamic rudders replaced the MP-1's braking panels at the tail of the glider. Like the 27 December 1961 flight of MP-1, M-12 flew to a maximum altitude of 405 kilometers, 1,760 kilometers down range from the Soviet Air Force's launch pad No. 1 test site at Kapustin Yar and reentered the atmosphere at a velocity of 3,800 meters per second. Combined with the data from the successful December launch, these two launches gave the Soviets the material and confidence to continue development. Two additional boost-gliders would be constructed: an unmanned R-1, and a manned R-2.[592]

Chelomey's OKB-52 would use the R-1 flight to test all the subsystems of the glider in preparation for the manned launch in 1964. On the R-2 flight, the cosmonaut would test the control-monitoring, communication, and observation subsystems of the boost-glider. The R-2 would attain an elliptical orbit with a perigee of 160 kilometers and an apogee of 290 kilometers probably by a *Soyuz* booster or a booster designed by

---

[591]Cantwell, *The Air Force in Space Fiscal Year 1963*, p. 27.

[592]Rudenko, "Star Wars," p. 32; Kirpil and Okara, "Designer of Space Planes," p. 14.

KB-52.[593] Total flight time would be 24 hours. OKB-52 expected the cosmonaut to experience no more than three and one half to four times his weight upon reentry.[594]

Responding to OSD

On 10 May 1963, a committee composed of officials from ASD, SSD, and Aerospace Corporation completed their response to Secretary McNamara's direction. The committee felt that the existing X-20 program could be rapidly, and with relative economy, adapted to test military subsystems and operations. They felt this for several reasons. Dyna-Soar's 7-cubic-feet payload capacity, its power supply, and its cooling ability would all be sufficient for testing a large number of military components. Furthermore, the orbital duration could be extended to 24 hours or longer. With modifications to the transtage section, its payload capacity could be enlarged as well. Consequently, the X-20 demonstration of flexible reentry would be an important result of the flight test program.[595]

Concerning Gemini, the committee recognized this program would enhance the Air Force's knowledge of orbital maneuverability. As a result, it recommended the incorporation of a series of experiments into NASA's Gemini program. These experiments would lead to the eventual testing of military subsystems. Farther in the

---

[593]Dennis Newkirk, Unpublished file notes from various Soviet sources acquired by Newkirk after the publication of his 1990 article, p. 7.

[594]Rudenko, "Star Wars," p. 32; Kirpil and Okara, "Designer of Space Planes," p. 14.

[595]Geiger, *History of the X-20 Dyna-Soar,* p. 116.

future, both vehicles could be adapted to serve as test craft for military subsystems. But, neither could--without modification--become a fully qualified weapon systems for any of the missions specified by Secretary McNamara. With the employment of the Titan IIIC, instead of the planned Titan II booster, and the incorporation of a mission module, SSD believed the Gemini system could provide greater orbital maneuverability and payload capacity than the X-20. On the other hand, Dyna-Soar would provide greater flexibility during reentry and, unlike Gemini, would return the military subsystems to Earth for examination and reuse.[596]

Concerning reconnaissance missions, the committee thought the X-20 program could develop low-orbit operational techniques and refine a ground-object identification ability. The research data from the program would also be applicable to help verify the feasibility, design, and employment of glide bombs. The X-20's maneuvering techniques and quick-return methods made the program valuable for the development of satellite defensive missions as well. Because the glider's deceleration occurred slowly during it hypersonic reentry, it would provide a safe physiological environment for transfer of personnel from space stations and for other logistical missions. Last, a significant amount of information for the development of future maneuvering reentry spacecraft would be obtained from the X-20 program.[597]

---

[596]Ibid., p. 117.

[597]Clarence J. Geiger, *Termination of the X-20A Dyna-Soar* (Wright-Patterson AFB OH: Air Force Systems Command, 1964), pp. 3-4.

The committee then detailed the necessary modifications to the X-20 glider for the incorporation of either reconnaissance or satellite inspection equipment. A test program of four X-20A (a new designation) flights--two demonstration flights and six reorientation flights for testing reconnaissance subsystems--would total $206 million from FYs 1964 through 1968. The same type of program--for the demonstration and testing of inspection subsystems--would total $228 million.[598]

In contrast, the technology being developed by NASA's Gemini program related to the ability to rendezvous and orbit for long durations, prerequisites for landing a man on the moon, the prime objective of Kennedy's national space policy. The committee estimated about $16.1 million from FYs 1964 through 1966 would be needed to incorporate a series of military experiments into the current NASA program, with only minor equipment and operational flight changes. If DOD conducted two Gemini launches and employed the same Titan II booster as NASA, the cost for inspection and reconnaissance experiments would total $129 million from FYs 1964 through 1967. If DOD conducted six flights, the total would be $458 million.[599] Of course, whatever DOD did with NASA's Gemini, it would be helping the nation achieve its goal of placing a man on the moon. Dyna-Soar would not help NASA meet this goal.

---

[598]Ibid.

[599]Ibid., pp. 4-5.

Then the committee considered a series of Gemini launches conducted by the DOD using the Titan IIIC. With a payload capacity of only 10 cubic feet, the committee felt that the 5,000 pound Gemini capsule would need an additional mission module. The largest test module yet considered had a volume of 700 cubic feet. Next the committee examined the applicability of such a test system to reconnaissance and inspection missions. Considering a six-flight program beginning in July 1966, with flights following at five-month intervals, an inspection test flight program would total $509 million. A reconnaissance flight test program would cost $474 million.[600]

The main advantage of the Gemini vehicle was its lighter weight. Consequently, it could carry more fuel for orbital maneuvering or carry a larger payload in its mission module. The inherent advantages of the X-20 were its reusability and maneuverability during reentry. Such qualities meant it could land quicker, would have more landing site options, and would be ready to fly again in a much shorter period of time. Based on these discussions, the committee recommended a series of military experiments for Gemini and additional flights of the X-20. While both systems could be modified to perform reconnaissance, inspection, satellite defense, and logistical missions, neither would directly provide a means of introducing offensive weapons into earth orbit.

On 22 May, Gen. Ritland forwarded this report to HQ Air Force. The deputy for manned spaceflight recommended that the X-20 program be continued because of

---

[600]Ibid.

the contribution its hypersonic maneuverable reentry could make for possible military missions. Air Force participation in the Gemini program, however, should be confined to establishing a small field office at the NASA Manned Spacecraft Center in Houston and insuring that military experiments became a part of NASA's program.[601] The report was not forwarded to McNamara until 5 June.

With the X-20 and Gemini approaches to orbital flight under examination, the Dyna-Soar SPO also found itself confronted with a pending budget reduction. On 15 January 1963, the Dyna-Soar office had completed a tentative package program, including the same funding and flight schedules as its 10 October 1962 proposal. The central difference was the incorporation of the Westward-Ho proposal.[602] However, this system development plan would not be submitted to HQ AFSC for approval. In accordance with its 12 April 1963 instructions, the X-20 office completed another system development plan on 6 May and distributed it to the various program participants for comments. On 9 May, before any comments could be received, General Schriever assigned the orbital test responsibilities to the SSD. Consequently,

---

[601]Major General O. J. Ritland, Deputy to the Commander for Manned Spaceflight, "Response to Secretary McNamara's 15 March 1963 Questions," Letter to Commander, Manned Spaceflight, HQ AFSC (Andrews AFB MD, 22 May 1963).

[602]Directorate of Systems Management Dyna-Soar SPO, "Tentative System Package Program, System 620A" (Wright-Patterson AFB OH, 15 January 1963), pp. 2-27, 11-5.

HQ AFSC again instructed the Dyna-Soar SPO to revise the X-20 system development plan. This time headquarters wanted it by 13 May.[603]

In the 13 May system development plan, the X-20 office estimated that $130 million would be required for FY 1963, $135 million for 1964, $130 million for 1965, $110 million for 1966, and $73 million for 1967. The air-launch program would be extended from March 1965 through January 1966, with the two unmanned ground-launches occurring in January and April 1966. The first piloted flight would take place in July 1966, with the first multiorbit flight in May 1967. The eighth and final piloted flight would be conducted in November 1967.[604] Brigadier General D. M. Jones, acting commander of ASD, informed HQ AFSC that insufficient time forced ASD to leave out the details of the new test reorganization. Furthermore, a funding level of $130 million and $135 million for FYs 1963 and 1964 would delay Dyna-Soar flights by more than the two months anticipated in the 12 April guidance of USAF headquarters.[605]

On 27 May, another system development plan was completed. While the Dyna-Soar SPO retained the same funding rates as the 13 May proposal, it revised the flight schedule to conform with the contractor's estimates. The air-launch program would be

---

[603] HQ AFSC, "MFSA-9-5-17," TWX to HQ ASD (Andrews AFB MD, 9 May 1963).

[604]Directorate of Systems Management Dyna-Soar SPO, "System Package Program, System 620A" (Wright-Patterson AFB OH, 13 May 1963).

[605]Brigadier General D. M. Jones, Acting Commander, "Revised X-20A System Package Program," Letter to HQ AFSC (Wright-Patterson AFB OH, 13 May 1963).

extended from May 1965 through May 1966. The two air-launches would take place in January and April 1966, with the first piloted launch in July 1966. Recognizing the necessity for a four-month interval between single and multiorbit flights, the X-20 office set August, instead of May, 1967 for the first multiorbit launch. The Dyna-Soar flight test program would terminate in February 1968 with the eighth orbital launch.[606] The Secretary of the Air Force gave his approval to this system development plan on 8 June 1963; however, OSD did not accept the recommended funding.[607]

As McNamara notified the Dyna-Soar SPO that he would not accept its 27 May funding proposal for FY 1964, he approved the incorporation of Air Force experiments in the NASA Gemini program on 20 June 1963. He then informed Secretary Zuckert of his manned military program policy decision. The plethora of Air Force manned military spaceflight studies--Dyna-Soar, Blue Gemini, MODS, an aerospace plane--was forcing DOD to make selections within the next year because the cost of concurrent development would be prohibitive. DOD would need to minimize the number of its projects by instituting a policy of commonality within the entire national space program. As such, McNamara wanted Zuckert to submit an integration plan to OSD, one that assured the integration of the Air Force's study efforts with Gemini, providing McNamara with an additional basis for making comprehensive program decisions on

[606]Directorate of Systems Management Dyna-Soar SPO, "System Package Program, System 620A" (Wright-Patterson AFB OH, 27 May 1963), pp. 1-5.

[607]Directorate of Systems Management Dyna-Soar SPO, "System Package Program, System 620A" (Wright-Patterson AFB OH, 3 September, 1963), pp. 1-5.

manned military space programs and military missions. At the end of FY 1963, Air Force manned military aspirations would depend greatly on Zuckert's response to McNamara's request for the commonality approach. Based on McNamara's previous inclinations, there would be a military man-in-space program and it would be some type of a space station. On the other hand, its relationship to Gemini, the extent of Air Force participation in Gemini, and the role of Dyna-Soar, all remained open questions, apparently biased in favor of a greater Gemini role. The Air Staff and AFSC sought Zuckert's approval to initiate another planning study to define military requirements for an orbiting military space station, but Zuckert delayed action. In light of the 27 April McNamara-Webb agreement, he believed a national program would soon emerge.[608]

Meanwhile, assistant secretary for R&D McMillan forwarded Gen. Ritland's response to McNamara on 5 June 1963. He noted that neither the X-20 nor Gemini, as defined, would produce an on-orbit operational capability of military significance. Growth would be possible in both, but this would increase costs. McMillan asserted that he could not find any unwarranted duplication. Each program explored a unique aspect of space technology and neither could meet all of the objectives of the other. He urged the energetic continuance of the X-20, insisting that Dyna-Soar represented the only effort underway to explore hypersonic flight and maneuverable reentry while offering the military advantages implicit in these characteristics. While other Air Force projects would advance the technologies required to perform the four military missions,

[608]Cantwell, *The Air Force in Space Fiscal Year 1963*, pp. 27, 32-33.

none would lead to an early initial operational capability. McMillan attributed this to the limited knowledge of hypersonic and space technology. He also identified OSD's managerial constraints--such as confining the X-20 to research status--and the fiscal limitations they imposed as additional factors contributing to the lack of knowledge. OSD did not make a final determination on the relationship between the X-20 and Gemini. Accordingly, Gen. Estes cautioned the Dyna-Soar SPO at the end of June that the Secretary of Defense was still studying the military potential of both approaches. The AFSC vice-commander believed that the Dyna-Soar system office should balance its position between ensuring the continuation of the program and restricting contractor actions so as to ensure minimum liability in the event of cancellation.[609]

Refining Capabilities

At the request of HQ AFSC, the program office then completed a study use of the X-20 as an ASAT intercepter. The Dyna-Soar office proposed an X-20B with an interim operational capability of satellite inspection and neutralization. The program office felt that the last six flights of the current X-20A program could be altered to carry inspection sensors and additional fuel to demonstrate the spacecraft's maneuverability. Two additional flights would be added to demonstrate an interim operational capability. This would necessitate a weight reduction of 700 pounds for the glider, which could be achieved through a series of design changes. Such a program

[609]Lieutenant General H. M. Estes, Jr., "X-20 Program Guidance for FY 1964," Letter to Major General Ruegg, Commander, ASD (Andrews AFB MD, 21 June 1963).

would total $227 million from FYs 1964 through 1968. To conduct a 50-flight operational program following the completion of the two demonstration flights was to cost $1.229 billion from FYs 1965 through 1972.[610]

Near the end of June 1963, SSD asked the X-20 office to conduct another analysis of the current Dyna-Soar vehicle, as well as modified versions, to fulfill satellite inspection missions.[611] With the assistance of Boeing, the glider contractor, the Minneapolis-Honeywell, an associate contractor, and the Air Force Aerospace Medical Division, the Dyna-Soar office completed its report by the middle of November. This study offered an inspection vehicle, the X-20X, capable of carrying provisions for a one or two-man crew, orbiting for 14 days, and inspecting targets as high as 1,000 nautical miles. The Dyna-Soar office estimated a first flight date for the X-20X in September 1967 and a probable funding requirement, depending upon the extent of modifications, ranging from $324 million to $364.2 million for FYs 1965 though 1971.[612]

On 27 June, the Manned Spaceflight Panel of the AACB submitted its recommendations to DOD-NASA officials. Although the panel had deliberated the joint roles of DOD-NASA in near-Earth orbit since 27 April, the panel's

---

[610]Directorate of Systems Management Dyna-Soar SPO, "X-20 Anti-Satellite Mission," Report (Wright-Patterson AFB OH, 1 June 1963), pp. 7-8, 12, 21.

[611]Colonel W. D. Brady, Acting Deputy, "Program 706, Phase 0," Letter to Colonel Moore, X-20 Program Manager (Los Angeles CA, 25 June 1961).

[612]Colonel William L. Moore, Program Director, "Phase 0 Study of X-20 Program 706," Report (Wright-Patterson AFB OH, 18 November 1963), pp. I, 2, 14-15.

recommendations fell far short of McNamara's desires for commonality within the two agencies. Indeed, McNamara wanted an agreement on a complete joint course of action rather than the continued coordination and exchange of information recommended by the AACB panel. By August, when the AACB approved the panel's recommendations, McNamara would have another avenue open for him to attain his objectives.[613]

By July 1963, the issue of NASA's civilian-scientific requirements for a space station came before the NASC, chaired by Vice-President Johnson. Realizing Johnson would not support both a DOD and NASA space station, McNamara and Webb met again. They agreed to incorporate the requirements of both agencies for a space laboratory under a single Manned Orbital Laboratory (MOL).[614] Without consulting Air Force officials, McNamara simplified the original Air Force proposals for a military space station into a program for joint DOD/NASA development.[615] On 3 July, HQ AFSC informed the Dyna-Soar office that attempts to secure additional funding failed. The funding level for FY 1964 would be $125 million.[616] By September, the

---

[613]Gerald T. Cantwell, *The Air Force in Space Fiscal Year 1964* (USAF Historical Liaison Office: GPO, 1967), p. 16.

[614]Hansen, *Spaceflight Revolution*, pp. 293-309.

[615]Adam Greun, "History of the Space Station, 1923-1972," Chapter 5, "MOL.," Ph.D. dissertation (Duke University, 1989).

[616]Dyna-Soar SPO, "System Package Program."

consequences of this reduced funding level would be clear to the Dyna-Soar office: multiorbital flight would be delayed from the seventh to the ninth ground-launch.[617]

Since the completion of the Step IIA and IIB studies by Boeing in June 1962, the Dyna-Soar office had, on several occasions, requested funds for more intensive military application studies. On 8 July 1963, W. E. Lamar, Director of the X-20 Engineering Office, reiterated this request during a presentation to the Secretary of the Air Force Zuckert.[618] A few days later, Zuckert, in a meeting of the DSMG, directed the Dyna-Soar SPO to initiate studies of the X-20's operational applications. He still felt that the program would prove invaluable to the national military space program.[619]

OSD Gains Commonality

Before the purpose of these studies (Step IIA and IIB) could be clarified, the future of the Dyna-Soar became tied to the projected space station program. On 22 July, having previously noted--with a high degree of pleasure--the amount of cooperation between DOD and NASA on the Gemini program, Johnson raised the question of the importance of a space station to national security. Accordingly, he requested the Secretary of Defense to prepare a statement on this subject.[620]

---

[617]Ibid., pp. 1-5.

[618]William E. Lamar, Director X-20 Engineering Office, "X-20 Status Report," Presentation to Secretary of the Air Force (Wright-Patterson AFB OH, 8 July 1963).

[619]Colonel C. R. Tosti, Executive Secretary, "65th Meeting, DSMG," DSMG Minutes (Washington, D.C., 12 July 1963).

[620]Lyndon B. Johnson, "Space Stations," Memo to Secretary of Defense (Washington, D.C., 22 July 1963).

On 9 August, McNamara replied, firmly supporting a joint space station program. He stressed requirements the Air Force had to consider, which favored multimanned orbital flights of long duration in a facility capable of allowing men to move about and perform useful tasks. The secretary outlined some premises for America's manned military space program. He said the investigation of a military role in space would be important to national security. Because he believed a clearly defined military space mission did not exist, present efforts should be directed towards the establishment of a technological and experience base, just in case military missions could be defined. Air Force participation in the Gemini program would provide much of this technological base. While he did not press for the assignment of the space station program to DOD, McNamara felt the initiation of a space station would necessitate assignment of a new national mission by the president on behalf of all interests--similar to his moon landing announcement. Such a system might eventually evolve into an operational military vehicle. McNamara hoped to have the characteristics of a space station delineated by early 1964.[621] Indeed, the secretary's efforts with the vice-president offered him the alternative means of achieving the kind of commonality he wanted with NASA for joint operations in near-Earth orbit.

McNamara then resumed his discussions with NASA Administrator Webb. After reviewing AACB's proposal for space station operations, he wrote to Webb suggesting they sign a new formal agreement. McNamara forwarded a draft of the

---

[621]Robert S. McNamara, "Orbital Space Station," Memo to the Vice-President (Washington, D.C., 19 August 1963).

agreement and, on 17 August, NASA submitted a counterproposal. Although McNamara still had reservations about NASA's alternative, he signed. In sum, the two agencies agreed that any requirements for a vehicle larger than Gemini and Apollo could be encompassed into a single program. Advanced space station studies undertaken by either would be coordinated through AACB. They would also evaluate any concepts evolving from these studies. DOD and NASA would then jointly prepare a national requirement statement to include a recommendation on which agency should direct the work. Should the president decide to proceed, a joint DOD-NASA board would formulate specific objectives and approve experiments to be conducted.[622]

In September, a subcommittee of PSAC, the Space Vehicle Panel, was formed to review a manned orbiting station. The President's Office of Science and Technology asked the Air Force to brief the subcommittee on possible military space missions, biomedical experiments, and the capability of Gemini, Apollo, and the X-20 vehicles to meet future requirements.[623] Additional instructions concerning the X-20 portion of the PSAC briefing would be relayed from DDR&E by HQ Air Force to ASD. Modifications to the X-20 and discussions of an orbital space station should be emphasized. Ironically, HQ Air Force felt DOD was not convinced an orbital space station would be needed. Instead, a study of the requirements to test military

---

[622]Cantwell, *The Air Force in Space Fiscal Year 1964*, pp. 17-18.

[623]N. E. Golovin, Office of Science and Technology, "Briefing of Lees Subcommittee of PSAC Space Vehicle Panel," Memo to A.C. Hall, Deputy, DDR&E (Washington, D.C., 12 September 1963).

equipment in space would be necessary to answer questions such as equipment characteristics and the usefulness of man in space.[624]

Meanwhile, discussions on the joint space station continued between DOD and NASA. Interestingly, neither had agreed on a managing agency. Subsequently, in October 1963 meeting between McNamara and Webb, McNamara completely bypassed Dyna-Soar, requesting a military follow-on to Gemini, similar to the "Blue Gemini" and the MODS programs proposed by Air Force leaders and rejected by McNamara earlier in the year. NASA countered by suggesting a military MOL. As Air Force planners lauded the merits of using Dyna-Soar as a supply vehicle for MOL, McNamara refused to accept their continuing initiatives to organize simultaneously several manned military space programs.[625]

The successful implementation of the Air Force's requirements for manned military operations outlined by Dyna-Soar's 1963 program plans depended less on military necessity and more on political acumen concerning yet another change in the administration's attitude about military applications in space. In June, a Partial Test Ban Treaty had been signed in the U.N. after 10 days of high-level secret meetings with Moscow (because the Joint Chiefs of Staff and the Atomic Energy Commission had opposed similar agreements, they were excluded from the process and handed a *fait*

---

[624]Major General W. B. Keese, Deputy Chief of Staff, "Briefing to PSAC Panel on 10 October 1963," Letter to HQ ASD (Washington, D.C., 19 September 1963).

[625]U.S. Arms Control and Disarmament Agency, *Documents and Disarmament*, pp. 292, 1123; *New York Times,* 4 December 1963.

accompli by the Kennedy administration), eliminating the detonation of nuclear warheads in space and setting the stage for additional U.N. action. By October 1963 U.N. preliminary settlement between the United States and the Soviet Union had been reached renouncing the orbiting of "weapons of mass destruction" and finalizing these pledges in U.N. Resolution #1884. This was followed by the General Assembly's adoption of a Declaration of the Legal Principles for the Use of Outer Space in December. In addition to these agreements on the use of nuclear weapons and anti-satellite weapon systems, both nations now had operational reconnaissance satellites providing valuable intelligence information and neither side wished to jeopardize the balance.[626] Because Dyna-Soar had been initially conceived as a delivery platform for nuclear weapons and later as a satellite interceptor, two of the primary justifications for its existence had disappeared.[627] Preempted by conciliatory treaties limiting the military use of space, Soviet efforts to prohibit American reconnaissance satellite overflights ended when both nations tacitly accepted existing territorial overflights.[628] Accordingly, the key to the Air Force's manned military space operations would lie in its ability to tie a program's military requirements to the political, economic, and social

---

[626]Ibid.; *Yearbook of the United Nations, 1963* (Washington, D.C., 1963), pp. 101-02, 133-34; Steinberg, *Satellite Reconnaissance*, pp. 150-52.

[627]Walter C. Clements, *Outer Space and Arms Control* (Cambridge MA, 1966), p. 44.

[628]Steinberg, *Satellite Reconnaissance*, pp. 64-67, 86-87.

ramifications of McNamara's quest for commonality and the evolving international relationship between the United States and the Soviet Union.

Dyna-Soar's Military Missions

A few days later, Dr. Lester Lees, chairman of the PSAC subcommittee, gave additional information to William Lamar about the coming presentation. Emphasis was to be on specific, meaningful experiments that the Air Force could conduct with either Gemini, Apollo, or the X-20, in order to provide a technological basis for future military space missions. Lees suggested it would be necessary to convince a number of governmental officials of the need for a military man in space. Because of existing reconnaissance capabilities, the usual arguments for manned spaceflight, such as decision-making and flexibility, would be inadequate. More specific reasons must be given. Otherwise, extensive funds would not be available for the development of manned space systems.[629]

The briefings to PSAC on 10 October essentially covered the same comparative findings regarding Gemini and the X-20 made in the 10 May report to McNamara. However, they did present more detail on the X-20's shuttle capabilities of rendezvous and docking. They also presented an orbital development laboratory configuration of the X-20. After completion of the presentations, Lees told Lamar that he had previously been against the continuation of the Dyna-Soar program. Now that he saw a definite need for the X-20, he would no longer oppose the program.

---

[629]William E. Lamar, Director X-20 Engineering Office, "Briefing to PSAC," Trip Report (Wright-Patterson AFB OH, 23 September 1963).

While Dyna-Soar seemed to be gaining support outside OSD, DOD refused to sanction a revision of the X-20's development plan. From May through September 1963, several changes involving the test organization and funding had been made. On 9 May 1963, Gen. Schriever directed that the Dyna-Soar orbital test program be assigned to SSD. The AFSC commander further ordered that the mission control center be located at the Satellite Test Center in Sunnyvale, California, instead of the Air Force Missile Test Center.[630] The 27 May 1963 system development plan reflected this change in the test program and registered a requirement of $135 million for FY 1964. While HQ Air Force approved this system development plan in June, DOD would only allow $125 million for FY 1964. On 3 July, the HQ AFSC informed the X-20 office that its attempts to obtain the higher funding level had failed.[631] DDR&E considered the primary purpose of the program to be the acquisition of data on maneuverable reentry. Incorporation of multiorbital flight would only be of secondary importance. The X-20 office could defer the first multiorbital flight date to remain within budget limitations.[632] HQ AFSC then directed that a revised system development plan be completed by early September.[633]

---

[630]Schriever, "X-20 Program."

[631] HQ AFSC, "SCCP-3-7-2," TWX to HQ ASD (Andrews AFB MD, 3 July 1963).

[632]Brown, "Rationale."

[633] HQ AFSC, "MFSA-30-7-47," TWX to HQ ASD (Andrews AFB MD, 30 July 1963).

Before this could be accomplished, Schriever transferred not only orbital test direction to the space division but also responsibility for the air-drop program and the training of X-20 pilots.[634] These additional changes would also have to be incorporated into the revised system development plan. Subsequently, the 3 September program package presented the adjusted financial estimates and flight schedules. Considering that $125 million had been authorized for FY 1964 and a total of $339.20 million had already been spent, the program office estimated that $139 million would be required for 1965, $135.12 million for 1966, $93.85 million for 1967, $31.85 million for 1968, and $3 million for 1969. The total cost for the Dyna-Soar program would amount to $867.02 million. The reduction of FY 1964 funds would be absorbed by delaying the necessary modifications for multiorbital flight and deferring the date of the ninth ground-launch (the first multiorbit flight) from August 1967 to December 1967. The 20 air-launches would occur from May 1965 through May 1966, and the two unmanned ground-launches would take place in January 1966 and April 1966. The first piloted ground-launch would occur in July 1966, and the last piloted flight was to be conducted in February 1968.[635]

Soon after the issuing of this program package, concern arose over the expense of relocating the mission control center to Sunnyvale. Col. Moore estimated this

---

[634] Schriever, "X-20 Program."

[635] Dyna-Soar SPO, "System Package Program," pp. 11-1, 11-3, 11-5.

relocation would increase program costs by several million dollars.[636] Major General L. I. Davis, special assistant to the AFSC vice-commander, supported Moore's argument in his letter to Schriever. It would be less expensive to keep both control centers at the Air Force Missile Test Center.[637]

At the request of HQ AFSC, the X-20 office forwarded, on 23 September, a revision of its 3 September system package program detailing adjustments to the program costs if the mission control center remained at Cape Canaveral. The X-20 office estimated that $138.13 million would be required for FY 1965, $130.66 million for 1966, $88.34 million for 1967 and $31.09 million for 1968. The total program cost would amount to $853.23 million instead of the previously estimated $867.02 million.[638] On 17 October 1963, HQ AFSC forwarded the system development plan to the Air Staff, informing them it was more feasible to locate the mission control center at the missile test center.[639] Ultimately, this program package did not receive the endorsement of either headquarters. As late as 21 November, the X-20 assistant

---

[636]Colonel William L. Moore, Program Director, "X-20 Test Program," Memo (Wright-Patterson AFB OH, 9 September 1963).

[637]Major General L. I. Davis, Special Assistant to the Vice Commander, "X-20 Test Program," Letter to General Schriever, Commander, AFSC (Andrews AFB MD, 19 September 1963).

[638]Directorate of Systems Management Dyna-Soar SPO, "Revision A, System Package Program, System 620A" (Wright-Patterson AFB OH, 23 September 1963).

[639]Lieutenant General H. M. Estes, Jr., "X-20 System Package Program," Letter to Lieutenant General Ferguson (Andrews AFB MD, 17 October 1963).

director, J. B. Trenholm, reminded HQ AFSC that it would be beneficial to the program if the systems command would approve the program package.[640]

By the end of October, the military purposes of the Dyna-Soar capability studies that Secretary Zuckert had requested in July had been clarified. HQ Air Force informed Major General R. G. Ruegg, ASD Commander, that the first study would formulate a program of military space experiments involving only engineering changes to the X-20 subsystems. The AFSC vice-commander believed this program of experiments should be compared to a similar one employing the Gemini vehicle to illustrate how the Dyna-Soar approach offered the most economical and effective means of fulfilling the task. A second study would integrate the findings of various other studies and establish a series of mission models for reconnaissance, surveillance, satellite inspection, and logistical support for a space station. A third study would examine the future operational potential of reentry vehicles with a lift-to-drag ratio greater than the X-20. A final study would examine the economic implications of various modes of recovering space vehicles from near-Earth orbit.[641]

---

[640]J. B. Trenholm, Assistant Director, "X-20 System Package Program," Letter to Lieutenant Colonel C. L. Scoville, Director, Military Space Program, HQ AFSC (Wright-Patterson AFB OH, 21 November 1963).

[641]A. H. Flax, Assistant Secretary of the Air Force, "Dyna-Soar Operational Capability Study," Memo (Washington, D.C., 18 September 1963); Lieutenant General H. M. Estes, Jr., "Space Planning Study," Letter to HQ ASD (Andrews AFB MD, 25 October 1963).

Manned Military Space Operations

Unfortunately, while the Air Force submitted a new Dyna-Soar development plan to OSD, McNamara's growing interest in a Gemini-based space station paralleled his disenchantment with Dyna-Soar. In October 1963, AFSC commander Schriever informed ASD and SSD that the Secretary of Defense intended to visit the Martin facilities in Denver, Colorado, on 23 October to receive briefings on the status of the X-20 and Titan IIIC programs.[642] Ironically, McNamara would want more than a status briefing at Denver.[643]

A few days later, on 23 October, McNamara, accompanied by Roswell L. Gilpatric, Deputy Secretary of Defense, Harold Brown, and Brockway McMillan, now Under Secretary of the Air Force, received a briefing in Denver by Titan IIIC and X-20 officials. At the conclusion of his presentation, Col. Moore said it would be desirable to have the DOD publicly state its confidence in the Dyna-Soar program. The X-20 director then asked if there were any questions.[644]

Both McNamara and Brown asked a series of questions about the need for manned military space systems. McNamara said the X-20 office had been authorized to study this problem since March 1963 and made it clear that he considered this the most important part of the X-20 program. Ignoring the previous briefings and white

---

[642] HQ AFSC, "SCG-0-10-6," TWX to HQ ASD (Andrews AFB MD, 10 October 1963).

[643]Moore, "Record Memorandum."

[644]Ibid.

papers on Dyna-Soar's military missions, the McNamara wanted to know what was planned for the Dyna-Soar program after it demonstrated maneuverable reentry. He insisted he could not justify the expenditure of some $1 billion for a program with no ultimate purpose, except the narrowly defined mission of scientific research, the mission he had specifically gave Dyna-Soar back in February 1962. He was not interested in further expenditures until he had an "understanding" of the possible space missions it could perform. Only then, he said, would OSD give a vote of confidence to the X-20 program. McNamara directed McMillan to get the answers.[645]

Ultimately, the secretary wanted to know the answer to a single question: why did the Air Force think that it needed military systems in space? Personally, he challenged the concept of a military man-in-space and challenged the concept of the military in space. He and DDR&E Brown both felt that the types of questions needing answers concerned satellite inspection--that is, what hardware was needed to accomplish the task; whether unmanned satellites could do the job; how would the costs and capabilities of simulators compare to live flights; would the Gemini or the X-20 be the best hardware for satellite inspection; if X-20 was the best, what changes needed to be made to make it efficient? McNamara seemed to ignore the briefings he

---

[645]William E. Lamar, Director X-20 Engineering Office, "Paraphrased Transcript of Discussion After X-20 Status Briefing to McNamara by Colonel Moore in Denver, 23 October 1963," Trip Report (Wright-Patterson AFB OH, No Date, 1963).

had received throughout the year and redefined his own 15 March guidelines on how he wanted the Dyna-Soar SPO to focus the X-20.[646]

When Boeing and the SPO discussed the costs of the satellite inspection missions, McNamara refused to believe their cost estimates. J. Harry Goldie, Boeing's chief engineer for the X-20, showed how each launch would cost $30 million. Using the estimated overall cost of the program as a base, Brown stated, "You want $1 billion for ten shots: that's $100 million per shot. What can you do that is worth $100 million? What can you do that SAMOS can't?" McNamara repeated his belief regarding the lack of a clearly defined purpose for Dyna-Soar. When he finally conceded that Dyna-Soar could perform at least a once-around reconnaissance mission, he said it could be done cheaper than $25 million (McNamara's figure) per launch with unmanned assets. Getting the information back to a specific landing site was not important. Nor would the Air Force's ability to quickly and routinely access space be worth the cost of the program.[647] Until the secretary received answers to his more general questions, he considered Dyna-Soar's future questionable at best. On the other hand, for their answers to be useful, the secretary needed to be listening.

Yet, even before these briefings, numerous indications regarding the uncertain future of Dyna-Soar arose. Several X-20 displays and activities planned for the Air

---

[646]Moore, "Record Memorandum"; Colonel William L. Moore, Program Director and Major General R. G. Ruegg, Commander ASD, "23 October Briefing to McNamara and Brown," Joint Personal Message to General Schriever (Wright-Patterson AFB OH, 29 October 1963).

[647]Moore, "23 October Briefing."

Force Association convention in the middle of September were canceled. One of the proposed events involved the continuous showing of a brief film on the nature and objectives of the Dyna-Soar program. Although this film was an updated version of a previously unclassified version, OSD refused it clearance for the convention.[648] Furthermore, neither Dr. A. C. Hall, Deputy Director for Space for the DDR&E, nor Dr. A. H. Flax, now Assistant Secretary of the Air Force for R&D, agreed to a briefing by the Air Force plant representative at Boeing on the necessity for manned military spaceflight.[649] Boeing officials became concerned over the future of the program after this visit. In addition, DDR&E Brown did not approve the release of funds for the X-20's range requirements at Edwards AFB, thus jeopardizing the range operational date of October 1965 for the Dyna -Soar program.[650] Last, Brown, in a speech before the United Aircraft Corporate Systems Center at Farmington, Connecticut, criticized the Air Force's manned space programs. In his view, both the Gemini and X-20 programs had very limited abilities to answer the question of what a

---

[648]Deputy Chief of Staff, R&D, *History Report, July-December 1963* (Washington, D.C., 11 August 1966), p. 77.

[649]Colonel W. H. Price., Air Force Plant Representative, "Report of Visit, Assistant Secretary of The Air Force," Letter to HQ Air Force (Seattle WA, 10 October 1963).

[650]Deputy Chief of Staff, *History Report*, p. 77; Estes, "X-20 System Package.".

military man could do in space. Unless an affirmative answer were found, there would be no successor to these programs.[651]

Some of the participants arrived at varying conclusions concerning McNamara's reaction to the briefing. Goldie optimistically thought the secretary did not appear to be firmly against the X-20 nor in favor of Gemini. Rather, he seemed willing to allow the Air Force to use the X-20 as a test craft, and as a military system, if a strong case could be made for a manned military space system.[652] Lamar did not believe that the Secretary of Defense was satisfied with the response. As such, "drastic consequences" were likely if a reply could not be made.[653] Col. Moore stated prophetically that McNamara probably would not ask again.[654]

OSD Alternatives to Dyna-Soar

OSD had no intention of asking again. On the day following the 23 October 1963 briefing to Secretary McNamara, Dr. Brown offered a manned orbiting laboratory program to the Air Force in exchange for the Air Force's agreement to terminate the X-20 program. Air Force Chief of Staff LeMay did not agree and told the Air Staff to prepare a rebuttal to such a proposal. Previously, in August 1963,

---

[651]Dr. Harold Brown, DDR&E, "National Space Program," Memo (Farmington CT, 17 October 1963).

[652]J. Harry Goldie, Chief Engineer, "Questions, Comments, and Impressions from McNamara Briefing in Denver, 23 October 1963 Paraphrased Transcript of Discussion After X-20 Status Briefing to McNamara by Colonel Moore in Denver, 23 October 1963," Trip Report (Denver CO, 24 October 1963).

[653]Lamar, "Paraphrased Transcript."

[654]Moore, "23 October Briefing."

Brown had approved an Air Force request to conduct a study of an orbital space station and had authorized $1 million on it for FY 1964. The Air Force would focus on the reconnaissance mission with the objective of assessing the utility of man for military purposes in space. In determining the characteristics of such a station, DDR&E directed the Air Force to consider the use of such programs as X-15, X-20, Mercury, Gemini, and Apollo. This study had to be concluded by early 1964.[655]

Before this space station study could be completed, Brown recommended the program to McNamara in a 14 November 1963 memorandum. The DDR&E analyzed varying sizes of space station systems that would incorporate either the Gemini or Apollo capsules as ferry vehicles. For boosters he suggested the employment of either the Titan II, the Titan IIIC, or the Saturn IB booster. Two of the approaches seemed most suitable. One involved the Lunar Excursion Module (LEM) adapter as a space station and the Saturn IB as the booster. The Apollo command module and the Titan IIIC would perform the logistics function. Brown estimated this approach would cost $1.286 billion from FY 1964 through 1969. The first manned ferry launch could take place in late 1966, and active station tests could be conducted by late 1967. The DDR&E, however, preferred to develop a space station with provisions for four men, use the Gemini spacecraft as a ferry vehicle, and separately launch both the station and spacecraft with a Titan IIIC booster. From FYs 1964 through 1968, this approach

---

[655]Dr. Harold Brown, DDR&E, "Military Orbiting Space Station," Memo to Secretary of the Air Force (Washington, D.C., 30 August 1963).

would total $983 million. The first manned ferry launch could occur in the middle of 1966, and active space station tests could begin in the middle of 1967.[656]

Concerned about the concept's primitive landing methods, Brown suggested the development of a low lift-to-drag ratio vehicle capable of performing maneuverable reentry and conventional landing. A close associate with the Aerospace Corporation and SSD, he proposed that the Air Force expand SSD's lifting-body research (the SV-5A/P unmanned and manned vehicles of the PRIME program) and the unmanned Aerothermodynamic, Structural Systems, Environmental, Test program (ASSET) program of ASD's FDL.[657] The DDR&E suggested models of such a craft could be tested as part of the ASSET program during 1964 and 1965. He estimated an improved ferry vehicle could be available for later station tests. The total for this more sophisticated vehicle program would amount to $443 million for FYs 1964 through 1968.[658] Ironically, the rest of the Dyna-Soar program would be less than or equal to this cost and achieve the objective sooner.

Dr. Brown's recommendation to Secretary McNamara was brief and to the point: cancel the X-20 program and begin development of a new manned military space station.[659] Additionally, Brown believed management of the Gemini program

---

[656]Dr. Harold Brown, DDR&E, "Approaches to a Manned Military Space Program," Memo to the Secretary of Defense (Washington, D.C., 14 November 1963).

[657]Hallion, *The Hypersonic Revolution*, pp. 449-80, 539-58.

[658]Brown, "Approaches."

[659]Cantwell, *The Air Force in Space Fiscal Year 1964*, p. 18.

should be transferred from NASA to the DOD by October 1965, a concept very similar to what he would later criticize the Air Force for suggesting because changing the management and disposition of a NASA program fell outside the power of OSD.[660]

Discussions between NASA and DOD officials throughout November made it clear that the space agency would agree to a coordinated military space program, but was not prepared to support a joint national space station program. Instead NASA suggested a program for an orbiting military laboratory without ferrying, docking, and resupplying. Naturally, Brown advised the Secretary of Defense that his space station proposal of 14 November still remained the most feasible and should be initiated.[661] As deliberations continued, tragedy struck the nation.

On 22 November, President Kennedy was assassinated in Dallas, Texas. Had he lived, he might have told the nation it need not fear the apparent Soviet lead in space. America's strategic missile build-up, its success in the Cuban missile crisis, and the Nuclear Test Ban Treaty had been easing concerns about the missile gap.[662] The president's efforts to negotiate arms control and space exploration agreements with the Soviet Union focused Dyna-Soar's military mission on its reconnaissance abilities,

---

[660]Brown, "Approaches to a Manned Military Space Program."

[661]Dr. Harold Brown, DDR&E, "Evaluation of an Orbital Test Module," Memo to the Secretary of Defense (Washington, D.C., 30 November 1963).

[662]Roger D Launius and Howard E. McCurdy, "Johnson, Project Apollo, and the Politics of Space Program Planning," Chapter 3 of Presidential Leadership, False Hopes, and the Decline of the U.S. Space Program (Unpublished Manuscript, 1995), p. 140.

placing the Air Force in direct conflict with the NRO and its highly classified "black" reconnaissance satellites and their follow-on programs. This topic was only lightly broached during McNamara's 23 October meeting with Dyna-Soar officials in Denver. In Kennedy's place, former Vice-President Johnson now resided. President Johnson would still be looking for his report on the merits of a national space station and the pace of McNamara's quest for commonality between DOD and NASA hardware.

Sensing the conflict between DOD and NASA over a national space station, on 30 November Brown suggested McNamara offer NASA his proposal as a separate military space program rather than a joint effort. While NASA offered a simplified Gemini approach, it by no means concurred with OSD's proposed termination of the X-20 program. The Associate Administrator for Advanced Research and Technology, Dr. R. L. Bisplinghoff, reiterated the importance of developing the technology of maneuverable hypersonic vehicles with high-temperature, radiatively cooled metal structures. Test facilities or simulators could not recreate a similar lifting reentry environment. Consequently, X-20 flights would be necessary to provide such data. NASA had always supported Dyna-Soar through several of its laboratories. Should it be canceled, the space agency would have to initiate a substitute program.[663]

In order to obtain data on reentry, Bisplinghoff recommended some changes to the Dyna-Soar program. After completion of an adequate air-drop program and a single satisfactory unmanned ground-launch flight, a piloted orbital flight should be

---

[663]R. L. Bisplinghoff, Associate Administrator, "X-20 Program," Letter to Associate Administrator, NASA (Langley VA, 22 November 1963).

conducted.[664] Brown asked Flax to examine such an alternative for the X-20.[665] With the assistance of the X-20 program office and HQ AFSC, Flax completed his reply on 1 December. He estimated a curtailed program would reduce the total cost by $174.4 million through FY 1969. The approach, however, would result in a disproportionate loss of technical data compared to the financial savings.[666]

On the same day, in a memorandum to the Secretary of the Air Force, Flax firmly disagreed with the recommendations of Brown's 14 November memorandum. Flax knew OSD refused to give Dyna-Soar any serious consideration as an element in any of the space station proposals. He emphasized the need for modifications in both the Gemini and the X-20 to complement any space station program. Furthermore, Dyna-Soar offered several advantages: the vehicle could make emergency landings without the costly deployment of air and sea elements, there would be a more tolerable force of vehicle deceleration during reentry, and it would be reusable. Additionally, its technology would not only support the development of reentry vehicles--including Brown's SSD-sponsored lifting-body ferry vehicle--but it would also support an entire class of hypersonic winged-vehicles. Because about $400 million had already been

---

[664]Ibid.

[665]Dr. Harold Brown, DDR&E, "X-20 Program," Memo to the Assistant Secretary of the Air Force, R&D (Washington, D.C., 29 November 1963).

[666]Colonel William L. Moore, Program Director, "Telephone Request from HQ AFSC," Memo (Wright-Patterson AFB OH, 3 December, 1963); A. H. Flax, Assistant Secretary of the Air Force, "X-20A Program," Memo to DDR&E (Washington, D.C., 4 December 1963).

expended on the X-20 program, the assistant secretary severely questioned any proposal to cancel Dyna-Soar and initiate a new program with similar objectives. While he endorsed the purposes of the space station program, Flax believed the decision to begin such a program was independent of the question to terminate the X-20.[667]

The Air Force Replies to OSD

Immediately, Secretary of the Air Force Zuckert forwarded Flax's 1 December memorandum to McNamara, noting that it represented the best technical advice available in the Air Force. Also, both he and Brockway McMillan agreed with Flax's position. Indeed, Secretary Zuckert did not wish to see the Air Force abandon a well-established program such as Dyna-Soar and start a new program based on an optimistically compiled set of schedules and costs created by its rivals for a manned space mission the SSD.[668]

As an additional Air Force reply to Brown's 14 November memorandum, Major General J. K. Hester, the Assistant Vice-Chief of Staff, suggested several alternatives for varying sizes of space stations, all employing the X-20, to Zuckert. The first alternative offered an extended X-20 transition section providing a module of 700 cubic feet. This would be a two-man station employing an X-20 launched by a Titan IIIC. The second approach comprised a separately launched two-room station by

---

[667]Ibid.

[668]Eugene M. Zuckert, Secretary of the Air Force, "Manned Military Space Program," Memo to the Secretary of Defense (Washington, D.C., 4 December 1963).

the Titan II. This would have 1,000 cubic feet of volume and would be serviced by an X-20 shuttle vehicle boosted with a Titan IIIC. The third alternative, recommended by Hester as the most feasible, involved a five-man station launched by a Titan IIIC and capable of orbiting for one year. For the development of a space station and the X-20 ferry vehicle, it would require $978.4 million from FYs 1964 through 1969.[669]

The assistant vice-chief of staff considered the first space station launch could take place by the middle of 1967. With an X-20 approach to a space station program, it would not be necessary to have a separate program for an improved ferry vehicle. Only an annual funding level of $6.4 million for the ASSET program would be required to advance space technology. Therefore General Hester recommended the initiation of a space station program employing the X-20 and, if economy became an issue in the national space program, the cancellation of the Gemini program.[670]

On the next day, Zuckert forwarded Gen. Hester's memorandum to McNamara. The Air Force secretary felt the Air Staff study clearly indicated no definite reason existed for omitting the X-20 from consideration as a reentry vehicle for the manned orbiting laboratory program. He considered the safety and cost advantages the X-20

---

[669]Major General J. K. Hester, Assistant, Vice Chief of Staff, HQ Air Force, "Approaches to Manned Military Space Programs," Memo to the Secretary of the Air Force (Washington, D.C., 4 December 1963).

[670]Ibid.

offered for long-duration orbital missions particularly important. Secretary Zuckert believed the X-20 alternative deserved serious consideration.[671]

As OSD debated the future of Dyna-Soar, Chelomey's OKB-52 launched *Polet*-1, a maneuverable satellite, into orbit. Whether this was the unmanned R-1 hypersonic boost-glider is still unknown. In January 1964, OKB-52 launched another "maneuverable satellite," *Polet*-2, repeating their triumph of November. Whether this was the manned R-2 is still unknown.[672] Regardless, with the fall of Nikita Khrushchev on 13 October 1964, Chelomey's successful boost-glide operations were over.[673] By 1965, work on the boost-glider was suspended and the effort was transferred to the Mikoyan OKB where work begin on an SST-based two-stage-to-orbit hypersonic glider--*Spiral*.[674] OKB-52 shifted its focus to the military space station *Almaz* and to the *Proton* booster. Nevertheless, under Chelomey's guidance, OKB-52 had developed and launched at least two hypersonic boost-gliders, whereas the United States had launched none. Indeed, the United States was about to cancel its only manned hypersonic space program and shift its emphasis to a military space station concept

---

[671]Zuckert, "Manned Military Space Program."

[672]Rudenko, "Star Wars," p. 33.

[673]McDougall, *The Heavens and the Earth*, pp. 292-93.

[674]Dennis Newkirk, "Soviet Space Planes," *Spaceflight* 32 (October 1990):351-52.

similar to *Almaz*. Interestingly, in 1974 Chelomey again attempted to develop a boost-glider.[675]

OSD Cancels Dyna-Soar

On 8 December, as the Soviets continued their hypersonic research, a rumor circulated in HQ Air Force: DOD was reducing X-20 FY 1964 funds from $125 million to $90 million and getting no money at all for FY 1965.[676] The next day, defense officials conferred with President Johnson. Since the NASC meetings of July, Johnson consistently favored a national space station based on NASA's Gemini spacecraft. Not surprisingly, Secretary McNamara, who also favored the closer cooperation and commonality a national space station would bring to DOD-NASA relations, agreed with Brown's recommendation to terminate Dyna-Soar. LBJ agreed.[677] On 10 December, McNamara announced the cancellation of the X-20 program. In its place would be a manned orbital laboratory called MOL (NASA's recommendation to Brown station based on the Gemini spacecraft's technology and explained in his 30 November 1963 memorandum). The Secretary of Defense also said there would be an expanded ASSET program (a part of Brown's 14 November memorandum) to explore a wide range of manned and unmanned reentry shapes and

---

[675]Rudenko, "Star Wars," pp. 33-34; Kirpil and Okara, "Designer of Space Planes," pp. 15-16.

[676]Deputy Chief of Staff, *History Report*, p. 81.

[677]*New York Times,* 10 December 1963.

techniques. By taking the Gemini approach to a military space program, McNamara estimated $100 million would be saved in the following 18 months.[678]

The Secretary of Defense explained his reasons for canceling the X-20. The purpose of the program had been to demonstrate maneuverable reentry and landing at a precise point. The Dyna-Soar vehicle was not intended to develop a capability for carrying on space logistics operations. Furthermore, the X-20 was not intended to place substantial payloads into space, nor to fulfill extended orbital missions. In his view, "about $400 million had already been expended on a program still requiring several hundred million dollars to achieve a very narrow objective."[679]

A few days after the termination announcement, Brown replied to the arguments of Flax and Gen. Hester in a memorandum to the Secretary of the Air Force . Brown said that OSD had carefully considered the Air Force alternatives before reaching a decision. It found three objections. The Air Force-recommended program involved construction of a space station and a new and larger X-20. OSD considered such a large step unjustified. Instead, OSD felt a laboratory test module and Gemini spacecraft were the logical first steps. Furthermore, the Air Force suggestion to cancel Gemini was not within the power of the DOD because it was a NASA program (yet Brown had suggested DOD should takeover management of the program after 1965 in his 14 November memorandum). Last, the Air Force recommendation involved a

---

[678]Ibid.

[679]Robert S. McNamara, Secretary of Defense, "Cancellation of the X-20 Program," News Brief (Washington, D.C., 10 December 1963).

greater degree of schedule risk than the chosen program. The Air Force proposal could not be accepted as a feasible substitute for the Manned Orbiting Laboratory program.[680]

Following McNamara's news conference on 10 December, HQ Air Force informed all its commands of the termination of the X-20 and the initiation of MOL.[681] On the same day, General Schriever met with some of his staff to discuss the new approach. He felt the orbiting laboratory and the expanded ASSET programs would be placed under the management of SSD.[682] Later, Gen. Schriever requested the commander of the Research and Technology Division, Major General Marvin C. Demler, to aid the space division in their preparation of a new ASSET development plan. The objective of this program, as first announced by Brown, remained unchanged: the development of an advanced lifting-body ferry vehicle.[683]

Although the X-20 SPO did not receive official instructions from HQ AFSC until 17 December, it instructed its contractors and various Air Force agencies to stop all activities involving the expenditure of X-20 funds on 10 December. The next day,

---

[680]Dr. Harold Brown, DDR&E, "X-20 Program," Memo to the Secretary of the Air Force (Washington, D.C., 12 December 1963).

[681] HQ Air Force, "AFCVC-1918/63," TWX to All Commands (Washington, D.C., 10 December 1963).

[682]Lieutenant Colonel Scoville, "Events Concerning the X-20 Cancellation," Memo (Washington, D.C., no date, 1963).

[683]General Bernard A. Schriever, Commander, "Manned Space Program," Letter to Major General Marvin Demler, Commander RTD (Andrews AFB MD, 16 December 1963).

secretary Zuckert authorized the Air Force to terminate the X-20 program. The Air Force, however, would continue certain X-20 efforts deemed important to other space programs. The secretary wanted a preliminary report before 16 December.[684] The day following this direction, the Dyna-Soar program office recommended the continuation of ten activities: studies of pilot control of booster trajectories, fabrication of the Dyna-Soar heat protection system, construction of the full pressure suit, fabrication and testing of the high-temperature elevon bearings, final development testing of the nose cap, flight testing on the ASSET vehicle of coated molybdenum panels, final acceptance testing of the test instrumentation subsystem ground station, development of the very high frequency (VHF) search and rescue receiver and transmitter, employment of existing Boeing simulator crew station and flight instruments for further research, and development of certain sensoring and transducing equipment for telemetry instrumentation.[685] On 18 December, HQ Air Force informed the program office that the secretary of the Air Force had approved the ten items. Funding for continuation of these contracts would be limited to $200,000 a month.[686]

---

[684] Secretary of the Air Force, TWX to HQ AFSC (Washington, D.C., 11 December, 1963); E. M. Zuckert, Secretary of the Air Force, "Dyna-Soar Termination," Memo to the Chief of Staff, Air Force (Washington, D.C., 12 December 1963).

[685]Geiger, *Termination*, p. 24.

[686] HQ AFSC, "MSF-17-12-45," TWX to HQ ASD (Washington, D.C., 17 December 1963).

The Technical Legacy

Interestingly, the X-20 engineering office recommended a list of several items for reinstatement in addition to the ten efforts continued by the program director. The X-20 program director did not support the engineering office items, either, because he did not consider them of sufficiently wide applicability or because he could not adequately establish their merit.[687] On 14 December representatives from HQ AFSC, the SSD, ASD, and Research and Technology Division (RTD) revised the list. These officials decided to identify the items not only by technical area, as originally presented by the engineering office, but also by four categories. Category A involved efforts whose cost for completion would be equal to the termination expense. Category B comprised items applicable to various space programs. Category C included items contributing to the advancement of the state-of-the-art. The final classification, Category D, contained efforts possessing a potential future use.[688]

At the end of the month, officials from USAF headquarters, HQ AFSC, ASD, and RTD again reviewed proposed items for continuation. This time they suggested a new classification system. Category I included items that would advance the state-of-the-art. Category II involved only items requiring feasibility demonstration or

---

[687]Geiger, *Termination*, p. 25.

[688]HQ AFSC, "MSF-17-12-45."

design verification. Category III comprised nearly completed equipment, and Category IV consisted of efforts needing further justification.[689]

By 3 January 1964, the representatives completed a last revision of the proposed useful efforts. They added a Category V to include items suggested for continuation by various organizations but were considered unacceptable by the X-20 engineering office. Essentially, the engineering office recommended continuing the 38 efforts in Categories I, II, and III. All the original ten items offered by the program office were included in one or more of these categories. A few days later, General Estes requested authority from HQ Air Force to retain sufficient funds for program termination, including $3.1 million for the completion of the first three categories. On 23 January , HQ Air Force informed AFSC of the Secretary of the Air Force's approval. With the exception of two items, all the efforts listed under the first three categories could be continued. The Air Force would allow an expenditure of $70 million from FY 1964 funds for the Dyna-Soar program, $2.09 million would be directed towards completing the three categories.[690]

Conclusion

For some time the Air Force wanted to put a man into space to prove he could perform various military missions. To this end, the service pursued several programs, reaching various degrees of maturity by December 1963. The most advanced, and the

---

[689]Geiger, *Termination*, p. 26.

[690] HQ AFSC, "MSFAM-16-1-38," TWX to HQ ASD (Washington, D.C., 16 January 1963).

one the Air Force held the deepest interest in and commitment for, was Dyna-Soar. Additionally, the Air Force studied and sought OSD approval for the development of a space station. Pursued under various designations, the idea crystallized as MODS by November 1962. During FY 1963 the Air Force also investigated an aerospace plane concept--a single-stage-to-orbit vehicle capable of making a conventional horizontal landing like Dyna-Soar. Through Program 651, the Air Force hoped to demonstrate system feasibility. However, low funding dimmed its hopes. As such, the program did not promise tangible results before 1970. Finally, for a number of previously mentioned reasons, the Air Force sought a role in NASA's Gemini program. Although it hoped for a direct role, it soon found itself--by OSD direction--confined to developing a series of experiments with NASA to be conducted on future Gemini flights. By the beginning of FY 1964, it appeared the Air Force would be able to field some kind of manned military space program. Yet, most important, its relationship to Gemini, the extent of Air Force participation, or the role of Dyna-Soar, all remained open questions, seemingly biased in favor of a greater Gemini role.[691] By 10 December 1963, the question would be answered.

At the time of its cancellation, the Air Force calculated that Boeing had completed 41.74 percent of its tasks. Minneapolis-Honeywell, the associate contractor for the primary guidance subsystem, had finished 58 percent, and RCA, the associate contractor for the communication and tracking subsystem, had completed 59 percent of

---

[691]Cantwell, *The Air Force in Space Fiscal Year 1964*, pp. 15-27.

its work. Boeing had 6,475 people involved in the X-20 program, Honeywell had 630, and RCA 565. The governmental expenditure for these contracts amounted to $410 million.[692]

While OSD canceled the hypersonic boost-glider program at its mid-point, the Dyna-Soar program definitely advanced the hypersonic state-of-the-art, especially the technology of radiation-cooled structures. Thirty-six X-20 tasks were continued; all would directly contribute to other Air Force and NASA space efforts. Specifically, SSD's initiation of an expanded ASSET program was directed towards the development of a lifting-body shuttle vehicle. Paradoxically, the cancellation of the X-20 and the shift to SSD made the maneuverable reentry concept far more acceptable to OSD officials and to some elements within the Air Force, more so than during the six years of Dyna-Soar's existence.

Within the Air Force, proponents of lifting-body technology at SSD and the Aerospace Corporation doggedly competed with ASD to capture the Air Force's sole manned military space program. As the interagency rivalry continued, OSD redirected manned military space operations away from radiatively cooled hypersonic boost-glide technology and towards NASA's ballistic technology--an approach initiated by Gen. Schriever when he was commander of SSD's predecessor, WDD--and SSD's ablatively cooled lifting-body technology. In an effort to establish a system of manned military space programs, Air Force leaders appeared to place their hopes for a quickly

---

[692]Geiger, *Termination*, p. 27.

obtainable manned military role based on ballistic reentry ahead of the unique capabilities of a hypersonic boost-glider.

Throughout the debate, NRO's reconnaissance satellites provided valuable strategic intelligence. McNamara took the opportunity proved by several operational reconnaissance systems to probe the question of mission. As he had asked Bill Lamar on 23 October 1963, "don't you know SAMOS is performing the same kind of mission you are proposing that Dyna-Soar perform?" Consequently, the Air Force lost Dyna-Soar to the tacit acceptance by both the United States and the Soviet Union of highly classified unmanned reconnaissance satellite overflights--the "freedom of space," OSD's quest for commonality in a national space program--the hardware of the Gemini program, and an apparent near-term solution to the cooling problems of hypersonic reentry--the use of ablative materials.

Regardless of Dyna-Soar's inherent abilities to perform all the manned missions defined by OSD, McNamara, supported by the vice-president, did not want a manned military space program separate from a national manned space program. Unwilling to envision the far-reaching consequences of routine access to space provided by a reusable glider, McNamara remained satisfied with the *status quo* regarding military space operations. As long as the NRO's reconnaissance satellites continued to yield information, McNamara saw no need for a separate manned military space program. If a shuttle were to be required in the future, a systematic building-block approach to SSD's lifting-body would provide the answer. If a manned military space program were to be needed in the future, a systematic building-block approach to SSD's MOL would yield the solution. He did not believe either would be necessary.

CONCLUSION

> ...it is national policy to maintain a viable space program, not a separate program for NASA and another for Defense and still another for each of several other agencies. Likewise it is understood that the United States does not have a division between peaceful and non-peaceful objectives for space, but rather has space missions to help keep the peace and space missions to improve our ability to live well in peace.

Lyndon B. Johnson,
Vice-President,
January 1962[693]

> ...It appears to me that the Gemini is advanced beyond the Dyna-Soar in technique and technology and potential. There is no clear requirement, in my mind, at the present time for manned military operations in space....But were we to require manned military operations in low earth orbit, it appears to me that the Gemini approach is a far more practical approach...

Robert S. McNamara, Secretary of Defense,
DOD Appropriations Hearings, U.S. Congress,
House of Representatives, February 1963[694]

On 9 December 1963, President Johnson prepared to make his first major space policy decision. In a meeting with McNamara, Deputy Defense Secretary Roswell

[693]John F. Kennedy, *United States Aeronautical and Space Activities, 1961*, Message from the President of the United States Transmitting a Report on United States Aeronautical and Space Activities for Calender Year 1961, House Document 324, 87th Congress, 2nd Session (Washington, D.C.: GPO, 1962), p. 6.

[694] U.S. Congress, House, *DOD Appropriations for 1964*, pp. 385-87.

Gilpatric, Chairman of the Joint Chief of Staff General Maxwell D. Taylor, Secretary of State Dean Rusk, Budget Director Kermit Gordon, Dr. Jerome B. Wiesner, Presidential Science Advisor, and his assistant McGeorge Bundy, the president made an extensive and thorough review of military spending and forecasted what it would be for years ahead. Repeatedly emphasizing his desire to curb military spending, Johnson looked for opportunities to make cuts. As vice-president and chairman of the NASC, Johnson had enthusiastically supported the civilian space program as an instrument of national prestige and technological growth. He also promoted the military space program. As president, Johnson faced a different set of decisions. Under strong political pressure to hold FY 64's budget to $103 billion, he asked McNamara to reduce defense spending by $5 billion a year through 1967. OSD's skepticism about the military need for Dyna-Soar, an opinion supported outside OSD by Wiesner, offered the defense secretary an opportunity to implement a decision he had reached before President Kennedy's death. He suggested the cancellation of Dyna-Soar. The president agreed. His first space policy decision was in full countenance with his January 1961 national space policy statement and its economic ramifications.[695]

While the cancellation of Dyna-Soar was a severe setback for the Air Force, the Secretary of the Air Force and the Air Staff viewed it as one of several programs in an overall system of manned military space operations.[696] Although McNamara

---

[695]*New York Times,* 9 December 1963.

[696]Vern Haugland, "Manned Spaceflight," *Ordnance*, January-February 1963, pp. 430-34.

questioned the need and architecture of this system at every turn of its evolution, in the wake of Dyna-Soar's cancellation, OSD gave tacit approval for the development of a Manned Orbiting Laboratory (MOL) based on Gemini technology. Not believing a need truly existed, McNamara saw MOL solely as a building-block for the investigation of manned military space operations.[697] Ultimately, he had not wanted Dyna-Soar to become an operational system, and he would not want MOL to become an operational system, either.

What had begun in 1952 as feasibility studies for a manned hypersonic reusable boost-glider for strategic bombardment and reconnaissance missions became a means for the Air Force to justify its role in, and several missions for, manned military space operations by 1957. From 1957 through 1963 the Air Force argued with OSD as it attempted to justify the military need of a hypersonic boost-glider. Ultimately, the Air Force's inability to rationalize Dyna-Soar's military mission with the administration's national space policy and allay perceptions about the radical nature of the program's radiatively cooled approach to hypersonic flight forced its cancellation.

From the initial forecasts of *Toward New Horizons*, highlighting the 1945 hypersonic boost-glide technology of Major General Dornberger's A4b and A-9/A10 through the administration's declaration of "Freedom of Space" in NSC-5520, Air Force leaders believed advances in aerospace technology would ensure their continued independence from the other services while providing the best possible means for

---

[697]*New York Times*, 10 December 1963.

national defense. Yet, contrary to Dornberger's belief, technological solutions to boost-glide weapon systems did not appear to be within easy reach. Even ballistic missile technology seemed elusive when problems relating to accuracy and thrust could not be quickly resolved. With the development of the smaller and more powerful hydrogen bomb, the need for accuracy and the problems of weight seemed to be solved. Additionally, the increasing concern over the threat of Soviet ICBMs highlighted the need for, and America's inability to obtain, timely and accurate reconnaissance information. The Eisenhower administration responded by seeking a new, highly classified, means to obtain information about the closed Soviet society. Initially, the U-2 filled the void; however, even its high-altitude capabilities would not keep it out of harm's way indefinitely. The administration believed a follow-on would be necessary. While satellite reconnaissance would yield the necessary information, such technology would also need ballistic missile technology. Boost-glide technology offered another alternative; but, like reconnaissance satellites, it, too, would require ballistic missile technology. Ultimately, Air Force leaders embraced ballistic missiles, as did the other services, in their quest to gain a larger share of decreasing defense appropriations and to maintain technological parity with the Soviet Union.[698] After gaining the opportunity to develop and deploy the Atlas ICBM and the reconnaissance satellite system WS 117L, Air Force leaders appeared to be the victors. Still, as the

[698]Michael R. Terry, "Formulation of Aerospace Doctrine, 1955-59," *Air Power History* 38, 1 (Spring 1991): 48-52; Carl H. Builder, *The Icarus Syndrome* (New Brunswick NJ: Transaction Publishers, 1994).

Air Force gained the lion's share of strategic defense appropriations and prominence to address these short-term objectives, the long-term objectives addressed by boost-glide technology did not receive proportionate attention. Instead, the publicly- acknowledged Atlas ICBM and the highly classified WS 117L gained top priority.

Regardless of the potential advantages of hypersonic boost-glide technology, proponents found it difficult to gain and maintain confidence in its feasibility. Questions about its unknown viability to perform a bombardment or reconnaissance mission, the technological feasibility of such a radical concept, industry's ability to meet the technological challenge, and the short-term realities of the Soviet threat, kept boost-glide technology low on the totem pole of military priority.

In March 1955, the Eisenhower administration signified its view of space as a unique opportunity for intelligence gathering with NSC 5520, a report subject to special security precautions and limited distribution. In the report, the NSC gave indubitable primacy to the Air Force's reconnaissance satellite program WS 117L and its approval of an IGY satellite by calling for a freedom-of-space or space-for-peace policy. By mid-August 1958, the administration publicized its space-for-peace policy in NSC 5814/1, "Preliminary United States Policy on Outer Space," defining the types of military weapon systems it would contemplate for deployment in space, while keeping the medium open to peaceful international cooperation.[699] American policy would attempt to prohibit the military use of space, contingent upon the establishment

---

[699]McDougall, *The Heavens and the Earth*, pp. 74-132.

of an effective means of space-based reconnaissance. The United States must "seek urgently a political framework which will place the uses of U.S. reconnaissance satellites in a political and psychological context more favorable to the U.S. intelligence effort."[700] The Kennedy administration followed a similar space policy while applying a "black-out" to all reconnaissance satellite publicity beginning in January 1961. The tacit acceptance of the premise of reconnaissance satellite overflights by United States and the Soviet Union in August of 1963 was a testament to the policy's success. Throughout this process, the Air Force pushed for a stronger military space policy. Having established itself as the *aerospace* service, it felt it had the strongest case for being the nation's preeminent practitioner of space operations. The opposing views were like oil and vinegar, while they could be combined, they separated easily. In such cases, the administration's "oil" would always cling to the top, leaving the majority of the Air Force's "vinegar" at the bottom of the national space policy salad bowl.

The 4 October 1957 technological Pearl Harbor of Sputnik caused Air Force leadership to reconsider its conservative views of space as a medium for warfare and the nature of warfare in space. Space warfare would no longer be the sole purview of science fiction and "Buck Rogers." If BMD's ballistic missile technology offered a short-term solution to the first technological step to manned military space operations, what would be the long-term solution to the second step of extended operations in

---

[700]Ibid., pp. 180-83

space? If proponents could not gain high priority status for hypersonic flight could they afford to continue to push the state-of-the-art? Det. 1 believed, by using a non-proprietary approach to boost-glide technology, that it could maximize the use of a conceptual test vehicle for later phases (Steps II and III) of a new program called Dyna-Soar while it minimized program costs. With only a low level of funding initially, $3 million for FY 1958, the only available course of action was a timely evolution of technical knowledge rather than a crash program like Atlas. This ensured a minimum loss of R&D funding should preliminary studies prove a boost-glide weapon system unsatisfactory. Should the studies prove the system satisfactory, costs would still be minimized because such a long-term R&D program could be funded step-by-step The historical precedent for replacing older weapon systems with newer ones capable of advancing the technology, its five years of boost-glide feasibility studies, and the nature of the recent Soviet threat combined to enable Det. 1 to acquire the critical elements necessary to foster a favorable atmosphere for boost-glide technology. With Dyna-Soar, the Air Force maintained its institutional affinity for a manned strategic bombardment role while it incorporated ballistic missile technology and reconnaissance satellite technology into a manned weapon system.[701]

Meanwhile, Major General Schriever, Commander BMD, created a 10-15 year forecast for manned spaceflight exploration. The plan envisioned the attainment of manned spaceflight in a minimum of time and with a minimum of new development.

---

[701] HQ Air Force, "Hypersonic Glide Rocket Weapon System," Development Directive (Washington, D.C., 25 November 1957).

By using the existing missile technology and facilities within the BMD, or those currently under development, the Air Force could begin to investigate military astronautics and space technology at the earliest possible time.[702] By allowing both approaches to manned spaceflight to proceed, HQ ARDC believed the Air Force could put the first man into space. As the Air Force pushed the state-of-the-art, proponents of boost-glide technology hoped to propel their concept into the realms of space. Such a manned military agenda did not, however, fit into Eisenhower's space-for-peace policy.

In 1958, three basic themes emerged from the interaction of Eisenhower's space-for-peace policy and the service's quest for military space programs. These themes carried over into the Kennedy administration: military space activities should be regarded as extensions of the service's regular roles and missions, like defending the United States by maintaining aerospace superiority (role of the Air Force) through strategic reconnaissance (an Air Force mission); only those space activities that fulfilled strict military requirement "proofs" for direct military applications, like communications and reconnaissance, should be encouraged; for space systems with future military value, it would be necessary to engage in basic research to create "building-blocks," rather than "concurrently" tackling basic research while developing

---

[702]L. D. Ely, Colonel, "Manned Spaceflight Program," Memo to Colonel C. H. Terhune, Deputy Commander, Weapon Systems, BMD (Los Angeles CA, 13 December 1957); Air Force Ballistic Missile Division, *Chronology of Early Air Force Man-in-Space Activity, 1955-1960* (Los Angeles CA: Space Systems Division, 1965), p. 7.

an operational weapon system (like the Air Force did with the Atlas ICBM).[703] These themes justified the development of specific military space programs--like unmanned reconnaissance, communication, and weather satellites--and allowed them to be deployed during the Eisenhower administration. The same type of systems would continue to operate in the Kennedy administration and serve as the comparative foundation for OSD's justification of all other military space programs. In essence, these military space systems withstood the test of both administrations' space-for-peace policies.[704] Dyna-Soar would not. Although it might perform several types of reconnaissance missions, such routine manned space operations would be difficult for the Kennedy administration to conduct without challenging its own "black-out" policy on space-based reconnaissance assets.

As Eisenhower exerted authority over space policy, he ensured military space programs remained subordinate to civilian space programs. Eisenhower did not want to get into a space race with the Soviets. When Congress and the public cried for the simplification of the DOD's missile organization in 1958, the president did not eliminate the "czars"; he elaborated on them. The newly created institutions of ARPA, NASA, and DDR&E tightened and strengthened the administration's ability to direct the nation's classified and unclassified space programs by controlling their fiscal and administrative policies.

---

[703]Robert H. Puckett, "The Military Role in Space: A Summary of Official, Public Justifications," RP (RAND Paper)-2681 (Los Angeles CA, 1963).

[704]Kennedy, *United States,* p. iii.

Initially, confusion resulted from the overlapping agencies and programs. It increased as the international situation kept the question of whether space would be a civilian responsibility used for peaceful purposes or a military responsibility used for national defense in the press. By the first half of 1959, the administration's efforts began to bear fruit. Yet a disturbing pattern began to emerge. For every cluster of published American accomplishments, the Soviets, seemingly without fuss or furor, surpassed American achievements. Naturally, this generated criticism on Capitol Hill, throughout the military and among the press. Most singled out the space-for-peace policy. Though widely supported as an ideal, the policy suffered stinging criticism for dividing America's space program into two seemingly unsynchronized parts: one seeking to move with the tempo of military necessity and one seeking to progress with the philosophical calm of deliberate research. This debate disguised the administration's continuing development of classified reconnaissance satellites.

Through the entire period, the Air Force attempted to frame its own space policy as it tried to influence and conform to the administration's space-for-peace policy. As the doctrine of the indivisibility of the aerospace continuum took shape, the Air Staff exercised its authority over the single space program remaining solely under its jurisdiction--Dyna-Soar.

Yet the luxury of such a technologically challenging and necessarily expensive undertaking came at a price. The Air Force needed to emphasize Dyna-Soar's suborbital characteristics as a follow-on to manned strategic jet bomber and reconnaissance systems while attempting to retain the military potential of orbital flight. Additionally, ARPA, NASA, and DDR&E had the Air Force support the space programs no longer under its jurisdiction. Naturally, these designated responsibilities required Air Force funding, which the Step I suborbital portion of Dyna-Soar would not receive. As the administration's space-for-peace policy embraced operational reconnaissance satellites, the Air Force would want to regain a greater portion of these vital national programs. Ultimately, the Air Force's changing focus meant the Air Staff could not afford the increased expenditures needed for the R&D capabilities Dyna-Soar offered as a military weapon system or as the means of launching the first American into orbit. Conversely, the proven capabilities of ICBMs and the politically and militarily less threatening, less destabilizing, characteristics of unmanned reconnaissance satellites meant Dyna-Soar would need to match or surpass these satellites's abilities or lose the its justification for existence.

Within weeks of his narrow victory, President-elect Kennedy appointed Dr. Jerome Wiesner of MIT to head a special nine-man ad hoc committee to review the nation's space programs. Wiesner had been one of the members of Killian's original PSAC and a close associate of both Killian and Kistiakowsky, Killian's successor. As these scientific advisors of Eisenhower stayed on with the Kennedy administration, the term "missile gap" soon disappeared from the administration's lexicon. The continuing flow of intelligence information provided by the classified reconnaissance satellites of the "black hats" in NRO confirmed the Soviets were not translating their earlier lead in ICBM development into a corresponding lead in operational missile deployment. Another twist in the election rhetoric followed. Despite the common expectations of many, both in and out of Air Force circles, the changeover in administrations reflected continuity and consolidation in the scientific, technical, and defense-oriented agencies of the government. Many of the same people who played the principal roles of formulating the defense policies under Eisenhower continued to do so in the new Kennedy administration.

McNamara invited all five of the research and development officials at the presidential-appointee level to stay. Four did: Herbert F. York, Joseph Charyk, Dr. James Wakelin, Jr., Assistant Secretary for the Navy, Research and Development, and Richard S. Morse, Director of Research and Development for the Army. By 1 May 1961, York would be replaced by his good friend, Dr. Harold Brown, maintaining the mental, if not physical continuity of the previous administration.[705]

Much the same occurred in the White House science positions. Wiesner became Kennedy's Special Assistant for Science and Technology. PSAC membership remained the same except for a few of its 17 members. Wiesner became chairman. When Kennedy created a new agency, the Office of Science and Technology, Wiesner became its director. Some of Eisenhower's special assistant staff became part of this new agency's staff. Because of this continuity of people and ideology, no revolutionary changes in the development of strategic weapons programs occurred.

Subsequently, York's position regarding spaceflight and exploration not as ends in themselves but rather as integral parts of a total defense effort for the United States

---

[705]York, *The Advisors*, pp. 147-49.

and its allies perpetuated into the Kennedy administration. In turn, the defense effort would be considered within the administration's national space policy. Accordingly, administration officials believed it would not be logical to formulate long-term military space plans or programs separate and distinct from the administration's defense plans and programs. Subsequently, while the Air Force believed Dyna-Soar represented the only avenue for exploring the usefulness of manned military space missions and would be the best technological approach for developing a maneuverable, reusable, boost-glider for routine access to space, officials within OSD barely shared their vision. Still, they did share a portion of the vision. Air Staff officers followed the administration's space-for-peace lead by emphasizing the basic research aspects of the suborbital, Step I, portion of Dyna-Soar. Eventually, they gained approval to study the military configurations of Steps II and III. When the Kennedy administration gave its approval for orbital flight originally designated for Step II. It approved the funding for Step II and III military studies and it approved the substitution of Titan II, a booster with greater orbital potential, for Step I. Yet gaining approval for the development of Step II, much less Step III, would be extremely hard. It seemed the closer the administration came to committing itself publicly to a program dedicated to putting a military man in space, the harder the administration pushed to delay it. Unquestionably, these small steps did not mean OSD believed Dyna-Soar would surpass existing, or planned, reconnaissance, ICBM, or ASAT programs. Rather these steps meant the Air Force managed to inspire a degree of technological confidence and fiscal support for research on their hypersonic boost-glide weapon system while the administration examined ways to integrate military space operations with civilian operations of NASA under the auspices of a national space-for-peace policy. For proponents of Dyna-Soar, this proved to be a tenuous existence at best.

Thus, the situation reverted, in large measure, to what it had been before the Air Force attempted to push for a reexamination of the civilian-military relationship at the beginning of the Kennedy administration. The Air Force would not be getting a larger portion of the nation's space program. Mirroring these sentiments, Deputy Secretary of Defense Roswell L. Gilpatric told a Senate committee, that the DOD remained very conscious of the need to ensure the United States' technological parity with, or superiority over, the Soviet Union's military space capability. DOD would accomplish this task by continuing to support the national objective of space-for-peace.[706] Additionally, Dr. Harold Brown, DDR&E, specifically stated that the OSD fully supported the language and intent of the Space Act of 1958. It would not preempt areas, such as manned spaceflight, designated for NASA. Indeed, he observed, DOD's planned space efforts for the following year would be much smaller than NASA's.[707]

At a press conference on 14 June, the president also commented on the civilian-military space issue. Responding to a correspondent's question, Kennedy said that the

---

[706]Roswell L. Gilpatric, Deputy Secretary of Defense, *NASA Authorization for FY 1963*, Statement made during Senate hearings before the Committee on Aeronautical and Space Sciences, 87th Congress, 2nd Session (Washington, D.C.: GPO, 1962).

[707]Dr. Harold Brown, DDR&E, *NASA Authorization for FY 1963*, Statement made during hearings before the Committee on Aeronautical and Space Sciences, 87th Congress, 2nd Session (Washington, D.C.: GPO, 1962).

existing mix between civilian and military space efforts--with NASA as the primary--should continue. As a result, the Air Force's efforts to win a larger role in space and to modify the space-for-peace policy came to an end, at least temporarily.[708] When Glenn's orbital flight eliminated the international prestige factor as a justification for Dyna-Soar, congressional political support to use the program as part of an expanding Air Force-sponsored manned military space program seemed to erode as well. Once again, officials within the OSD viewed the program solely as a research project, denying its military utility by refusing to fund its military development.

In February 1962, McNamara finally identified the specific missions of a manned military space initiative. The initiative should establish the technology and experience necessary for manned space missions to rendezvous with uncooperative targets, demonstrate maneuverability on-orbit through to a precise recovery, and ensure the reusability of these vehicles with minimum refurbishment. In order to achieve these objectives, McNamara offered to support three programs. Dyna-Soar's orbital research program would provide the technological basis for maneuverability on-orbit and through to a precision landing. A cooperative effort with NASA and its Gemini program would provide commonality between the agencies while providing additional rendezvous experience and on-orbit maneuverability. Finally, McNamara saw a

---

[708]*New York Times*, 15 June 1962.

manned space laboratory to conduct sustained tests of military systems as useful for demonstrating exactly what a military man-in-space could accomplish.[709]

As McNamara established a building-block approach to manned military space operations, he also officially requested new nomenclature to emphasize Dyna-Soar's experimental, rather than military, nature. While McNamara's redirection of the program to orbital flight marked an advance over the three-step approach, in as much as orbital and multiorbital flights became established objectives of the first step, DOD officials refused to embrace the military objectives offered by the Dyna-Soar program office. To McNamara and other OSD officials, the "real" program remained centered on a research vehicle.[710]

For some time the Air Force wanted to put a man into space to fulfill OSD's requirement to prove he could perform various military missions. To this end, the service pursued several programs, reaching various degrees of maturity by December 1963. The farthest along, and the one the Air Force held the deepest interest and commitment for, was Dyna-Soar. Following OSD's February 1962 logic, the Air Force studied and sought approval for the development of a manned military space station. While the concept was explored under various designations, by November 1962 it became known as MODS. To fulfill near-term objectives, the Air Force sought

---

[709]Robert S. McNamara, "The Air Force Manned Military Space Program," Memo to Secretary of the Air Force Eugene M. Zuckert (Washington, D.C., 23 February 1962).

[710]Ibid.

a role in NASA's Gemini program. Although it hoped for a direct role, it soon found itself, by OSD direction, confined to developing a series of experiments for future Gemini flights. By the beginning of FY 1964, it appeared the Air Force would field some kind of manned military space program in support of the administration's national space policy. Yet, its relationship to NASA's Gemini, the extent of Air Force participation, or the role of Dyna-Soar remained open questions.[711] By December 1963, the question would be answered.

On 10 December 1963, OSD canceled the hypersonic boost-glider program midway through its development. The first Dyna-Soar vehicle was more than 55 percent complete and was scheduled for its first air launch from a B-52 "mother-ship" in 1965.[712] Unquestionably, the Dyna-Soar program advanced the hypersonic state-of-the-art, especially the technology of radiatively-cooled structures. Thirty-six X-20 tasks were continued; all directly contributed to other Air Force and NASA space efforts, specifically, SSD's initiation of an expanded ASSET program to develop a lifting-body rather than a boost-glide shuttle vehicle. Paradoxically, the cancellation of ASD's boost-glide approach to maneuverable reentry and the shift to SSD's lifting-body approach made the maneuverable reentry concept far more acceptable to OSD officials and some agencies within the Air Force. Presumably this occurred because of the proven ability of ablative materials technology to cool spacecraft during reentry as

[711]Cantwell, *The Air Force in Space Fiscal Year 1963*, pp. 5-27.

[712] Boeing Company, "Boeing News" (Seattle WA, 12 December 1963).

opposed to the unproven, but well researched, nature of radiative materials technology. At the time of its cancellation, governmental expenditures amounted to $410 million.[713]

Two months after the X-20's cancellation, before the Senate Subcommittee on DOD appropriations, McNamara summarized Dyna-Soar's cancellation:

> The X-20 (Dyna-Soar) was not contemplated as a weapon system or even as a prototype of a weapon system...it was a narrowly defined program, limited primarily to developing the techniques of controlled reentry at a time when the broader question of "Do we need to operate in near-earth orbit?" has not yet been answered.... I don't think we should start out a one billion dollar program until we lay down very clearly what we will do with the product, if and when it proves successful.[714]

Contrary to the secretary's statement, Air Force leaders did, from the program's conception, define the military requirements for Dyna-Soar as a weapon system and placed the program into the broader context of the administration's national defense policy. When the Eisenhower administration began to centralize its military space programs outside the purview of the Air Force in 1958, Air Force leaders fought to keep them, justifying their arguments in terms of their previous experience with missile development and the Soviet threat. Yet, the Eisenhower administration's military space policy, begun in 1955 with NSC 5520, emphasized the strategic importance of unmanned reconnaissance satellites and the need to make their overflights legal internationally rather than stressing the development of space-based manned bombers or reconnaissance programs. At the same time, Eisenhower refused to allow the

---

[713]Geiger, *Termination*, p. 27.

[714]U.S. Congress, House, *DOD Appropriations for 1964*, pp. 171-75.

country to become involved in a space race or an arms race in space. The Kennedy administration maintained Eisenhower's space-for-peace policy while imposing an information black-out on reconnaissance satellites and placing the United States in a race to the moon. As the NRO's reconnaissance satellites continued to provide the administration with critical strategic information about the Soviet Union, the Soviets began to embrace the politically stabilizing principles of mutual reconnaissance satellite overflights. The administration's black-out policy gave the Soviets an alternative to military action because they were not publicly embarrassment by America's reconnaissance satellite overflights. These changes to Eisenhower's space-for-peace policy prompted OSD's reconsideration of manned military space operations. In fact, OSD canceled Dyna-Soar largely because of its incompatibility with the administration's space-for-peace policy, OSD's desire to establish their principle of hardware commonality within the national space program, and its propensity to require comparative "proof" of man's ability to meet or exceed the abilities of existing unmanned weapon systems before sanctioning the new program's development. When the United States and the Soviet Union tacitly accepted the principle of mutual satellite overflight in 1963, Dyna-Soar's Step II mission of reconnaissance duplicated the on-orbit capabilities of NRO's classified reconnaissance satellites. Additionally, because Dyna-Soar had not been effected by the administration's black-out policy, its public profile made its Step III ASAT mission of defensive aerospace superiority a political hindrance, threatening to unbalance international stability. Indeed, OSD was developing a competitive classified unmanned satellite in the "black" world, beyond public scrutiny to fulfill the same mission.[715]

Within the Air Force, proponents of lifting-body technology at SSD and the Aerospace Corporation competed with ASD to capture the Air Force's manned military space program. As the interagency rivalry continued, OSD redirected manned military space operations away from hypersonic boost-glide reentry technology and towards ballistic reentry technology--an approach initiated by General Schriever when he was commander of SSD's predecessor, WDD. Ultimately, Air Force leaders found themselves forced into accepting a quickly obtainable manned military role based on ballistic reentry technology or conceding all hope for a manned military space program. In such a program, hypersonic flight became a means of ferrying astronauts to a manned space station rather than a separate military weapon system. Consequently, the Air Force lost Dyna-Soar because it duplicated the abilities of existing unmanned reconnaissance satellites, its radiatively-cooled reentry technology had yet to be demonstrated in flight, the Air Force was unable to place Dyna-Soar's military missions within the administration's space-for-peace policy without jeopardizing international relations, and OSD insisted on commonality in a national space program.[716]

---

[715]Cantwell, *The Air Force in Space, Fiscal Year 1963*, pp. 5-27.

[716]Puckett, *The Military Role in Space*.

Regardless of its technical ability to perform all the manned missions defined by OSD's February 1962 policy statement and outperform existing reconnaissance satellites because of its payload capacity, its potential for growth, and its ability to surprise an enemy through the unpredictable timing of its overflight, McNamara did not want a manned military space program separate from a national space program. The Vice-President Johnson supported this position and continued to support it as president when he agreed to the cancellation of Dyna-Soar. Indeed, why should the administration support a separate military space program when it could combine the two under the auspices of a national space program and a secret military space program to wage a Cold War of prestige and technology against the Soviet Union?[717] Unwilling to envision the far-reaching military and economic consequences of routine access to space, McNamara remained satisfied with the *status quo* of existing military space operations and the potential of the national space program to demonstrate the feasibility of future manned military spaceflight. As long as the NRO's reconnaissance satellites continued to provide vital strategic information, McNamara saw no need for a separate manned military space program. Once Dyna-Soar was canceled, NASA began to acquire an increasing amount of the Air Force's hypersonic research until its Space Shuttle offered the Air Force another chance for a joint venture equal in scope to Dyna-Soar. This time, however, NASA would be the lead organization rather than the Air

[717]McDougall, *The Heavens and the Earth*, pp. 415-61.

Force, leaving Col. Crews and the "T-Rex" as a flight of fantasy for some future science fiction novel rather than a flight of fact for the texts of spaceflight history.

WORKS CITED

Primary

Adams, Brigadier General M. B., Deputy Director. "Development Directive 411." Letter to Commander ARDC. Washington, D.C., 12 October, 1960. Found in the Dyna-Soar [hereafter cited as DS] supporting documents on file at the History Office of the Aeronautical Systems Division, Wright-Patterson AFB, Ohio [hereafter cited as HO/ASD].

Aero and Space Vehicle Panel of the Scientific Advisory Board. "Dyna-Soar and Phase Alpha Review." Report of the Aero and Space Vehicles Panel, SAB, Washington, D.C., 15 April, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Dyna-Soar." Report of the Aero and Space Panel, SAB. Washington, D.C., January, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Report of the Aero and Space Vehicle Panel of the SAB on Dyna-Soar." Washington, D.C., 2-4 December, 1959. Found in the DS supporting documents on the file at the HO/ASD.

------. "Presentation to the SAB Ad Hoc Committee to Study Advanced Weapons Technology and Environment." BMD Presentation. Washington, D.C., 29 July, 1957. Found in the Ballistic Missile Division documents of file at the Historical Division, Office of Information, Space Systems Division, Los Angles CA [hereafter cited as HD/SSD].

Aircraft Panel, USAF Scientific Advisory Board. "Some Remarks of the Aircraft Panel on New Technical Developments of the Next Ten Years." Washington, D.C., 1 October, 1954. Found in the SAB files at OH/ASD.

------. "Some Remarks of the Aircraft Panel on Technical Developments of the Next Ten Years." Washington, D.C., 1 October, 1954. Found in the SAB files of the OH/ASD.

Anderson, S. E., Commander AMC. "AMC and ARDC Management Procedures for the Dyna-Soar Program." Memo to Lieutenant General B. A. Schriever, ARDC Commander. Los Angeles CA, 8 February, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Management of the Dyna-Soar Program." Letter to Lieutenant General B. A. Schriever, ARDC Commander. Los Angeles CA, 11 December, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. TWX to Lieutenant General B. A. Schriever, Commander ARDC. Los Angeles CA, 14 October, 1959. Found in the DS supporting documents on file at the HO/ASD.

------, and Lieutenant General Bernard A. Schriever, ARDC Commander. "Dyna-Soar Selection." Joint Letter to HQ Air Force. Wright-Patterson AFB OH, 4 November, 1959. Found in the DS supporting documents on file at the HO/ASD.

Anderson, S. E., Commander ARDC. "FY 1959 Dyna-Soar Funding." Letter to Lieutenant General R.C. Wilson, Deputy Chief of Staff, Development, HQ Air Force. Wright-Patterson AFB OH, 24 July, 1958. Found in the DS supporting documents on file at the HO/ASD.

Arnold, Gen. Henry H. *Global Mission*. New York: Harper & Brothers, 1949.

------. General H. H. Arnold to Dr. Theodore von Kármán, 7 November 1944. Andrews AFB MD. As quoted in Michael Gorn, *Vulcan's Forge* (Andrews AFB MD: Office of Air Force History, 1989), 1.

------. *Third Report of the Commanding General of the AAF to the Secretary of War.* Washington, D.C.: War Department, 12 November 1945.

ASD Field Test Office. "ASFP-5-10-1." TWX to HQ ASD. Patrick AFB FL, 5 October, 1962. Found in the DS supporting documents on file at the HO/ASD.

Becker, John V. "The X-15 Project." *Aeronautics and Astronautics*, February 1964, 52-61.

Bell Aircraft Company. "Advanced Strategic Weapon System-Final Summary Report." Report D143-945-018. Wright-Patterson AFB OH, 29 April, 1955. Found in the DS Antecedents supporting documents on file at the OH/ASD.

------. "BRASS BELL Briefing." Report D143-945-048. Wright-Patterson AFB OH, 1 July, 1957. Found in the DS Antecedents supporting documents on file at the OH/ASD.

------. "Hypersonic Systems Research Airplane." Proposal D192-945-001. Wright-Patterson AFB OH, 21 May, 1956. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Bisplinghoff, R. L., Associate Administrator. "X-20 Program." Letter to Associate Administrator, NASA. Langley VA, 22 November, 1963. Found in the DS supporting documents on file at the HO/ASD.

Boeing Aircraft Company. "Summary Report MX-2145." D-15104, Boeing Aircraft Company. Wright-Patterson AFB OH, 30 April, 1954. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Boeing Airplane Company. "Preliminary Study of Design Characteristics of Hypersonic Bombardment Rockets." D-15105, Boeing Aircraft Company. Wright-Patterson AFB OH, 22 April, 1954. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Boeing Company. "Boeing News." Seattle WA, 12 December, 1963.

Boushey, Homer A., Brigadier General. "Approval of Abbreviated Development Plan for System 464L." Letter. Washington, D.C., 15 November, 1957. Found in the DS supporting documents on file at the OH/ASD.

------. Letter to HQ ARDC. Andrews AFB MD, 15 January, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Proposed Military Position on Space." Washington, D.C., December, 1959. As cited in Lee Bowen, *Ah Air Force History of Space Activities, 1945-1959.*

------. "Required Action on Dyna-Soar." Letter to HQ ARDC. Andrews AFB MD, 29 October, 1959.

------. "Required Action on Dyna-Soar." Letter to HQ ARDC. Andrews AFB MD, 29 October, 1959. Found in the DS supporting documents on file at the HO/ASD.

Brady, Colonel W. D., Acting Deputy. "Program 706, Phase 0." Letter to Colonel Moore, X-20 Program Manager. Los Angeles CA, 25 June, 1961. Found in the DS supporting documents on file at the HO/ASD.

Brooks, Representative Overton, and Senator Richard B. Russell. *New York Times,* 7 August 1961.

Brown, Dr. Harold, DDR&E. "Approaches to a Manned Military Space Program." Memo to the Secretary of Defense. Washington, D.C., 14 November, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Military Orbiting Space Station." Memo to Secretary of the Air Force. Washington, D.C., 30 August, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. *NASA Authorization for FY 1963.* Statement made during hearings before the Committee on Aeronautical and Space Sciences. 87th Congress, 2nd Session. Washington, D.C.: Government Printing Office [hereafter cited as GPO], 1962.

------. "National Space Program." Memo. Farmington CT, 17 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Rationale for RDT&E Program Adjustments by OSD." Memo. Washington, D.C., 19 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Program." Memo to the Secretary of the Air Force. Washington, D.C., 12 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Program." Memo to the Assistant Secretary of the Air Force, R&D. Washington, D.C., 29 November, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Evaluation of an Orbital Test Module." Memo to the Secretary of Defense. Washington, D.C., 30 November, 1963. Found in the DS supporting documents on file at the HO/ASD.

Bush, Vannevar. *Modern Arms and Free Men.* New York: Simon and Schuster, 1949.

Bushnell, David. "General Principles and Construction of a Submarine Vessel, Communicated by D. Bushnell of Connecticut, the Inventor, in a Letter of October, 1787, to Thomas Jefferson Then Minister Plenipotentiary of the United States at Paris." *Transactions of the American Philosophical Society* 4 (1799).

Charyk, Dr. Joseph V., Assistant Secretary of the Air Force. "D&F 50-11-284 Dyna-Soar Program." Memo to Deputy Chief of Staff, Development, HQ Air Force. Washington, D.C., 20 November, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Dyna-Soar "Phase Alpha" Program." Memo to Deputy Chief of Staff, Development, HQ Air Force. Washington, D.C., 4 January, 1960. Found in the DS supporting documents on file at the HO/ASD.

Chief of Staff, Air Force. "AFRAE-69512." TWX to HQ AFSC. Washington, D.C., 18 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "AFRDD-79094." Telecommunications Message [hereafter cited as TWX] to HQ AFSC. Washington, D.C., 18 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

Colchagoff, Major G. D., Deputy Commander/Weapon Systems. "New Research Systems." Memo to Lieutenant Colonel R. C. Anderson, Commander, Research & Target Division, HQ ARDC. Andrews AFB MD, 16 February, 1956. Found in the DS supporting documents on file at the HO/ASD.

Commander, Det. 1, HQ ARDC. "RDZSXB--59RDZ-3995." TWX to HQ Air Force. Wright-Patterson AFB OH, 13 February, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "RDZSXB-30164-E." TWX to HQ Air Force. Wright-Patterson AFB OH, 6 February, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "RDZSXB-3117." TWX to HQ Air Force. Wright-Patterson AFB OH, 16 September, 1958. Found in the DS supporting documents on file at the HO/ASD.

Cooper, Major General M. F., Deputy Chief of Staff. "X-20 System Package Program." Letter to Lieutenant General H. M. Estes, Jr., Vice Commander, ASD. Andrews AFB MD, 16 November, 1962. Found in the DS supporting documents on file at the HO/ASD.

Cox, R. N. "Experimental Facilities for Hypersonic Research." In *Progress in Aeronautical Sciences*, edited by Antonio Ferri, D. Kuchemann and L. H. G. Sterne. New York: Pergamon Press, 1962.

Crowley, J. W., Associate Director for Research. "Comments on Project BOMI." Letter to Commander Det. 1, Directorate of Systems Management. Wright-Patterson AFB OH, 12 February, 1956. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Davis, Major General L. I., Special Assistant to the Vice Commander. "X-20 Test Program." Letter to General Schriever, Commander, AFSC. Andrews AFB MD, 19 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

Davis, Major General W. A., Commander ASD. "System 620A Package Program." Letter to Major General M. F. Cooper, Deputy Chief of Staff, Systems, HQ Air Force. Wright-Patterson AFB OH, 25 April, 1962. Found in the DS supporting documents on file at the HO/ASD.

Davis, Major General W. A., Commander BSD. "Support of Test Programs by the 6555 ATW, Patrick AFB, FL." Memo to Commander ASD. Patrick AFB FL, 16 October, 1962. Found in the DS supporting documents on file at the HO/ASD.

Demler, Major General M. C., Director. "System 620A, Dyna-Soar Step I Booster." Report. Washington, D.C., 9 January, 1961. Found in the DS supporting documents on file at the HO/ASD.

Department of Defense. *Semi-Annual Report of the Secretary of Defense and the Semiannual Reports of the Secretary of the Army, Secretary of the Navy, Secretary of the Air Force, 1 July to 31 December 1949*. Washington, D.C.: GPO, 1949.

Deputy Chief of Staff, Systems and Logistics. "Dyna-Soar Adaptation to Titan Booster." Letter to Secretary of the Air Force. Washington, D.C., 3 August, 1962. Found in the DS supporting documents on file at the HO/ASD.

Deputy Secretary of Defense. "Release of Dyna-Soar Funds." Memo. Washington, D.C., 7 January, 1959. Found in the DS supporting documents on file at the HO/ASD.

Det. 1, Directorate of Systems Management, HQ Air Force. "Abbreviated Development Plan, System 464L." Wright-Patterson AFB OH, 1 November, 1959. Found in the DS supporting documents on file at the HO/ASD or through the Defense Technical Information Center service [hereafter cited as DTIC].

------. "Preliminary Development Plan, System 464L." Wright-Patterson AFB OH, November, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "RDZSXB-12-31619-E." TWX to HQ Air Force. Wright-Patterson AFB OH, 31 December, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "Report on Dyna-Soar Meeting." 59RDZ-23128. Wright-Patterson AFB OH, July-August, 1959. Found in the DS supporting documents on file at the HO/ASD.

Det. 1, Directorate of Systems Management, HQ ARDC. "Dyna-Soar Substantiation of RDZ Program." Report to HQ ARDC. Wright-Patterson AFB OH, No Date, 1959. Found in the DS supporting documents on file at the HO/ASD.

Director, Development, Deputy Chief of Staff, R&D. History Report, July-December 1963. Washington, D.C., 11 August, 1966. Found in the DS supporting documents on file at the HO/ASD.

Directorate of Systems Management. "Daily Activity Reports." Wright-Patterson AFB, 3 March, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. TWX RDZSXB-31261-E. Wright-Patterson AFB OH, 13 November, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activities Report." Wright-Patterson AFB OH, 17 November, 1955. Found in the DS supporting documents on the file at OH/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 14 June, 1955. Found in the DS supporting documents on file at the OH/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 12 January, 1956. Found in the DS supporting documents on file at OH/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 22 December, 1956. Found in the DS supporting documents on file at the OH/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 31 October, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 14 November, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 10 April, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 18 December, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright Patterson AFB OH, 12 June, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 13 November, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 5 February, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 15 January, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 16 April, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 8 April, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. and Directorate of Systems Management. "Weekly Activity Report." Wright-Patterson AFB OH, 7 June, 1955. Found in DS supporting documents on file at the OH/ASD.

Directorate of Systems Plans. "Abbreviated Development Plan for Weapon System 464L." First Development Plan for Dyna-Soar. Wright-Patterson AFB, 23 August, 1957.

DOD. *DOD News Release*. Number 84-63. Washington, D.C.: GPO, 22 January, 1963.

------. "DOD-NASA Agreement." News Release. Washington, D.C., 22 January, 1963.

------. "Dyna-Soar Designated X-20." News Release. Washington, D.C., 26 June, 1962.

Dornberger, Walter R. "Arms in Space: Something Else to Worry About." *U.S. News & World Report*, 9 October 1961.

------. *V-2*. 2nd. ed. Translated by James Cleugh and Geoffrey Halliday, 281. New York: Viking Press, 1955.

Douglas Aircraft Company. *Preliminary Design of an Experimental World Circling Spaceship*. Report SM-118271946.

Dyna-Soar SPO, Directorate of Systems Management, ASD. "Abbreviated Development Plan, System 620A." Wright-Patterson AFB OH, 7 October, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Abbreviated Development Plan, System 620A." Wright-Patterson AFB OH, 7 October, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. Daily Activity Report. Wright-Patterson AFB OH, 19 April, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "Development Plan, Dyna-Soar." Wright-Patterson AFB OH, 16 November, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Program Summary, 620A." Daily Activity Report. Wright-Patterson AFB OH, 19 March, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "Revision A, System Package Program, System 620A." Wright-Patterson AFB OH, 23 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "System Package Program, 620A." Wright-Patterson AFB OH, 14 May, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "System Package Program, System 620A." Wright-Patterson AFB, 26 April, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "System Package Program, System 620A." Wright-Patterson AFB OH, 10 October, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "System Package Program, System 620A." Wright-Patterson AFB OH, 3 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "System Package Program, System 620A." Wright-Patterson AFB OH, 27 May, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "System Package Program, System 620A." Wright-Patterson AFB OH, 13 May, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "System Program Package, 620A." Wright-Patterson AFB OH, 26 June, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Tentative System Package Program, System 620A." Wright-Patterson AFB OH, 15 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Anti-Satellite Mission." Report. Wright-Patterson AFB OH, 1 June, 1963. Found in the DS supporting documents on file at the HO/ASD.

Dyna-Soar WSPO, Directorate of Systems Management, WADD. "System Development Plan, Dyna-Soar (Step I) Program, 620A." Wright-Patterson AFB OH, 1 April, 1960. Found in the DS supporting documents on file at the HO/ASD and DTIC.

Editorial. *Newsweek*, 18 November 1957.

------. *Time*, 19 January 1960.

Eisenhower, Dwight D. *The White House Years*. Garden City NJ: Doubleday, 1965.

Eisenhower, Dwight David. *Farewell Radio and Television Address to the American People, 17 January 1961*. Vol. 8 of *Public Papers of the Presidents, Dwight D. Eisenhower 1953-1961*. Washington, D.C.: GPO, 1961.

Ely, L. D., Colonel. "Manned Spaceflight Program." Memo to Colonel C. H. Terhune, Deputy Commander, Weapon Systems, BMD. Los Angeles CA, 13 December, 1957. Found in the Ballistic Missile Division documents on file at HD/SSD.

Enthoven, Alain, and K. Wayne Smith. *How Much is Enough? Shaping the Defense Program, 1961-1969*. New York, 1971.

Estes, Brigadier General H. M., Jr. "Evaluation of Project BOMI." Letter to Deputy Commander, Weapon Systems, HQ ARDC. Andrews AFB MD, 21 December, 1955.

Estes, Lieutenant General H. M., Jr. "Manned, Military, Space, Capability, Vehicle Study." Letter to General Schriever. Wright-Patterson AFB OH, 28 September, 1961. Found in the DS supporting documents on file at the HO/ASD.

Estes, Lieutenant General H. M., Jr. "Space Planning Study." Letter to HQ ASD. Andrews AFB MD, 25 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Program Guidance for FY 1964." Letter to Major General Ruegg, Commander, ASD. Andrews AFB MD, 21 June, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Program." Letter to HQ Air Force. Andrews AFB MD, 30 March, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 System Package Program." Letter to Lieutenant General Ferguson. Andrews AFB MD, 17 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

Ferer, Lieutenant Colonel B. H., Assistant. "Assistant Secretary Air Force Research and Development Restrictions on Dyna-Soar Determinations and Findings." Memo. Andrews AFB MD, 24 November, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Dyna-Soar Briefing to Dr. Charyk." Memo on the 23 June Briefing to Dr. Charyk. Washington, D.C., 23 June, 1959. Found in the DS supporting documents on file at the HO/ASD.

Finletter, Thomas R. *Power and Policy, US Foreign Policy and Military Power in the Hydrogen Age*. New York: Harcourt, Brace, & Company, 1954.

Flax, A. H., Assistant Secretary of the Air Force. "X-20A Program." Memo to DDR&E. Washington, D.C., 4 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Dyna-Soar Operational Capability Study." Memo. Washington, D.C., 18 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

Fleming, David M., Captain. "Request for Proposal." HQ ARDC Letter to Aircraft Companies. Andrews AFB MD, 19 Dec, 1955. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Freedman, Lawrence. *The Evolution of Nuclear Strategy*. New York: St. Martin's Press, 1981.

Gardner, Trevor. "But We Are Still Lagging." *Life*, 4 November 1957.

Gilpatric, Roswell L., Deputy Secretary of Defense. *NASA Authorization for FY 1963*. Statement made during Senate hearings before the Committee on Aeronautical and Space Sciences. 87th Congress, 2nd Session. Washington, D.C.: GPO, 1962.

Goldie, J. Harry, Chief Engineer. "Questions, Comments, and Impressions from McNamara Briefing in Denver, 23 October 1963 Paraphrased Transcript of Discussion After X-20 Status Briefing to McNamara by Colonel Moore in Denver, 23 October 1963." Trip Report. Denver CO, 24 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

Golovin, N. E., Office of Science and Technology. "Briefing of Lees Subcommittee of PSAC Space Vehicle Panel." Memo to A.C. Hall, Deputy, DDR&E. Washington, D.C., 12 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

Grosse, A. V. "Report on the Present Status of the Satellite Program."1953. As cited in Walter A. McDougall, *The Heavens and the Earth* (New York: Basic Books, Inc., 1985).

Haugen, Major General V. R., Commander. "Dyna-Soar I Program Guidance." Letter to HQ Air Force. Wright-Patterson AFB OH, 15 May, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Status of Dyna-Soar." Letter to Lieutenant General R. C. Wilson, Deputy Chief of Staff, Development, HQ Air Force. Wright-Patterson AFB OH, 6 August, 1958. Found in the DS supporting documents on file at the HO/ASD.

Haugland, Vern. "Manned Spaceflight." *Ordnance*, January-February 1963, 430-34.

Heaton, Donald H., Lt. Col. "Rocket Bomber Feasibility Studies." Letter to the Commander ARDC. Washington, D.C., 28 November, 1952. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Hester Major General J. K., Assistant, Vice Chief of Staff, HQ Air Force. "Approaches to Manned Military Space Programs." Memo to the Secretary of the Air Force. Washington, D.C., 4 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

Hewlett, Richard G., and Oscar E. Anderson, Jr. *The New World, 1939-1946*. Vol. 1 of *A History of the United States Atomic Energy Commission*. University Park PA: Pennsylvania State University Press, 1962.

Holloway, Bruce K., Major General. "Requirements for Aerospace Weapon Systems." *Air University Quarterly Review* XII, 3/4 (Winter/Spring 1960-1961): 213.

Holzapple, Major General Joseph R., Deputy Chief of Staff. "Amendment 1 to Systems Program Directive 4." Washington, D.C., 2 February, 1962. Found in the DS supporting documents on file at the HO/ASD.

HQ Air Force Systems Command. "LSCSAD-23-7-18." TWX to HQ ASD. Andrews AFB MD, 25 July, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "MFSA-30-7-47." TWX to HQ ASD. Andrews AFB MD, 30 July, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "MFSA-9-5-17." TWX to HQ ASD. Andrews AFB MD, 9 May, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "MSF-17-12-45." TWX to HQ ASD. Washington, D.C., 17 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "MSFAM-16-1-38." TWX to HQ ASD. Washington, D.C., 16 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "SCCP-3-7-2." TWX to HQ ASD. Andrews AFB MD, 3 July, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "SCG-0-10-6." TWX to HQ ASD. Andrews AFB MD, 10 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "SCGV-11-8-18." TWX to Deputy Commander, Aerospace Systems. Wright-Patterson AFB OH, 11 August, 1961. Found in the DS supporting documents in file at the HO/ASD.

------. "SCLDA-8-1-2-E." TWX to HQ ASD. Wright-Patterson AFB OH, 8 January, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "SCRAS-3-4-2." TWX to HQ ASD. Washington, D.C., 4 April, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "SCSAS-28-1-59." TWX to Chief of Staff, Air Force. Andrews AFB MD, 28 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "SCSS-19-21-1." TWX to HQ ASD. Andrews AFB MD, 19 Dec, 1962. Found in the DS supporting documents on file at the HO/ASD.

HQ Air Force. "AFCVC-1918/63." TWX to All Commands. Washington, D.C., 10 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAP-78950." TWX to HQ AFSC. Andrews AFB MD, 16 June, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-48049." TWX to Commander, Det 1. Andrews AFB MD, 16 January, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-51437." TWX to Commander, Det 1. Andrews AFB MD, 28 May, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-53166." TWX to Commander Det. 1, HQ ARDC. Andrews AFB MD, 10 July, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-54520." TWX to Commander, Det 1. Andrews AFB MD, 30 December, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-55061." TWX to Commander, Det 1. Andrews AFB MD, 14 January, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-56643." TWX to Commander, Det 1. Andrews AFB MD, 17 February, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-58885." TWX to Commander, Det 1. Andrews AFB MD, 30 September, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-59299." TWX to Commander, Det 1. Andrews AFB MD, 24 April, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-89082." TWX to HQ ARDC. Andrews AFB MD, 26 April, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDRD-AN-31317." TWX to Commander, Det 1, HQ ARDC. Wright-Patterson AFB OH, 16 June, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDSD-66668." TWX to HQ ARDC. Andrews AFB MD, 5 December, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDSD-76644." TWX to HQ ARDC. Washington, D.C., 12 January, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDSD-82107." TWX to HQ ARDC. Washington, D.C., 3 February, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDSD-AS/O-93477." TWX to HQ ARDC. Washington, D.C., 13 October, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "AFRDC-92965." TWX to HQ AFSC. Washington, D.C., 12 April, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "AFRDDG-86985." TWX to HQ AFSC. Washington, D.C., 4 January, 1964. Found in the DS supporting documents on file at the HO/ASD.

------. "AFSDC-5-9-65922." TWX to HQ AFSC. Washington, D.C., 13 July, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "AFSDC-67166." TWX to HQ AFSC. Washington, D.C., 3 October, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "AFSDC-85-081." TWX to HQ AFSC. Washington, D.C., 11 December, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "AFSDC-S-67777." TWX to HQ AFSC. Washington, D.C., 5 October, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Development Directive 411." Andrews AFB MD, 12 October, 1960. Found in the DS supporting documents on file at the HO/ASD and DTIC.

------. "General Operational Requirement 92, Revised." Andrews AFB MD, 17 February, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Hypersonic Glide Rocket Weapon System." Development Directive. Washington, D.C., 25 November, 1957. Found in the DS supporting documents on file at the OH/ASD.

------. "System Development Requirement 19." Andrews AFB MD, 21 July, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Systems Program Directive 4." Washington, D.C., 27 December, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. TWX to Commander, ARDC. Andrews AFB MD, 7 December, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. TWX to Commander, ARDC. Andrews AFB MD, 17 November, 1959. Found in the DS supporting documents on file at the HO/ASD.

HQ Air Research and Development Command. "Evaluation Report of the Ad Hoc Committee for ARDC System Requirement 126, ROBO." ARDC-TR-57-130. Andrews AFB MD, 1 August, 1957. Found in the DS supporting documents on file at the OH/ASD.

------. *HQ ARDC Annual History, 23 January 1950-30 June 1951*. Andrews AFB MD: HQ ARDC, 1951.

------. *HQ ARDC Semi-Annual History, 1 January -30 June*. Andrews AFB MD: HQ ARDC, 1956.

------. *HQ ARDC Semi-Annual History, 1 January -30 June*. Andrews AFB MD: HQ ARDC, 1958.

------. *HQ ARDC Semi-Annual History, 1 January-30 June*. Andrews AFB MD: HQ ARDC, 1956.

------. *HQ ARDC Semi-Annual History, 1 July-31 December*. Andrews AFB MD: HQ ARDC, 1955.

------. *HQ ARDC Semi-Annual History, 1 July-31 December*. Andrews AFB MD: HQ ARDC, 1956.

------. "Hypersonic Weapons Research and Development Supporting System 455L--HYWARDS." System Requirement 131. Andrews AFB MD, 29 June, 1956. Found in the DS Antecedents supporting documents on file at the OH/ASD.

------. "RDG-23-7-5-E." TWX to HQ BMD. Andrews AFB MD, 23 July, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "RDRA-30-9-43." TWX to HQ WADD. Andrews AFB MD, 30 September, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "RDROF-9-6-4." TWX to HQ WADD. Andrews AFB MD, 9 June, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Rocker Bomber Study." System Requirement 126. Andrews AFB MD, 12 June, 1956. Found in the DS supporting documents on file at the OH/ASD.

------. "Statement of Agreement, System 620A, Dyna-Soar I for the Air Force Ballistic Missile Division, ARDC." Memo to HQ BMD. Wright-Patterson AFB OH, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Supplement 1 to the Evaluation Report." ARDC-TR-57-130. Andrews AFB MD, 1 October, 1957. Found in the DS supporting documents on file at the OH/ASD.

------. "System Development Directive 464L." Andrews AFB MD, 12 December, 1957. Found in the DS supporting documents on file at the HO/ASD.

------. "Systems Requirement 201." Wright-Patterson AFB OH, 7 May, 1959. Found in the DS supporting documents on file at the HO/ASD.

HQ Space Systems Division. "Proposed Development Plan for an Advanced Reentry Technology Program." Los Angeles, 29 May, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "SSBT-31-8-26." TWX to HQ ASD. Los Angeles CA, 31 August, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "SSVS-10-7-3." TWX to HQ ASD1961. Found in the DS supporting documents on file at the HO/ASD.

------. "System Program Package, Expanded SAINT." Los Angeles CA, 29 May, 1961. Found in the DS supporting documents on file at the HO/ASD.

HQ Wright Air Development Center. "Evaluation and Recommendations for BOMI." Letter to the Commander ARDC. Wright-Patterson AFB OH, 23 December, 1953. Found in the DS Antecedents supporting documents on file at the OH/ASD.

------. "Reasons for Rejecting the Rocket Bomber." Letter to Commander ARDC. Wright-Patterson AFB OH, 10 April, 1953. Found in the DS Antecedents supporting documents on file at the OH/ASD.

HQ Wright Air Development Division. "WWDR-7-11-2." TWX to HQ ARDC. Wright-Patterson AFB OH, 8 November, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "WWZR-5-11081." TWX to HQ ARDC. Wright Patterson AFB OH, 5 January, 1961. Found in the DS supporting documents on file at the HO/ASD.

Huntington, Samuel P. *The Common Defense: Programs in National Politics*. New York: Columbia University Press, 1961.

Intelligence and Reconnaissance Division, HQ ARDC. "BRASS BELL." Research and Development Report Card, System 459L. Wright-Patterson AFB OH, 31 December, 1956. Found in the DS supporting documents on file at the OH/ASD.

Johnson, Lyndon B., Vice-President. "Space Stations." Memo to Secretary of Defense. Washington, D.C., 22 July, 1963. Found in the DS supporting documents on file at the HO/ASD.

Johnston, R. C., Chairman. "Titan II Booster Presentation." Trip Report to HQ Air Force, 9-11 January. Washington, D.C., 12 January, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Trip Report to HQ Air Force." Wright-Patterson AFB OH, 9-11 January, 1961. Found in the DS supporting documents on file at the HO/ASD.

Jones, Brigadier General D. M., Acting Commander. "Revised X-20A System Package Program." Letter to HQ AFSC. Wright-Patterson AFB OH, 13 May, 1963. Found in the DS supporting documents on fila at the HO/ASD.

Joseph R. Trueblood. Offensive Mission Plans Division. Edited by C. H. Uyehara. Andrews AFB MD, 4 May, 1960. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Kecskemeti, Paul. *The Satellite Rocket Vehicle: The Political and Psychological Problems*. RM-567. RAND, 4 October 1950.

Keese, Major General W. B., Deputy Chief of Staff. "Briefing to PSAC Panel on 10 October 1963." Letter to HQ ASD. Washington, D.C., 19 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

Keese, Major General W. B., Deputy Chief of Staff. "Amendment 1 to ADO 19." Washington, D.C., 21 February, 1962. Found in the DS supporting documents on file at the HO/ASD.

Kennan, George. "The Sources of Soviet Conduct." *Foreign Affairs* 25 (July 1947): 566-82.

Kennedy, John F. *New York Times*, 26 May; 26 September 1961; 15 June 1962.

------. *United States Aeronautical and Space Activities, 1961*. Message from the President of the United States Transmitting a Report on United States Aeronautical and Space Activities for Calender Year 1961, House Document 324. 87th Congress, 2nd Session. Washington, D.C.: GPO, 1962.

------. *Missiles and Rockets*, 10 October 1960, 10.

Killian, James R. *Sputnik, Scientists, and Eisenhower: A Memoir of the First Special Assistant to the President for Science and Technology*. Cambridge MA: MIT Press, 1976.

Kistiakowsky, George B. *A Scientist at the White House: The Private Diary of President Eisenhower's Special Assistant for Science and Technology*. Cambridge MA: Harvard University Press, 1976.

Klocko, Richard Colonel. "The Impact of Guided Missile Upon the USAF." Air War College Graduate Study Group Thesis #4. Maxwell AFB AL, 4 March, 1954.

Lamar, William E. . Interview edited by Clarence J. Geiger. Wright-Patterson AFB OH, 14 January, 1964.

------. Interview edited by Clarence J. Geiger. Wright-Patterson AFB OH, 27 February, 1964.

------. Interview edited by Roy F. Houchin, II. Lamar Home, Dayton OH, 1-8 June, 1994.

------. Interview edited by Roy F. Houchin, II. Auburn AL, 8 March, 1995. Telephone conversation.

------. Interview edited by Roy F. Houchin, II. Auburn AL, 22 April, 1995. Telephone conversation.

------. Letter to Roger McCormick. Dayton OH, 25 June, 1993. Found in the personal files of William E. Lamar.

------. "Hypersonic Strategic Weapon System." Management Report. Wright-Patterson AFB OH, 4 February, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. Chairman. "Conference at NASA Regarding RVX-2 Test for Dyna-Soar." Memo. Wright-Patterson AFB OH, 1961. Found in the DS supporting documents on file at the HO/ASD

.

------. Chief, Dyna-Soar Engineering Office, DSE, WADD. Edited by C. H. Uyehara. Wright-Patterson AFB, 2 May, 1960. Found in the DS Antecedents supporting documents on file at the OH/ASD.

------. Deputy Director. "Conference at NASA Regarding RVX-2 Test for Dyna-Soar." Wright-Patterson AFB OH, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "History of Dyna-Soar to Present." Presentation to HQ ARDC. Wright-Patterson AFB OH, 20 February, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. Director X-20 Engineering Office. "Briefing to PSAC." Trip Report. Wright-Patterson AFB OH, 23 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Paraphrased Transcript of Discussion After X-20 Status Briefing to McNamara by Colonel Moore in Denver, 23 October 1963." Trip Report. Wright-Patterson AFB OH, No Date, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Status Report." Presentation to Secretary of the Air Force. Wright-Patterson AFB OH, 8 July, 1963. Found in the DS supporting documents on file at the HO/ASD.

Legislative Reference Service. *United States Defense Policies in 1957*. Washington, D.C.: GPO, 1959.

------. *United States Defense Policies in 1958*. Washington, D.C.: GPO, 1960.

------. *United States Defense Policies Since World War II*. Washington, D.C.: GPO, 1957.

Lukasiewicz, Julius. *Experimental Methods of Hypersonics*. New York: Marcel Dekker, Inc., 1973.

Martin Company. "Martin Program Plan." Program 202. Los Angeles CA, September, 1961. Found in the Prime/START supporting documents on file at Satellite and Missile Systems Organization History Division [hereafter cited as SAMSO/HD].

Martin, Colonel J. L., Jr. "Action on Dyna-Soar." Letter to Commander, Det 1, Directorate of Systems Management, HQ ARDC. Andrews AFB MD, 19 September, 1958. Found in the DS supporting documents on file at the HO/ASD.

McKee, Lieutenant General W. F., Vice Commander. "The Dyna-Soar Program." Letter to Commander, ARDC. Los Angeles CA, 23 September, 19959. Found in the DS supporting documents on file at the HO/ASD.

McMillan, Brockway, Assistant Secretary of the Air Force, R&D. "Dyna-Soar Briefing to Secretary McNamara." Memo to Secretary of the Air Force. Washington, D.C., 18 March, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Secretary McNamara's Trip to Seattle." Memo to Secretary of the Air Force. Washington, D.C., 15 March, 1963. Found in the DS supporting documents on file at the HO/ASD.

McNamara, Robert S., Secretary of Defense. "The Air Force Manned Military Space Program." Memo to Secretary of the Air Force Eugene M. Zuckert. Washington, D.C., 23 February, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "Cancellation of the X-20 Program." News Brief. Washington, D.C., 10 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "DOD Support of NASA." DOD Directive. Washington, D.C., 24 February, 1962.

------. "Gemini and Dyna-Soar." Memo to DDR&E. Washington, D.C., 18 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Orbital Space Station." Memo to the Vice President. Washington, D.C., 19 August, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Review of Gemini." Memo to DDR&E. Washington, D.C., 19 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Review of Titan IIIC." Memo to DDR&E. Washington, D.C., 19 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20, Gemini, and Military Missions." Memo to Secretary of the Air Force. Washington, D.C., 15 March, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20, Gemini, and Military Missions." Memo to Vice President Johnson. Washington, D.C., 9 August, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. and James E. Webb, NASA Administrator. "DOD-NASA Agreement." Memo. Washington, D.C., 21 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. *The Essence of Security: Reflections in Office*. London: Harper & Row, 1968.

Missiles and Rockets, 7 January 1962, 9.

"MOL Requirements Will Be Set By January 1." *Aviation Week*, 23 December 1963, 19-20.

Moore, Colonel William L., Chairman. "Dyna-Soar HETS Program." Letter to HQ ARDC. Wright-Patterson AFB OH, 5 October, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. Chairman. "Presentation on Status of Dyna-Soar Program." Trip Report to Brigadier General A, T. Culbertson, Director, Systems Management, WADD. Wright-Patterson AFB, 31 March, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. Program Director." 'Stand-By' Program." Memo. Wright-Patterson AFB OH, 20 March, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Dyna-Soar, SSD Advanced Re-entry Technology Program and SAINT II Proposed Conflict." Letter to Brigadier General A. T. Culbertson, Director, Directorate of Systems Management, ASD. Wright-Patterson AFB OH, 28 June, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Manned Spaceflight Review Group." Letter to Major General Ruegg, ASD Commander. Wright-Patterson AFB OH, 2 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Phase 0 Study of X-20 Program 706." Report. Wright-Patterson AFB OH, 18 November, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Preliminary Results of Dyna-Soar 'Stand-By' Program Study." Letter to Commander ARDC. Wright-Patterson AFB OH, 23 February, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Project Streamline." Presentation to the Strategic Air Panel. Washington, D.C., 3 August, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Record Memorandum of the X-20 Presentation to Secretary of Defense McNamara, 23 October 1963, and Pertinent Background." Memo. Wright-Patterson AFB OH, 30 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Telephone Request from HQ AFSC." Memo. Wright-Patterson AFB OH, 3 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Status Report to Secretary McNamara." Memo. Wright-Patterson AFB OH, 24 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Test Program." Memo. Wright-Patterson AFB OH, 9 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. and Major General R. G. Ruegg, Commander ASD. "23 October Briefing to McNamara and Brown." Joint Personal Message to General Schriever. Wright-Patterson AFB OH, 29 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

NACA Committee for Aeronautics. "Requested Comments on Project MX-2276[BOMI]." Letter from to Commander, WADC. Wright-Patterson AFB OH, 30 September, 1955. Found in the DS Antecedents supporting documents on file at the HO/ASD.

NASA. "The Atlas RVX-2 and Communications Experiments Proposed by NASA."1961. Found in the DS supporting documents on file at the HO/ASD.

------. *NASA Release 59-116.* 17 April. Washington, D.C.: NASA, 1959.

"National Security Council (NSC)-68." *Foreign Relations of the United States* 1 (14 April 1950): 234-92.

National Security Council. *U.S. Policy on Outer Space.* NSC 5918/1. Washington, D.C.: NSC, 1960.

------. *Satellite Program.* NSC-5520. As quoted in Walter A. McDougall, *The Heavens and the Earth* (New York: Basic Books, Inc., 1970), 120-121.

------. *U.S. Policy on Outer Space.* NSC 5814/1, Annex A, Soviet Space Systems. Washington, D.C.: GPO, 18 August 1958.

New York Times. 10 December 1947; 7 Nov 1950; 4 October 1951; 9 October; 8 November 1957; 9, 13 January; 6 February; 3 April 1958; 1, 2 March; 14 April 1959; 12 January; 23 October; 26 September; 4, 9, 10 December 1963.

Office of Information. *Air Force Information Fact Sheet: X-20 Dyna-Soar.* Fact Sheet. Washington. D.C.: Office of the Secretary of the Air Force, 1963.

Page, J. D., Brigadier General. *Aviation Week,* 28 November 1960.

PL 85-568. *National Aeronautics and Space Act of 1958.* Washington, D.C.: GPO, 1958.

Power, General Thomas S., Commander. *New York Times,* 11 October 1961.

President's Science Advisory Committee. *Report of the President's Science Advisory Committee.* Washington, D.C.: GPO, 1958.

Price., Colonel W. H., Air Force Plant Representative. "Report of Visit, Assistant Secretary of The Air Force." Letter to HQ Air Force. Seattle WA, 10 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

Public Affairs. *New York Times,* 14 October 1961.

Puckett, Robert H. "The Military Role in Space: A Summary of Official, Public Justifications." RP (RAND Paper)-2681. Los Angeles CA, 1963.

Putt, Lieutenant General Donald L., Deputy Chief of Staff. "Advanced Hypersonic Research Aircraft." Letter. Washington, D.C., 31 January, 1958. Found in the DS supporting documents on file at the HO/ASD.

Research Airplane Committee. "A Report on the Conference on the Progress of the X-15 Project." Compilation of the Papers Presented at the Langley Aeronautical Laboratory. Langley VA, 25-26 October, 1956. Found in the X-15 files at the OH/ASD.

Richelson, Jeffery T. *America's Secret Eyes in Space.* New York: Harper & Row, Publishers, Inc, 1990.

Ritland, Major General O. J. *Los Angeles Times,* 1960.

------. Deputy to the Commander for Manned Spaceflight. "Gemini-Dyna-Soar Task Groups." Letter to Commander, SSD. Andrews AFB MD, 31 January, 1963. Found in the DS supporting document son file at the HO/ASD.

------. "Response to Secretary McNamara's 15 March 1963 Questions." Letter to Commander, Manned Space Flight, HQ AFSC. Andrews AFB MD, 22 May, 1963. Found in the DS supporting document son file at the HO/ASD.

Roy Johnson, Director ARPA. "Reconnaissance Satellites and Manned Space Exploration." Wright-Patterson AFB OH, 28 February, 1958. Found in the DS supporting documents on file at the OH/ASD.

Rubel, John H., Deputy Director of DDR&E. *Missiles and Rockets*, 5 March 1962.

Scientific Advisory Board Ad Hoc Committee to Study Advanced Weapons Technology and Environment. "Report of the SAB Ad Hoc Committee to Study Advanced Weapons Technology and Environment." SAB Report. Washington, D.C., 9 October, 1957. Found in the Ballistic Missile Division documents on file at HD/SSD.

Sandstrom, R. J., Vice President, Engineering, Bell Aircraft Corporation. "Proposed Glide Bomber Study." Letter to HQ WADC (Attn: Chief, Weapon System Division)17 April 1952.

Sänger-Bredt, Irene. "The Silver Bird Story: A Memoir." In *Essays of the History of Rocketry and Astronautics: Proceedings of the Third Through the Sixth History Symposia of the International Academy of Astronautics*, edited by R. Cargill Hall, 195-228. Washington, D.C.: NASA, 1977.

------. "The Silver Bird Story: A Memoir." In *History of Rocketry and Astronautics.* Vol. 7, Part 1 of *AAS History Series*, edited by R. Cargill Hall, 195-228. San Diego CA: American Astronautical Society Publications, 1986.

Sänger, Eugene, and Irene Bredt. *Uber Einen Rakentenantrieb Fur Fernbomber, Deutsche Luftfahrtforschung*. UM 3538. Translated by Bureau of Aeronautics Naval Technical Information Branch, United States Navy. Ainring: DFS, 22 September 1944.

Schriever, General Bernard A., "Manned Space Program." Letter to Major General Marvin Demler, Commander, Research and Technology Division. Andrews AFB MD, 16 December, 1963. Found in the DS supporting documents on fila at the HO/ASD.

------. *New York Times*, 8 October 1961.

------. "X-20 Program Management." Letter to Commander, SSD. Andrews AFB MD, 9 May, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Program." Letter to Commander, ASD. Andrews AFB MD, 31 July, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "The USAF and Space." *Air Force and Space Digest*, May 1964, 161-62.

Schriever, Lieutenant General Bernard A., ARDC Commander. "Management of Dyna-Soar Project." Letter to Lieutenant General S.E. Anderson, AMC Commander. Wright-Patterson AFB OH, 5 December, 19959. Found in the DS supporting documents on file at the HO/ASD.

Schriever, Major General Bernard A. "The USAF Ballistic Missile Program." *Air University Review*, Summer 1957, 8.

Scoville, Lieutenant Colonel. "Events Concerning the X-20 Cancellation." Memo. Washington, D.C., No Date, 1963. Found in the DS supporting documents on file at the HO/ASD.

Seaberg, J. D., Major. "Trip Report to Bell Aircraft Company." WCOWB/WADC Trip Report on the November 1952 Visit to Bell Aircraft Company. Wright-Patterson AFB OH, 20-21 November, 1952. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Seaberg, John D.. Letter to John L. Sloop, NASA HQ. Wright-Patterson AFB OH, 25 June, 1976. Found in the personal files of William E. Lamar.

Secretary of the Air Force. TWX to HQ AFSC. Washington, D.C., 11 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

Sessums, Major General John W., Jr. "Dyna-Soar Program." Letter to Lieutenant General R. C. Wilson, Deputy Chief of Staff, Development, Air Force HQ. Washington, D.C., 11 July, 1958. Found in the DS supporting documents on file at HO/ASD.

Space Systems Division. *Partial System Package Plan, Military Orbital Development System (MODS), System Number 648C*. Los Angeles CA: Space Systems Division, 1962.

------. *Partial System Package Plan, Program 287, Supplement I (Blue Gemini)*. Los Angeles CA: Space Systems Division, 1962.

Stennis, Senator John, Chairman. *Congressional Record*. Volume 107, Part 17, p. 21252. Washington, D.C.: GPO, 1961.

Swofford, Lieutenant General R. P., Jr. "Selection of Contractor for WS 464L (Dyna-Soar) Development." Letter to Commander, ARDC. Andrews AFB MD, 25 June, 1958. Found in the DS supporting documents on file at the HO/ASD.

Teller, Edward. *Report of the Teller Ad Hoc Committee*. Wright-Patterson AFB OH: HQ ARDC, 1957.

Terhune, Brigadier General C. H., Jr. "Dyna-Soar Booster Evaluation." Letter to Det 1, HQ ARDC. Los Angeles CA, 13 August, 1959. Found in the DS supporting document on file at the HO/ASD.

Tosti, Colonel C. R., Executive Secretary. "65th Meeting, DSMG." DSMG Minutes. Washington, D.C., 12 July, 1963. Found in the DS supporting documents on file at the HO/ASD.

Trenholm, J. B., Assistant Director. "X-20 System Package Program." Letter to Lieutenant Colonel C. L. Scoville, Director, Military Space Program, HQ AFSC. Wright-Patterson AFB OH, 21 November, 1963. Found in the DS supporting documents on file at the HO/ASD.

U.S. Arms Control and Disarmament Agency. *Documents and Disarmament 1961*. Washington, D.C.: GPO, 1962.

------. *Documents and Disarmament 1962*. Washington, D.C.: GPO, 1963.

U.S. Congress. House. Hearings Before the Subcommittee on Manned Spaceflight of the Committee on Science and Astronautics. *Agreement Between the NASA and* *the DOD Concerning the Gemini Program, January 1963*. 88th Congress, 1st Session. Washington, D.C.: GPO, 1963.

------. Hearings Before the House DOD Subcommittee on Appropriations. *The Ballistic Missile Program*. 85th Congress, 1st Session. Washington, D.C.: GPO, 1957.

------. Hearings Before the House Subcommittee on DOD Appropriations. *DOD Appropriation Bill, 1962*. House Report 574. 87th Congress, 1st Session. Washington, D.C.: GPO, 1961.

------. *DOD Appropriations for 1957*. 88th Congress, 2nd Session, Part 4. Washington, D.C.: GPO, 1956.

------. Hearings Before the Subcommittee of the Committee on Appropriations. *DOD Appropriations for 1959*. 85th Congress, 2nd Session. Washington, D.C.: GPO, 1958.

------. Hearings Before the Subcommittee of the Committee of Appropriations, House of Representatives *DOD Appropriations for 1960,*. 86th Congress, 1st Session, Part 5. Washington, D.C.: GPO, 1959.

------. Hearings Before the House Subcommittee on DOD Appropriations. *DOD Appropriations for 1961*. 86th Congress, 2nd Session. Washington, D.C.: GPO, 1960.

------. Hearings Before a Subcommittee on Appropriations. *DOD Appropriations for 1963*. 87th Congress, 2nd Session, Part 5. Washington, D.C.: GPO, 1963.

------. Hearings Before a Subcommittee of the Committee on Appropriations. *DOD Appropriations for 1964*. 88th Congress, 1st Session. Washington, D.C.: GPO, 1963.

------. *Military Aid and Supply Programs in Western Europe*. House Report 1371, 90th Report by the Committee on Government Operations. 85th Congress, 2nd Session. Washington, D.C.: GPO, 1959.

------. Hearings Before The Committee on Armed Services. *Military Posture Briefings*. 87th Congress, 2nd Session. Washington, D.C.: GPO, 1962.

------. Hearings Before the Committee on Science and Astronautics. *Missile Development and Space Sciences*. 86th Congress, 1st Session. Washington, D.C.: GPO, 1959.

------. *Organization and Management of Missile Programs*. House Report 1121. 86th Congress, 1st Session. Washington, D.C.: GPO, 1959.

------. Hearings Before the Select Committee on Astronautics and Space Exploration. *Problems of Congress Formulating Outer Space Legislation*. Memo from Eileen Galloway to Representative J. W. McCormick. 85th Congress, 2nd Session. Washington, D.C.: GPO, 1958.

------. *Report to the House Committee on Science and Astronautics*. DOD Directive 5160.32. 87th Congress, 1st Session. Washington, D.C.: GPO, 1962.

------. Hearings Before the Committee on Science and Astronautics. *Space Posture*. 87th Congress, 1st Session. Washington, D.C.: GPO, 1961.

------. Hearings Before the Committee on Science and Astronautics *Space Posture.*. 88th Congress, 1st Session. Washington, D.C.: GPO, 1963.

------. *Space, Missile, and the Nation*. House Report 2092. 86th Congress, 2nd Session. Washington, D.C.: GPO, 1961.

------. Hearings Before the Subcommittee for Special Investigations of the Committee on Armed Services. *Weapon System Management and Team System Concept in Government Contracting,* 86th Congress, 1st Session. Washington, D.C.: GPO, 1959.

------. Hearings Before the House Subcommittee on DOD Appropriations. *DOD Appropriations for 1962*. 87th Congress, 1st Session. Washington, D.C.: GPO, 1961.

------. Armed Services Committee. Hearings on Military Posture *House Report 9751.*. 87th Congress, 1st Session. Washington, D.C.: GPO, 1961.

------. House Committee on Astronautics and Space Exploration. *Aeronautic al and Astronautical Events of 1961*. House Report. 87th Congress, 1st Session. Washington, D.C.: GPO, 1962.

------. *Astronautics and Its Applications*. Staff Report. 85th Congress, 1st Session. Washington, D.C.: GPO, 1958.

------. *Review of the Space Program*. 86th Congress, 2nd Session. Washington, D.C.: GPO, 1960.

------. House Select Committee on Astronautics and Space Exploration. *HR 1758*. 85th Congress, 2nd Session. Washington, D.C.: GPO, 1959.

------. Report 1758. *The National Space Program*. 85th Congress, 2nd Session. Washington, D.C.: GPO, 1958.

U.S. Congress. Senate. Hearings Before the Preparedness Investigations Subcommittee on Armed Services. *Inquiry Into Satellite and Missile Programs*. 85th Congress, 1st and 2nd Sessions. Washington, D.C.: GPO, 1957.

------. Hearings Before the Preparedness Investigation Committee on Armed Services. *Inquiry Into Satellite and Missile Programs,* 85th Congress, 1st and 2nd Sessions, Part 1. Washington, D.C.: GPO, 1958.

------. Hearings Before the Subcommittee on the Government Organization for Space Activities of the Committee on Aeronautics and Space Sciences. *Investigation of Governmental Organization for Space*. 86th Congress, 1st Session. Washington, D.C.: GPO, 1958.

------. Hearings Before the Committee on Armed Services. *McNamara Testimony*. 88th Congress, 1st Session. Washington, D.C.: GPO, 1963.

------. Hearings Before the Committee on Military Procurement. *Military Procurement Authorization 1964*. 88th Congress, 1st Session. Washington, D.C.: GPO, 1963.

------. Hearings Before the NASA Authorizations Subcommittee of the Committee on Aeronautics and Space Science *NASA 1965 Authorizations.*. 88th Congress, 2nd Session. Washington, D.C.: GPO, 1964.

------. Hearings Before the NASA Authorizations Subcommittee of the Committee on Aeronautics and Space Sciences. *NASA Authorization for Fiscal Year 1960*. 86th Congress, 1st Session. Washington, D.C.: GPO, 1958.

------. Hearings Before the Committee on Aeronautical and Space Sciences. *NASA Authorizations for FY 1963*. 87th Congress, 1st Session. Washington, D.C.: GPO, 1962.

------. *Study of Airpower, Hearings Before the Subcommittee on the Air Force of the Committee on Armed Services*. 84th Congress, 2nd Session, Part 2. Washington, D.C.: GPO, 1956.

------. Hearings Before the Permanent Subcommittee on Investigations of the Committee on Government Operations *TFX Contract Investigation.*. 88th Congress, 1st Session. Washington D.C.: GPO, 1962.

------. Report of the NACA Special Committee on Space Technology. *Recommendations to NASA for a National Space Program.* 86th Congress, 1st Session. Washington, D.C.: GPO, 1958.

------. Military Affairs Committee. *Department of Armed Services, Department of Military Security: Hearings.* 79th Congress. 1st Session. Washington, D.C.: GPO, 1945.

USAF Flight Dynamics Laboratory. "Advanced Technology Program: Technical Development Plan for Aerothermodynamic/Elastic Structural Systems Tests (ASSET)." Wright-Patterson AFB OH, 9 September, 1963. Found in the ASSET supporting documents on file at the HO/ASD.

"USAF Pushes Pied Piper Space Vehicle." *Aviation Week*, 14 October 1957, 27.

von Kármán, Dr. Theodore H. *Where We Stand: A Report Prepared for the Scientific Advisory Group.* Washington, D.C.: United States Army Air Force, August, 1945.

------. editor. *Science, the Key to Air Supremacy.* Vol. 1 of *Toward New Horizons.* Washington, D.C.: United States Army Air Force, 1945.

------. *The Wind and Beyond: Theodore von Kármán, Pioneer in Aviation and Pathfinder in Science.* Toronto, 1967.

Wright Air Development Center. "Work Requirements for a Preliminary Feasibility Study for an Advanced Long Range Bombing and Reconnaissance Weapon System." Department of Defense (DD) Form 613, Research and Development Report Card. Wright-Patterson AFB OH, 26 September, 1952. Found in the Dyna-Soar [hereafter cited as DS] Antecedents supporting documents on file at the OH/ASD.

------. "RDZSXB-1-1420-E." TWX to HQ ARDC. Wright-Patterson AFB OH, 28 January, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "RDZSXB-30061-E." TWX to HQ ARDC. Wright-Patterson AFB OH, 20 January 1960, 1960. Found in the DS supporting documents on file at the HO/ASD.

Wall Street Journal. 20 October 1950.

Walter, William C. "Project Dyna-Soar: The Roots of Shuttle-A Memoir." IAA-92-0193, 1-24. 43rd Congress of the International Astronautical Federation. Washington, D.C.: International Astronautical Federation, 28 August-5 September, 1992.

------. "Visit to HQ Air Force on Project Dyna-Soar." Trip Report. Washington, D.C., 21 October, 1957. Found in the DS supporting documents on file at the OH/ASD.

Washington Evening Star. 7 September 1951.

Washington Post. 12 October 1951; 11 January 1961.

White, General Theodore D. "Air and Space Indivisible." *Air Force*, March 1958.

Wilson, Lieutenant General R. C., Deputy Chief of Staff. "Dyna-Soar Funding." Letter to Lieutenant General S. E. Anderson, ARDC Commander. Andrews AFB MD, 12 August, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "Dyna-Soar Program." Letter to Major General John W. Sessums, Jr., Vice Commander ARDC. Andrews AFB MD, 23 July, 1958. Found in the DS supporting documents on file at the HO/ASD.

WSPO, Directorate of Systems Management, WADD. "Dyna-Soar Step II and Step II Funding." Wright-Patterson AFB OH, 2 August, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "WWZRM-8-1041-E." TWX to HQ ARDC. Wright-Patterson AFB OH, 23 August, 1960. Found in the DS supporting documents on file at the HO/ASD.

Yearbook of the United Nations, 1963. Washington, D.C., 1963.

York, Herbert F., Director of Defense Research and Engineering. "Saturn, Dyna-Soar Propulsion." Memo to the Secretary of the Air Force and ARPA. Washington, D.C., 27 July, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. *The Advisors: Oppenheimer, Teller, and the Superbomb*. San Francisco: W. A. Freeman, 1976.

Zuckert, E. M., Secretary of the Air Force. Interview edited by Larry McQuade and Ned Trapnell. Washington, D.C., 27 June-11 July, 1964.

------. "Dyna-Soar Termination." Memo to the Chief of Staff, Air Force. Washington, D.C., 12 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Manned Military Space Program." Memo to the Secretary of Defense. Washington, D.C., 4 December, 1963. Found in the DS supporting documents on file at the HO/ASD

------. "Manned Military Space Program." Memo to the Secretary of Defense. Washington, D.C., 5 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

Secondary

Air Force Ballistic Missile Division. *Chronology of Early Air Force Man-in-Space Activity, 1955-1960*. Los Angeles CA: Space Systems Division, 1965.

Alexander, Charles C. *Holding the Line: The Eisenhower Era, 1952-1961*. Bloomington IN: Indiana University Press, 1975.

Anderson, Frank W., Jr. *Orders of Magnitude: A History of NACA and NASA*. 2nd ed. Washington, D.C.: NASA History Office, 1981.

Baals, Donald D., and William R. Corliss. *Wind Tunnels of NASA*. Washington, D.C.: NASA, 1981.

Baucom, Donald R. "Air Force Images of Research and Development and Their Reflections in Organizational Structure and Management Policies." Ph.D. Dissertation. Norman Oklahoma: University of Oklahoma, 1976.

Beard, Edmund. *Developing the ICBM: A Study in Bureaucratic Politics*. New York: Columbia University Press, 1976.

Berger, Carl. *The Air Force in Space Fiscal Year 1961*. USAF Historical Liaison Division Office: Office of Air Force History, 1966.

------. *The Air Force in Space, Fiscal Year 1962*. Washington, D.C.: USAF Historical Division Liaison Office, 1966.

Bilstein, Roger E. *Flight in America: From the Wrights to the Astronauts*. Baltimore MD: Johns Hopkins University Press, 1984.

Bloomfield, Lincoln. "Prospects for Law and Order." In *Outer Space, Prospects for Man and Society*. Englewood Cliffs, NJ: Prentice-Hall, 1962.

Bobkov, Valentin. "Unknown Spacecraft." In *History of the Soviet Space Program*. In *What's New in Life, Science, and Technology: Space Program and Astronomy Series*, edited by I. B. Afanasyev. Moscow: JRPS-USP-92-003, 13 December, 1991.

Bowen, Lee. *An Air Force History of Space Activities, 1945-1959*. Washington, D.C.: USAF Historical Division Liaison Office, 1964.

------. *The Threshold of Space: The Air Force in the National Space Program, 1945-1959*. Washington, D.C.: USAF Historical Division Liaison Office, 1960.

Bright, Charles D. *The Jet Makers*. Lawrence KS: Regents Press of Kansas, 1978.

Bruce, Robert V. *Lincoln and the Tools of War*. Chicago IL: University of Illinois Press, 1989.

Builder, Carl H. *The Icarus Syndrome*. New Brunswick NJ: Transaction Publishers, 1994.

Bamford, James. *The Puzzle Palace*. Boston: Houghton Mifflin, 1982.

Burrows, William E. *Deep Black*. New York: Random House, 1986.

Cantwell, Gerald T. *The Air Force in Space, Fiscal Year 1963*. USAF Historical Division Liaison Office: GPO, 1966.

------. *The Air Force in Space, Fiscal Year 1964*. USAF Historical Liaison Office: GPO, 1967.

Clements, Walter C. *Outer Space and Arms Control*. Cambridge MA: MIT Press, 1966.

Covault, Craig. "USAF Plans Manned Military Exercises on Space Shuttle." *Aviation Week and Space Technology*, 4 January 1988, 38.

Crickmore, Paul. *Lockheed SR-71 Blackbird*. London, England: Osprey Publishing Limited, 1986.

Daniels, George H. "Science, Scientism, and Planned Progress: The Uses of Science in Progressive Ideology." In *Science in American Society, A Social History*, 288-315. New York: Knopf, 1971.

Dehaven, Ethal M. *The Evolution of USAF Weapons Acquisition Policy, 1945-1961.* Washington, D.C.: Air Force Systems Command Historical Study, 1962.

Dreyup, Felicia Johnson. *Arms Makers in the Connecticut Valley*. Northampton MA, 1948.

Dupree, A. Hunter. "The Great *Instauration* of 1940: The Organization of Research for War." In *Twentieth Century Sciences*, edited by Gerald Holton, 445-54. New York: Norton, 1972.

------. *Science in the Federal Government*. Cambridge MA: Belknap Press of Harvard University Press, 1957.

Friedman, Robert Marc. *Appropriating The Weather*. Ithaca NY: Cornell University Press, 1989.

Futrell, Robert F. *Ideas, Concepts, Doctrine: A History of Basic Thinking in the United States Air Force, 1907-1964*. Maxwell AFB AL: Air University Press, 1974.

Geiger, Clarence J. *History of the X-20 Dyna-Soar*. Wright-Patterson AFB OH: Air Force Systems Command, 1963.

------. *Termination of the X-20A Dyna-Soar*. Wright-Patterson AFB OH: Air Force Systems Command, 1964.

Gielhoed, E. Bruce. *Charles E. Wilson and Controversy at the Pentagon, 1953-1957.* Detroit, 1979.

Gorn, Michael H. *Harnessing the Genie: Science and Technology Forecasting for the Air Force, 1944-1986*. Washington, D.C.: Office of Air Force History, 1988.

------. *The Universal Man: Theodore von Kármán's Life in Aeronautics*. Washington, D.C.: Smithsonian Institution Press, 1992.

------. *Vulcan's Forge: The Making of an Air Force Command for Weapons Acquisition, 1950-1985*. Andrews AFB MD: Office of History, Air Force Systems Command, 1989.

Gray, George C. *Frontiers of Flight: The Story of NACA Research*. New York: Knopf, 1948.

Green, Constance M., and Milton Lomask. *Vanguard: A History*. Washington, D.C.: GPO, 1970.

Greenberg, Daniel S. *The Politics of Pure Science*. New York: New American Library, 1967.

Greene, Warren E. *The Development of the SM-68 Titan*. Norton AFB CA: Historical Office Deputy Commander for Aerospace Systems, 1962.

Greun, Adam. "History of the Space Station, 1923-1972," Chapter 5, "MOL." Unpublished Doctorial Dissertation. Washington, D.C., 26 April, 1989.

Griffith, Robert. "Dwight D. Eisenhower and the Corporate Wealth." *American Historical Review* 87 (February 1982): 87-122.

Hall, R. Cargill. "Early U.S. Satellite Proposals." In *The History of Rocket Technology*, edited by Eugene M. Emme, 69-93. Detroit: American Astronautical Society, 1964.

------. "Earth Satellites: A First Look by the U.S. Navy." In *History of Rocketry and Astronautics*. Vol. 7, Part 1 of *AAS History Series*, 253-79. San Diego CA: American Astronautical Society Publications, 1986.

Hallion, Richard P., editor. *The Hypersonic Revolution: Eight Case Studies in the History of Hypersonic Technology*. Vol. 1. Wright-Patterson AFB OH: Aeronautical Systems Division, 1987.

------. *On the Frontier: Flight Research at Dryden, 1946-1981*. Washington, D.C.: NASA, 1984.

------. "Saga of the Rocket Ships." *Air Enthusiast*, March-June 1978, 90-91.

Hanle, Paul A. *Bringing Aerodynamics to America*. Cambridge MA: MIT Press, 1982.

Hansen, James R. Book Review of Robert Marc Friedman, *Appropriating the Weather* (Ithaca NY: Cornell University Press, 1989). *Isis* 81, 2 (1990): 382-83.

------. *Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917-1958*. Washington, D.C.: NASA History Office, 1987.

------. *Spaceflight Revolution: NASA Langley Research Center, From Sputnik to Apollo.* Washington, D.C.: NASA History Office, 1995.

Hilsman, Roger. *To Move a Nation.* New York: Doubleday, 1964.

Hindle, Brook. *The Pursuit of Science in Revolutionary America, 1735-1789.* Chapel Hill NC: University of North Carolina Press, 1956.

Hintz, Marvin E. *Chronology of the Arnold Engineering Development Center.* Tullahoma TN: HQ Arnold Engineering Development Center Historical Office, No Date.

Houchin, Roy F., II. "A Unit History of the 94th Pursuit Squadron, 5 March 1917 to 5 May 1918, with Emphasis on the Importance of Technology." M.A. Thesis. Bowling Green KY: Western Kentucky University, 1981.

Houston, Robert S. *Development of the X-15 Research Aircraft, 1954-1959.* Vol. 3 of *History of Wright Air Development Center, 1958.* Wright-Patterson AFB OH: Office of Information Services, 1959.

Jordan, John. *Machine Age Ideology.* Chapel Hill NC: University of North Carolina Press, 1994.

Kaplan, Fred. *The Wizards of Armageddon.* New York: Simon and Schuster, 1983.

Karr, Erica M. "Father of Dyna-Soar Awaits Air Force Decision." *Missiles and Rockets*, 4 May 1959, 29-31.

Kaufmann, William W. *The McNamara Strategy.* New York: Harper & Row, 1971.

Kirpil, Anatoliy, and Olga Okara. "Designer of Space Planes: Vladimer Chelomey Dreamed of Creating a Space Fleet of Rocket Planes." *JPRS-USP-94-006*, 9 August 1994, 14-16.

Klass, Philip J. *Secret Sentries in Space.* New York: Random House, 1971.

Launius, Roger D, and Howard E. McCurdy. "Johnson, Project Apollo, and the Politics of Space Program Planning." Chapter 3 of "Presidential Leadership, False Hopes, and the Decline of the U.S. Space Program." Unpublished manuscript, 1995.

Ley, Wiley. *Rockets, Missiles, and Space Travel.* New York: Viking Press, 1961.

May, Ernest. *Lessons of the Past: The Use and Misuse of History in American Foreign Policy*. New York: Oxford University Press, 1973.

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

Misenko, Albert, and Philip H. Pollock. *Engineering History from McCook Field to the Aeronautical Systems Division*. Wright-Patterson AFB OH: OH/ASD, 1978.

Neufeld, Jacob. *The Development of Ballistic Missiles in the United States Air Force, 1945-1960*. Washington, D.C.: Office of Air Force History, 1990.

------. editor. *Reflections on Research and Development in the United States Air Force: An Interview with General Bernard A. Schriever and Generals Samuel C. Phillips, Robert T. Marsh, James H. Doolittle, and Dr. Ivan A. Getting*. Conducted by Dr. Richard H. Kohn. Washington, D.C.: Center for Air Force History, 1993.

Nevin, Allen. *Kennedy, The Strategy for Peace*. New York: New York Publishing, 1960.

Newkirk, Dennis. "Soviet Space Planes." *Spaceflight* 32 (October 1990): 350-55.

------. Unpublished file notes from various Soviet sources acquired by Newkirk after the publication of his 1990 Article. Material sent to the author in April 1994.

Ordway, Frederick I., and Mitchell R. Sharpe. *The Rocket Team*. New York: Thomas Y. Crowell Publishers, 1979.

Peebles, Curtis. *Guardians: Strategic Reconnaissance Satellites*. Novato CA: Presido Press, 1987.

------. "Project BOMI." *Spaceflight* 22 (July-August 1980): 270-72.

Perry, Robert L. *Origins of the USAF Space Program, 1945-1956*. Wright-Patterson AFB: Office of History, Air Force Systems Command, 1961.

Petrakov, V. M. "Two Projects of V. M. Myasishchev." *Journal of the British Interplanetary Society* 47 (September 1994): 345-92.

Prados, John. *The Soviet Estimate: U.S. Intelligence Analysis and Russian Military Strength*. New York: Dial Press, 1982.

Ranelagh, John. *The Agency: The Rise and Decline of the CIA from Wild Bill Donovan to William Casey*. New York: Simon and Schuster, 1986.

Reeves, Richard. *President Kennedy: Profile of Power*. New York: Simon and Schuster, 1993.

Roland, Alex. *Model Research: A History of the National Advisory Committee for Aeronautics, 1915-1958*. Washington, D.C.: NASA History Office, 1985.

------. *Underwater Warfare in the Age of Sail*. Bloomington IN: University of Indiana Press, 1978.

Rosenberg, David A. "American Atomic Strategy and the Hydrogen Bomb Decision." *Journal of American History* 66 (June 1979):68-84.

Rosenberg, Max. *The Air Force in Space, 1959-1960*. USAF Historical Division Liaison Office: Office of Air Force History, 1962.

Rudenko, Mikhail. "Star Wars: History of the 'Death' of a Unique Spaceplane." *JPRS-USP-93-005*, 5 October 1993, 32-34.

Schwiebert, Ernest G. *Air Force Response to the Soviet Threat*. Wright-Patterson AFB: ARDC, 1960.

------. *A History of USAF Ballistic Missiles*. New York: Praeger Press, 1965.

Self, Mary R. *History of the Development of Guided Missiles, 1946-1950*. Wright-Patterson AFB: Air Material Command Historical Study, 1951.

Shapley, Deborah. *Promise and Power: The Life and Times of Robert McNamara*. Boston: Little, Brown, and Company, 1993.

Sigethy, Robert. "The Air Force Organization for Basic Research, 1945-1970: A Study in Change." Ph.D. Dissertation. American University, 1980.

Smith, Bruce L. R. *The RAND Corporation*. Cambridge MA: Harvard University Press, 1966.

Smith, Merritt Roe. *Harpers Ferry Armory and the New Technology*. Ithaca NY: Cornell University Press, 1977.

Stanley, Capt. Dennis J, and Capt. John J. Weaver. *Air Force Command for R&D, 1949-1976*. Andrews AFB MD: AFSC Office of History, 1976.

Stares, Paul B. *The Militarization of Space: U.S. Policy 1945-1984*. New York: Cornell University Press, 1985.

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

Strum, Thomas A. *The USAF Scientific Advisory Board: Its First Twenty Years, 1944-1964*. Washington, D.C.: Office of Air Force History, 1986.

Susskind, Charles, and Arlene Inouye. "Technological Trends and National Policy, 1937: The First Modern Technology Assessment." *Technology and Culture* 18 (1977): 593-621.

Terry, Michael R. "Formulation of Aerospace Doctrine, 1955-59." *Air Power History* 38 (Spring 1991): 48-52.

Trewhitt, Henry L. *McNamara: His Ordeal in the Pentagon*. New York: Harper & Row, 1971.

Uyehara, C. H. "Dyna-Soar Antecedents." Unpublished Manuscript. OH/ASD: Wright-Patterson AFB OH, 1964.

Van Keuren, David K. "Science, Progressivism, and Military Preparedness: The Case for the Naval Research Laboratory, 1915-1923." *Technology and Culture* 33, 4 (1992): 711-36.

Vitelli, John, Captain. *The Start Program and The SV-5 Configuration*. Los Angeles CA: Satellite and Missile Systems Office, Office of Information, Historical Division [hereafter cited as SAMSO/HD], 1967.

Wagner, Frederick. *Submarine Fighter of the American Revolution*. New York: Dodd, Mead & Company, 1963.

Watson, George M. *The Office of the Secretary of the Air Force, 1947-1965*. Washington, D.C.: GPO, 1993.

Wattendorf, Frank L. *A Chronology of the Background and Early History of the Arnold Engineering Development Center, 1938-1949*. Tullahoma TN: Arnold Engineering Development Center, 1986.

Wolf, Richard I. *The United States Air Force: Basic Documents on Roles and Missions*. Washington, D.C.: GPO, 1987.

Woodbury, Robert J. "The Legend of Eli Whitney and the Interchangeability of Parts." *Technology and Culture* 1 (1960): 235-51.

Yergin, Daniel. *Shattered Peace: The Origins of the Cold War and National Security State*. Boston, 1977.

WORKS CITED

Primary

Adams, Brigadier General M. B., Deputy Director. "Development Directive 411." Letter to Commander ARDC. Washington, D.C., 12 October, 1960. Found in the Dyna-Soar [hereafter cited as DS] supporting documents on file at the History Office of the Aeronautical Systems Division, Wright-Patterson AFB, Ohio [hereafter cited as HO/ASD].

Aero and Space Vehicle Panel of the Scientific Advisory Board. "Dyna-Soar and Phase Alpha Review." Report of the Aero and Space Vehicles Panel, SAB, Washington, D.C., 15 April, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Dyna-Soar." Report of the Aero and Space Panel, SAB. Washington, D.C., January, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Report of the Aero and Space Vehicle Panel of the SAB on Dyna-Soar." Washington, D.C., 2-4 December, 1959. Found in the DS supporting documents on the file at the HO/ASD.

------. "Presentation to the SAB Ad Hoc Committee to Study Advanced Weapons Technology and Environment." BMD Presentation. Washington, D.C., 29 July, 1957. Found in the Ballistic Missile Division documents of file at the Historical Division, Office of Information, Space Systems Division, Los Angles CA [hereafter cited as HD/SSD].

Aircraft Panel, USAF Scientific Advisory Board. "Some Remarks of the Aircraft Panel on New Technical Developments of the Next Ten Years." Washington, D.C., 1 October, 1954. Found in the SAB files at OH/ASD.

------. "Some Remarks of the Aircraft Panel on Technical Developments of the Next Ten Years." Washington, D.C., 1 October, 1954. Found in the SAB files of the OH/ASD.

Anderson, S. E., Commander AMC. "AMC and ARDC Management Procedures for the Dyna-Soar Program." Memo to Lieutenant General B. A. Schriever, ARDC Commander. Los Angeles CA, 8 February, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Management of the Dyna-Soar Program." Letter to Lieutenant General B. A. Schriever, ARDC Commander. Los Angeles CA, 11 December, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. TWX to Lieutenant General B. A. Schriever, Commander ARDC. Los Angeles CA, 14 October, 1959. Found in the DS supporting documents on file at the HO/ASD.

------, and Lieutenant General Bernard A. Schriever, ARDC Commander. "Dyna-Soar Selection." Joint Letter to HQ Air Force. Wright-Patterson AFB OH, 4 November, 1959. Found in the DS supporting documents on file at the HO/ASD.

Anderson, S. E., Commander ARDC. "FY 1959 Dyna-Soar Funding." Letter to Lieutenant General R.C. Wilson, Deputy Chief of Staff, Development, HQ Air Force. Wright-Patterson AFB OH, 24 July, 1958. Found in the DS supporting documents on file at the HO/ASD.

Arnold, Gen. Henry H. *Global Mission*. New York: Harper & Brothers, 1949.

------. General H. H. Arnold to Dr. Theodore von Kármán, 7 November 1944. Andrews AFB MD. As quoted in Michael Gorn, *Vulcan's Forge* (Andrews AFB MD: Office of Air Force History, 1989), 1.

------. *Third Report of the Commanding General of the AAF to the Secretary of War*. Washington, D.C.: War Department, 12 November 1945.

ASD Field Test Office. "ASFP-5-10-1." TWX to HQ ASD. Patrick AFB FL, 5 October, 1962. Found in the DS supporting documents on file at the HO/ASD.

Becker, John V. "The X-15 Project." *Aeronautics and Astronautics*, February 1964, 52-61.

Bell Aircraft Company. "Advanced Strategic Weapon System-Final Summary Report." Report D143-945-018. Wright-Patterson AFB OH, 29 April, 1955. Found in the DS Antecedents supporting documents on file at the OH/ASD.

------. "BRASS BELL Briefing." Report D143-945-048. Wright-Patterson AFB OH, 1 July, 1957. Found in the DS Antecedents supporting documents on file at the OH/ASD.

------. "Hypersonic Systems Research Airplane." Proposal D192-945-001. Wright-Patterson AFB OH, 21 May, 1956. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Bisplinghoff, R. L., Associate Administrator. "X-20 Program." Letter to Associate Administrator, NASA. Langley VA, 22 November, 1963. Found in the DS supporting documents on file at the HO/ASD.

Boeing Aircraft Company. "Summary Report MX-2145." D-15104, Boeing Aircraft Company. Wright-Patterson AFB OH, 30 April, 1954. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Boeing Airplane Company. "Preliminary Study of Design Characteristics of Hypersonic Bombardment Rockets." D-15105, Boeing Aircraft Company. Wright-Patterson AFB OH, 22 April, 1954. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Boeing Company. "Boeing News." Seattle WA, 12 December, 1963.

Boushey, Homer A., Brigadier General. "Approval of Abbreviated Development Plan for System 464L." Letter. Washington, D.C., 15 November, 1957. Found in the DS supporting documents on file at the OH/ASD.

------. Letter to HQ ARDC. Andrews AFB MD, 15 January, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Proposed Military Position on Space." Washington, D.C., December, 1959. As cited in Lee Bowen, *Ah Air Force History of Space Activities, 1945-1959.*

------. "Required Action on Dyna-Soar." Letter to HQ ARDC. Andrews AFB MD, 29 October, 1959.

------. "Required Action on Dyna-Soar." Letter to HQ ARDC. Andrews AFB MD, 29 October, 1959. Found in the DS supporting documents on file at the HO/ASD.

Brady, Colonel W. D., Acting Deputy. "Program 706, Phase 0." Letter to Colonel Moore, X-20 Program Manager. Los Angeles CA, 25 June, 1961. Found in the DS supporting documents on file at the HO/ASD.

Brooks, Representative Overton, and Senator Richard B. Russell. *New York Times,* 7 August 1961.

Brown, Dr. Harold, DDR&E. "Approaches to a Manned Military Space Program." Memo to the Secretary of Defense. Washington, D.C., 14 November, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Military Orbiting Space Station." Memo to Secretary of the Air Force. Washington, D.C., 30 August, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. *NASA Authorization for FY 1963*. Statement made during hearings before the Committee on Aeronautical and Space Sciences. 87th Congress, 2nd Session. Washington, D.C.: Government Printing Office [hereafter cited as GPO], 1962.

------. "National Space Program." Memo. Farmington CT, 17 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Rationale for RDT&E Program Adjustments by OSD." Memo. Washington, D.C., 19 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Program." Memo to the Secretary of the Air Force. Washington, D.C., 12 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Program." Memo to the Assistant Secretary of the Air Force, R&D. Washington, D.C., 29 November, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Evaluation of an Orbital Test Module." Memo to the Secretary of Defense. Washington, D.C., 30 November, 1963. Found in the DS supporting documents on file at the HO/ASD.

Bush, Vannevar. *Modern Arms and Free Men*. New York: Simon and Schuster, 1949.

Bushnell, David. "General Principles and Construction of a Submarine Vessel, Communicated by D. Bushnell of Connecticut, the Inventor, in a Letter of October, 1787, to Thomas Jefferson Then Minister Plenipotentiary of the United States at Paris." *Transactions of the American Philosophical Society* 4 (1799).

Charyk, Dr. Joseph V., Assistant Secretary of the Air Force. "D&F 50-11-284 Dyna-Soar Program." Memo to Deputy Chief of Staff, Development, HQ Air Force. Washington, D.C., 20 November, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Dyna-Soar "Phase Alpha" Program." Memo to Deputy Chief of Staff, Development, HQ Air Force. Washington, D.C., 4 January, 1960. Found in the DS supporting documents on file at the HO/ASD.

Chief of Staff, Air Force. "AFRAE-69512." TWX to HQ AFSC. Washington, D.C., 18 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "AFRDD-79094." Telecommunications Message [hereafter cited as TWX] to HQ AFSC. Washington, D.C., 18 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

Colchagoff, Major G. D., Deputy Commander/Weapon Systems. "New Research Systems." Memo to Lieutenant Colonel R. C. Anderson, Commander, Research & Target Division, HQ ARDC. Andrews AFB MD, 16 February, 1956. Found in the DS supporting documents on file at the HO/ASD.

Commander, Det. 1, HQ ARDC. "RDZSXB--59RDZ-3995." TWX to HQ Air Force. Wright-Patterson AFB OH, 13 February, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "RDZSXB-30164-E." TWX to HQ Air Force. Wright-Patterson AFB OH, 6 February, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "RDZSXB-3117." TWX to HQ Air Force. Wright-Patterson AFB OH, 16 September, 1958. Found in the DS supporting documents on file at the HO/ASD.

Cooper, Major General M. F., Deputy Chief of Staff. "X-20 System Package Program." Letter to Lieutenant General H. M. Estes, Jr., Vice Commander, ASD. Andrews AFB MD, 16 November, 1962. Found in the DS supporting documents on file at the HO/ASD.

Cox, R. N. "Experimental Facilities for Hypersonic Research." In *Progress in Aeronautical Sciences*, edited by Antonio Ferri, D. Kuchemann and L. H. G. Sterne. New York: Pergamon Press, 1962.

Crowley, J. W., Associate Director for Research. "Comments on Project BOMI." Letter to Commander Det. 1, Directorate of Systems Management. Wright-Patterson AFB OH, 12 February, 1956. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Davis, Major General L. I., Special Assistant to the Vice Commander. "X-20 Test Program." Letter to General Schriever, Commander, AFSC. Andrews AFB MD, 19 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

Davis, Major General W. A., Commander ASD. "System 620A Package Program." Letter to Major General M. F. Cooper, Deputy Chief of Staff, Systems, HQ Air Force. Wright-Patterson AFB OH, 25 April, 1962. Found in the DS supporting documents on file at the HO/ASD.

Davis, Major General W. A., Commander BSD. "Support of Test Programs by the 6555 ATW, Patrick AFB, FL." Memo to Commander ASD. Patrick AFB FL, 16 October, 1962. Found in the DS supporting documents on file at the HO/ASD.

Demler, Major General M. C., Director. "System 620A, Dyna-Soar Step I Booster." Report. Washington, D.C., 9 January, 1961. Found in the DS supporting documents on file at the HO/ASD.

Department of Defense. *Semi-Annual Report of the Secretary of Defense and the Semiannual Reports of the Secretary of the Army, Secretary of the Navy, Secretary of the Air Force, 1 July to 31 December 1949*. Washington, D.C.: GPO, 1949.

Deputy Chief of Staff, Systems and Logistics. "Dyna-Soar Adaptation to Titan Booster." Letter to Secretary of the Air Force. Washington, D.C., 3 August, 1962. Found in the DS supporting documents on file at the HO/ASD.

Deputy Secretary of Defense. "Release of Dyna-Soar Funds." Memo. Washington, D.C., 7 January, 1959. Found in the DS supporting documents on file at the HO/ASD.

Det. 1, Directorate of Systems Management, HQ Air Force. "Abbreviated Development Plan, System 464L." Wright-Patterson AFB OH, 1 November, 1959. Found in the DS supporting documents on file at the HO/ASD or through the Defense Technical Information Center service [hereafter cited as DTIC].

------. "Preliminary Development Plan, System 464L." Wright-Patterson AFB OH, November, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "RDZSXB-12-31619-E." TWX to HQ Air Force. Wright-Patterson AFB OH, 31 December, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "Report on Dyna-Soar Meeting." 59RDZ-23128. Wright-Patterson AFB OH, July-August, 1959. Found in the DS supporting documents on file at the HO/ASD.

Det. 1, Directorate of Systems Management, HQ ARDC. "Dyna-Soar Substantiation of RDZ Program." Report to HQ ARDC. Wright-Patterson AFB OH, No Date, 1959. Found in the DS supporting documents on file at the HO/ASD.

Director, Development, Deputy Chief of Staff, R&D. History Report, July-December 1963. Washington, D.C., 11 August, 1966. Found in the DS supporting documents on file at the HO/ASD.

Directorate of Systems Management. "Daily Activity Reports." Wright-Patterson AFB, 3 March, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. TWX RDZSXB-31261-E. Wright-Patterson AFB OH, 13 November, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activities Report." Wright-Patterson AFB OH, 17 November, 1955. Found in the DS supporting documents on the file at OH/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 14 June, 1955. Found in the DS supporting documents on file at the OH/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 12 January, 1956. Found in the DS supporting documents on file at OH/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 22 December, 1956. Found in the DS supporting documents on file at the OH/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 31 October, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 14 November, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 10 April, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 18 December, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright Patterson AFB OH, 12 June, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 13 November, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 5 February, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 15 January, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 16 April, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Weekly Activity Report." Wright-Patterson AFB OH, 8 April, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. and Directorate of Systems Management. "Weekly Activity Report." Wright-Patterson AFB OH, 7 June, 1955. Found in DS supporting documents on file at the OH/ASD.

Directorate of Systems Plans. "Abbreviated Development Plan for Weapon System 464L." First Development Plan for Dyna-Soar. Wright-Patterson AFB, 23 August, 1957.

DOD. *DOD News Release*. Number 84-63. Washington, D.C.: GPO, 22 January, 1963.

------. "DOD-NASA Agreement." News Release. Washington, D.C., 22 January, 1963.

------. "Dyna-Soar Designated X-20." News Release. Washington, D.C., 26 June, 1962.

Dornberger, Walter R. "Arms in Space: Something Else to Worry About." *U.S. News & World Report*, 9 October 1961.

------. *V-2*. 2nd. ed. Translated by James Cleugh and Geoffrey Halliday, 281. New York: Viking Press, 1955.

Douglas Aircraft Company. *Preliminary Design of an Experimental World Circling Spaceship*. Report SM-118271946.

Dyna-Soar SPO, Directorate of Systems Management, ASD. "Abbreviated Development Plan, System 620A." Wright-Patterson AFB OH, 7 October, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Abbreviated Development Plan, System 620A." Wright-Patterson AFB OH, 7 October, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. Daily Activity Report. Wright-Patterson AFB OH, 19 April, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "Development Plan, Dyna-Soar." Wright-Patterson AFB OH, 16 November, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Program Summary, 620A." Daily Activity Report. Wright-Patterson AFB OH, 19 March, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "Revision A, System Package Program, System 620A." Wright-Patterson AFB OH, 23 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "System Package Program, 620A." Wright-Patterson AFB OH, 14 May, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "System Package Program, System 620A." Wright-Patterson AFB, 26 April, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "System Package Program, System 620A." Wright-Patterson AFB OH, 10 October, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "System Package Program, System 620A." Wright-Patterson AFB OH, 3 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "System Package Program, System 620A." Wright-Patterson AFB OH, 27 May, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "System Package Program, System 620A." Wright-Patterson AFB OH, 13 May, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "System Program Package, 620A." Wright-Patterson AFB OH, 26 June, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Tentative System Package Program, System 620A." Wright-Patterson AFB OH, 15 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Anti-Satellite Mission." Report. Wright-Patterson AFB OH, 1 June, 1963. Found in the DS supporting documents on file at the HO/ASD.

Dyna-Soar WSPO, Directorate of Systems Management, WADD. "System Development Plan, Dyna-Soar (Step I) Program, 620A." Wright-Patterson AFB OH, 1 April, 1960. Found in the DS supporting documents on file at the HO/ASD and DTIC.

Editorial. *Newsweek*, 18 November 1957.

------. *Time*, 19 January 1960.

Eisenhower, Dwight D. *The White House Years*. Garden City NJ: Doubleday, 1965.

Eisenhower, Dwight David. *Farewell Radio and Television Address to the American People, 17 January 1961*. Vol. 8 of *Public Papers of the Presidents, Dwight D. Eisenhower 1953-1961*. Washington, D.C.: GPO, 1961.

Ely, L. D., Colonel. "Manned Spaceflight Program." Memo to Colonel C. H. Terhune, Deputy Commander, Weapon Systems, BMD. Los Angeles CA, 13 December, 1957. Found in the Ballistic Missile Division documents on file at HD/SSD.

Enthoven, Alain, and K. Wayne Smith. *How Much is Enough? Shaping the Defense Program, 1961-1969*. New York, 1971.

Estes, Brigadier General H. M., Jr. "Evaluation of Project BOMI." Letter to Deputy Commander, Weapon Systems, HQ ARDC. Andrews AFB MD, 21 December, 1955.

Estes, Lieutenant General H. M., Jr. "Manned, Military, Space, Capability, Vehicle Study." Letter to General Schriever. Wright-Patterson AFB OH, 28 September, 1961. Found in the DS supporting documents on file at the HO/ASD.

Estes, Lieutenant General H. M., Jr. "Space Planning Study." Letter to HQ ASD. Andrews AFB MD, 25 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Program Guidance for FY 1964." Letter to Major General Ruegg, Commander, ASD. Andrews AFB MD, 21 June, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Program." Letter to HQ Air Force. Andrews AFB MD, 30 March, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 System Package Program." Letter to Lieutenant General Ferguson. Andrews AFB MD, 17 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

Ferer, Lieutenant Colonel B. H., Assistant. "Assistant Secretary Air Force Research and Development Restrictions on Dyna-Soar Determinations and Findings." Memo. Andrews AFB MD, 24 November, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Dyna-Soar Briefing to Dr. Charyk." Memo on the 23 June Briefing to Dr. Charyk. Washington, D.C., 23 June, 1959. Found in the DS supporting documents on file at the HO/ASD.

Finletter, Thomas R. *Power and Policy, US Foreign Policy and Military Power in the Hydrogen Age*. New York: Harcourt, Brace, & Company, 1954.

Flax, A. H., Assistant Secretary of the Air Force. "X-20A Program." Memo to DDR&E. Washington, D.C., 4 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Dyna-Soar Operational Capability Study." Memo. Washington, D.C., 18 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

Fleming, David M., Captain. "Request for Proposal." HQ ARDC Letter to Aircraft Companies. Andrews AFB MD, 19 Dec, 1955. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Freedman, Lawrence. *The Evolution of Nuclear Strategy*. New York: St. Martin's Press, 1981.

Gardner, Trevor. "But We Are Still Lagging." *Life*, 4 November 1957.

Gilpatric, Roswell L., Deputy Secretary of Defense. *NASA Authorization for FY 1963*. Statement made during Senate hearings before the Committee on Aeronautical and Space Sciences. 87th Congress, 2nd Session. Washington, D.C.: GPO, 1962.

Goldie, J. Harry, Chief Engineer. "Questions, Comments, and Impressions from McNamara Briefing in Denver, 23 October 1963 Paraphrased Transcript of Discussion After X-20 Status Briefing to McNamara by Colonel Moore in Denver, 23 October 1963." Trip Report. Denver CO, 24 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

Golovin, N. E., Office of Science and Technology. "Briefing of Lees Subcommittee of PSAC Space Vehicle Panel." Memo to A.C. Hall, Deputy, DDR&E. Washington, D.C., 12 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

Grosse, A. V. "Report on the Present Status of the Satellite Program."1953. As cited in Walter A. McDougall, *The Heavens and the Earth* (New York: Basic Books, Inc., 1985).

Haugen, Major General V. R., Commander. "Dyna-Soar I Program Guidance." Letter to HQ Air Force. Wright-Patterson AFB OH, 15 May, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Status of Dyna-Soar." Letter to Lieutenant General R. C. Wilson, Deputy Chief of Staff, Development, HQ Air Force. Wright-Patterson AFB OH, 6 August, 1958. Found in the DS supporting documents on file at the HO/ASD.

Haugland, Vern. "Manned Spaceflight." *Ordnance*, January-February 1963, 430-34.

Heaton, Donald H., Lt. Col. "Rocket Bomber Feasibility Studies." Letter to the Commander ARDC. Washington, D.C., 28 November, 1952. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Hester Major General J. K., Assistant, Vice Chief of Staff, HQ Air Force. "Approaches to Manned Military Space Programs." Memo to the Secretary of the Air Force. Washington, D.C., 4 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

Hewlett, Richard G., and Oscar E. Anderson, Jr. *The New World, 1939-1946*. Vol. 1 of *A History of the United States Atomic Energy Commission*. University Park PA: Pennsylvania State University Press, 1962.

Holloway, Bruce K., Major General. "Requirements for Aerospace Weapon Systems." *Air University Quarterly Review* XII, 3/4 (Winter/Spring 1960-1961): 213.

Holzapple, Major General Joseph R., Deputy Chief of Staff. "Amendment 1 to Systems Program Directive 4." Washington, D.C., 2 February, 1962. Found in the DS supporting documents on file at the HO/ASD.

HQ Air Force Systems Command. "LSCSAD-23-7-18." TWX to HQ ASD. Andrews AFB MD, 25 July, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "MFSA-30-7-47." TWX to HQ ASD. Andrews AFB MD, 30 July, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "MFSA-9-5-17." TWX to HQ ASD. Andrews AFB MD, 9 May, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "MSF-17-12-45." TWX to HQ ASD. Washington, D.C., 17 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "MSFAM-16-1-38." TWX to HQ ASD. Washington, D.C., 16 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "SCCP-3-7-2." TWX to HQ ASD. Andrews AFB MD, 3 July, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "SCG-0-10-6." TWX to HQ ASD. Andrews AFB MD, 10 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "SCGV-11-8-18." TWX to Deputy Commander, Aerospace Systems. Wright-Patterson AFB OH, 11 August, 1961. Found in the DS supporting documents in file at the HO/ASD.

------. "SCLDA-8-1-2-E." TWX to HQ ASD. Wright-Patterson AFB OH, 8 January, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "SCRAS-3-4-2." TWX to HQ ASD. Washington, D.C., 4 April, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "SCSAS-28-1-59." TWX to Chief of Staff, Air Force. Andrews AFB MD, 28 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "SCSS-19-21-1." TWX to HQ ASD. Andrews AFB MD, 19 Dec, 1962. Found in the DS supporting documents on file at the HO/ASD.

HQ Air Force. "AFCVC-1918/63." TWX to All Commands. Washington, D.C., 10 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAP-78950." TWX to HQ AFSC. Andrews AFB MD, 16 June, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-48049." TWX to Commander, Det 1. Andrews AFB MD, 16 January, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-51437." TWX to Commander, Det 1. Andrews AFB MD, 28 May, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-53166." TWX to Commander Det. 1, HQ ARDC. Andrews AFB MD, 10 July, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-54520." TWX to Commander, Det 1. Andrews AFB MD, 30 December, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-55061." TWX to Commander, Det 1. Andrews AFB MD, 14 January, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-56643." TWX to Commander, Det 1. Andrews AFB MD, 17 February, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-58885." TWX to Commander, Det 1. Andrews AFB MD, 30 September, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-59299." TWX to Commander, Det 1. Andrews AFB MD, 24 April, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDAT-89082." TWX to HQ ARDC. Andrews AFB MD, 26 April, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDRD-AN-31317." TWX to Commander, Det 1, HQ ARDC. Wright-Patterson AFB OH, 16 June, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDSD-66668." TWX to HQ ARDC. Andrews AFB MD, 5 December, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDSD-76644." TWX to HQ ARDC. Washington, D.C., 12 January, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDSD-82107." TWX to HQ ARDC. Washington, D.C., 3 February, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "AFDSD-AS/O-93477." TWX to HQ ARDC. Washington, D.C., 13 October, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "AFRDC-92965." TWX to HQ AFSC. Washington, D.C., 12 April, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "AFRDDG-86985." TWX to HQ AFSC. Washington, D.C., 4 January, 1964. Found in the DS supporting documents on file at the HO/ASD.

------. "AFSDC-5-9-65922." TWX to HQ AFSC. Washington, D.C., 13 July, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "AFSDC-67166." TWX to HQ AFSC. Washington, D.C., 3 October, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "AFSDC-85-081." TWX to HQ AFSC. Washington, D.C., 11 December, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "AFSDC-S-67777." TWX to HQ AFSC. Washington, D.C., 5 October, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Development Directive 411." Andrews AFB MD, 12 October, 1960. Found in the DS supporting documents on file at the HO/ASD and DTIC.

------. "General Operational Requirement 92, Revised." Andrews AFB MD, 17 February, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Hypersonic Glide Rocket Weapon System." Development Directive. Washington, D.C., 25 November, 1957. Found in the DS supporting documents on file at the OH/ASD.

------. "System Development Requirement 19." Andrews AFB MD, 21 July, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Systems Program Directive 4." Washington, D.C., 27 December, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. TWX to Commander, ARDC. Andrews AFB MD, 7 December, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. TWX to Commander, ARDC. Andrews AFB MD, 17 November, 1959. Found in the DS supporting documents on file at the HO/ASD.

HQ Air Research and Development Command. "Evaluation Report of the Ad Hoc Committee for ARDC System Requirement 126, ROBO." ARDC-TR-57-130. Andrews AFB MD, 1 August, 1957. Found in the DS supporting documents on file at the OH/ASD.

------. *HQ ARDC Annual History, 23 January 1950-30 June 1951*. Andrews AFB MD: HQ ARDC, 1951.

------. *HQ ARDC Semi-Annual History, 1 January -30 June*. Andrews AFB MD: HQ ARDC, 1956.

------. *HQ ARDC Semi-Annual History, 1 January -30 June*. Andrews AFB MD: HQ ARDC, 1958.

------. *HQ ARDC Semi-Annual History, 1 January-30 June*. Andrews AFB MD: HQ ARDC, 1956.

------. *HQ ARDC Semi-Annual History, 1 July-31 December*. Andrews AFB MD: HQ ARDC, 1955.

------. *HQ ARDC Semi-Annual History, 1 July-31 December*. Andrews AFB MD: HQ ARDC, 1956.

------. "Hypersonic Weapons Research and Development Supporting System 455L--HYWARDS." System Requirement 131. Andrews AFB MD, 29 June, 1956. Found in the DS Antecedents supporting documents on file at the OH/ASD.

------. "RDG-23-7-5-E." TWX to HQ BMD. Andrews AFB MD, 23 July, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "RDRA-30-9-43." TWX to HQ WADD. Andrews AFB MD, 30 September, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "RDROF-9-6-4." TWX to HQ WADD. Andrews AFB MD, 9 June, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "Rocker Bomber Study." System Requirement 126. Andrews AFB MD, 12 June, 1956. Found in the DS supporting documents on file at the OH/ASD.

------. "Statement of Agreement, System 620A, Dyna-Soar I for the Air Force Ballistic Missile Division, ARDC." Memo to HQ BMD. Wright-Patterson AFB OH, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. "Supplement 1 to the Evaluation Report." ARDC-TR-57-130. Andrews AFB MD, 1 October, 1957. Found in the DS supporting documents on file at the OH/ASD.

------. "System Development Directive 464L." Andrews AFB MD, 12 December, 1957. Found in the DS supporting documents on file at the HO/ASD.

------. "Systems Requirement 201." Wright-Patterson AFB OH, 7 May, 1959. Found in the DS supporting documents on file at the HO/ASD.

HQ Space Systems Division. "Proposed Development Plan for an Advanced Reentry Technology Program." Los Angeles, 29 May, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "SSBT-31-8-26." TWX to HQ ASD. Los Angeles CA, 31 August, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "SSVS-10-7-3." TWX to HQ ASD1961. Found in the DS supporting documents on file at the HO/ASD.

------. "System Program Package, Expanded SAINT." Los Angeles CA, 29 May, 1961. Found in the DS supporting documents on file at the HO/ASD.

HQ Wright Air Development Center. "Evaluation and Recommendations for BOMI." Letter to the Commander ARDC. Wright-Patterson AFB OH, 23 December, 1953. Found in the DS Antecedents supporting documents on file at the OH/ASD.

------. "Reasons for Rejecting the Rocket Bomber." Letter to Commander ARDC. Wright-Patterson AFB OH, 10 April, 1953. Found in the DS Antecedents supporting documents on file at the OH/ASD.

HQ Wright Air Development Division. "WWDR-7-11-2." TWX to HQ ARDC. Wright-Patterson AFB OH, 8 November, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "WWZR-5-11081." TWX to HQ ARDC. Wright Patterson AFB OH, 5 January, 1961. Found in the DS supporting documents on file at the HO/ASD.

Huntington, Samuel P. *The Common Defense: Programs in National Politics*. New York: Columbia University Press, 1961.

Intelligence and Reconnaissance Division, HQ ARDC. "BRASS BELL." Research and Development Report Card, System 459L. Wright-Patterson AFB OH, 31 December, 1956. Found in the DS supporting documents on file at the OH/ASD.

Johnson, Lyndon B., Vice-President. "Space Stations." Memo to Secretary of Defense. Washington, D.C., 22 July, 1963. Found in the DS supporting documents on file at the HO/ASD.

Johnston, R. C., Chairman. "Titan II Booster Presentation." Trip Report to HQ Air Force, 9-11 January. Washington, D.C., 12 January, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Trip Report to HQ Air Force." Wright-Patterson AFB OH, 9-11 January, 1961. Found in the DS supporting documents on file at the HO/ASD.

Jones, Brigadier General D. M., Acting Commander. "Revised X-20A System Package Program." Letter to HQ AFSC. Wright-Patterson AFB OH, 13 May, 1963. Found in the DS supporting documents on fila at the HO/ASD.

Joseph R. Trueblood. Offensive Mission Plans Division. Edited by C. H. Uyehara. Andrews AFB MD, 4 May, 1960. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Kecskemeti, Paul. *The Satellite Rocket Vehicle: The Political and Psychological Problems*. RM-567. RAND, 4 October 1950.

Keese, Major General W. B., Deputy Chief of Staff. "Briefing to PSAC Panel on 10 October 1963." Letter to HQ ASD. Washington, D.C., 19 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

Keese, Major General W. B., Deputy Chief of Staff. "Amendment 1 to ADO 19." Washington, D.C., 21 February, 1962. Found in the DS supporting documents on file at the HO/ASD.

Kennan, George. "The Sources of Soviet Conduct." *Foreign Affairs* 25 (July 1947): 566-82.

Kennedy, John F. *New York Times*, 26 May; 26 September 1961; 15 June 1962.

------. *United States Aeronautical and Space Activities, 1961*. Message from the President of the United States Transmitting a Report on United States Aeronautical and Space Activities for Calender Year 1961, House Document 324. 87th Congress, 2nd Session. Washington, D.C.: GPO, 1962.

------. *Missiles and Rockets*, 10 October 1960, 10.

Killian, James R. *Sputnik, Scientists, and Eisenhower: A Memoir of the First Special Assistant to the President for Science and Technology*. Cambridge MA: MIT Press, 1976.

Kistiakowsky, George B. *A Scientist at the White House: The Private Diary of President Eisenhower's Special Assistant for Science and Technology*. Cambridge MA: Harvard University Press, 1976.

Klocko, Richard Colonel. "The Impact of Guided Missile Upon the USAF." Air War College Graduate Study Group Thesis #4. Maxwell AFB AL, 4 March, 1954.

Lamar, William E. . Interview edited by Clarence J. Geiger. Wright-Patterson AFB OH, 14 January, 1964.

------. Interview edited by Clarence J. Geiger. Wright-Patterson AFB OH, 27 February, 1964.

------. Interview edited by Roy F. Houchin, II. Lamar Home, Dayton OH, 1-8 June, 1994.

------. Interview edited by Roy F. Houchin, II. Auburn AL, 8 March, 1995. Telephone conversation.

------. Interview edited by Roy F. Houchin, II. Auburn AL, 22 April, 1995. Telephone conversation.

------. Letter to Roger McCormick. Dayton OH, 25 June, 1993. Found in the personal files of William E. Lamar.

------. "Hypersonic Strategic Weapon System." Management Report. Wright-Patterson AFB OH, 4 February, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. Chairman. "Conference at NASA Regarding RVX-2 Test for Dyna-Soar." Memo. Wright-Patterson AFB OH, 1961. Found in the DS supporting documents on file at the HO/ASD

.

------. Chief, Dyna-Soar Engineering Office, DSE, WADD. Edited by C. H. Uyehara. Wright-Patterson AFB, 2 May, 1960. Found in the DS Antecedents supporting documents on file at the OH/ASD.

------. Deputy Director. "Conference at NASA Regarding RVX-2 Test for Dyna-Soar." Wright-Patterson AFB OH, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "History of Dyna-Soar to Present." Presentation to HQ ARDC. Wright-Patterson AFB OH, 20 February, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. Director X-20 Engineering Office. "Briefing to PSAC." Trip Report. Wright-Patterson AFB OH, 23 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Paraphrased Transcript of Discussion After X-20 Status Briefing to McNamara by Colonel Moore in Denver, 23 October 1963." Trip Report. Wright-Patterson AFB OH, No Date, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Status Report." Presentation to Secretary of the Air Force. Wright-Patterson AFB OH, 8 July, 1963. Found in the DS supporting documents on file at the HO/ASD.

Legislative Reference Service. *United States Defense Policies in 1957*. Washington, D.C.: GPO, 1959.

------. *United States Defense Policies in 1958*. Washington, D.C.: GPO, 1960.

------. *United States Defense Policies Since World War II*. Washington, D.C.: GPO, 1957.

Lukasiewicz, Julius. *Experimental Methods of Hypersonics*. New York: Marcel Dekker, Inc., 1973.

Martin Company. "Martin Program Plan." Program 202. Los Angeles CA, September, 1961. Found in the Prime/START supporting documents on file at Satellite and Missile Systems Organization History Division [hereafter cited as SAMSO/HD].

Martin, Colonel J. L., Jr. "Action on Dyna-Soar." Letter to Commander, Det 1, Directorate of Systems Management, HQ ARDC. Andrews AFB MD, 19 September, 1958. Found in the DS supporting documents on file at the HO/ASD.

McKee, Lieutenant General W. F., Vice Commander. "The Dyna-Soar Program." Letter to Commander, ARDC. Los Angeles CA, 23 September, 19959. Found in the DS supporting documents on file at the HO/ASD.

McMillan, Brockway, Assistant Secretary of the Air Force, R&D. "Dyna-Soar Briefing to Secretary McNamara." Memo to Secretary of the Air Force. Washington, D.C., 18 March, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Secretary McNamara's Trip to Seattle." Memo to Secretary of the Air Force. Washington, D.C., 15 March, 1963. Found in the DS supporting documents on file at the HO/ASD.

McNamara, Robert S., Secretary of Defense. "The Air Force Manned Military Space Program." Memo to Secretary of the Air Force Eugene M. Zuckert. Washington, D.C., 23 February, 1962. Found in the DS supporting documents on file at the HO/ASD.

------. "Cancellation of the X-20 Program." News Brief. Washington, D.C., 10 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "DOD Support of NASA." DOD Directive. Washington, D.C., 24 February, 1962.

------. "Gemini and Dyna-Soar." Memo to DDR&E. Washington, D.C., 18 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Orbital Space Station." Memo to the Vice President. Washington, D.C., 19 August, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Review of Gemini." Memo to DDR&E. Washington, D.C., 19 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Review of Titan IIIC." Memo to DDR&E. Washington, D.C., 19 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20, Gemini, and Military Missions." Memo to Secretary of the Air Force. Washington, D.C., 15 March, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20, Gemini, and Military Missions." Memo to Vice President Johnson. Washington, D.C., 9 August, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. and James E. Webb, NASA Administrator. "DOD-NASA Agreement." Memo. Washington, D.C., 21 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. *The Essence of Security: Reflections in Office*. London: Harper & Row, 1968.

Missiles and Rockets, 7 January 1962, 9.

"MOL Requirements Will Be Set By January 1." *Aviation Week*, 23 December 1963, 19-20.

Moore, Colonel William L., Chairman. "Dyna-Soar HETS Program." Letter to HQ ARDC. Wright-Patterson AFB OH, 5 October, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. Chairman. "Presentation on Status of Dyna-Soar Program." Trip Report to Brigadier General A, T. Culbertson, Director, Systems Management, WADD. Wright-Patterson AFB, 31 March, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. Program Director." 'Stand-By' Program." Memo. Wright-Patterson AFB OH, 20 March, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Dyna-Soar, SSD Advanced Re-entry Technology Program and SAINT II Proposed Conflict." Letter to Brigadier General A. T. Culbertson, Director, Directorate of Systems Management, ASD. Wright-Patterson AFB OH, 28 June, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Manned Spaceflight Review Group." Letter to Major General Ruegg, ASD Commander. Wright-Patterson AFB OH, 2 January, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Phase 0 Study of X-20 Program 706." Report. Wright-Patterson AFB OH, 18 November, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Preliminary Results of Dyna-Soar 'Stand-By' Program Study." Letter to Commander ARDC. Wright-Patterson AFB OH, 23 February, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Project Streamline." Presentation to the Strategic Air Panel. Washington, D.C., 3 August, 1961. Found in the DS supporting documents on file at the HO/ASD.

------. "Record Memorandum of the X-20 Presentation to Secretary of Defense McNamara, 23 October 1963, and Pertinent Background." Memo. Wright-Patterson AFB OH, 30 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Telephone Request from HQ AFSC." Memo. Wright-Patterson AFB OH, 3 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Status Report to Secretary McNamara." Memo. Wright-Patterson AFB OH, 24 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Test Program." Memo. Wright-Patterson AFB OH, 9 September, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. and Major General R. G. Ruegg, Commander ASD. "23 October Briefing to McNamara and Brown." Joint Personal Message to General Schriever. Wright-Patterson AFB OH, 29 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

NACA Committee for Aeronautics. "Requested Comments on Project MX-2276[BOMI]." Letter from to Commander, WADC. Wright-Patterson AFB OH, 30 September, 1955. Found in the DS Antecedents supporting documents on file at the HO/ASD.

NASA. "The Atlas RVX-2 and Communications Experiments Proposed by NASA."1961. Found in the DS supporting documents on file at the HO/ASD.

------. *NASA Release 59-116.* 17 April. Washington, D.C.: NASA, 1959.

"National Security Council (NSC)-68." *Foreign Relations of the United States* 1 (14 April 1950): 234-92.

National Security Council. *U.S. Policy on Outer Space.* NSC 5918/1. Washington, D.C.: NSC, 1960.

------. *Satellite Program.* NSC-5520. As quoted in Walter A. McDougall, *The Heavens and the Earth* (New York: Basic Books, Inc., 1970), 120-121.

------. *U.S. Policy on Outer Space.* NSC 5814/1, Annex A, Soviet Space Systems. Washington, D.C.: GPO, 18 August 1958.

New York Times. 10 December 1947; 7 Nov 1950; 4 October 1951; 9 October; 8 November 1957; 9, 13 January; 6 February; 3 April 1958; 1, 2 March; 14 April 1959; 12 January; 23 October; 26 September; 4, 9, 10 December 1963.

Office of Information. *Air Force Information Fact Sheet: X-20 Dyna-Soar.* Fact Sheet. Washington. D.C.: Office of the Secretary of the Air Force, 1963.

Page, J. D., Brigadier General. *Aviation Week,* 28 November 1960.

PL 85-568. *National Aeronautics and Space Act of 1958.* Washington, D.C.: GPO, 1958.

Power, General Thomas S., Commander. *New York Times,* 11 October 1961.

President's Science Advisory Committee. *Report of the President's Science Advisory Committee.* Washington, D.C.: GPO, 1958.

Price., Colonel W. H., Air Force Plant Representative. "Report of Visit, Assistant Secretary of The Air Force." Letter to HQ Air Force. Seattle WA, 10 October, 1963. Found in the DS supporting documents on file at the HO/ASD.

Public Affairs. *New York Times,* 14 October 1961.

Puckett, Robert H. "The Military Role in Space: A Summary of Official, Public Justifications." RP (RAND Paper)-2681. Los Angeles CA, 1963.

Putt, Lieutenant General Donald L., Deputy Chief of Staff. "Advanced Hypersonic Research Aircraft." Letter. Washington, D.C., 31 January, 1958. Found in the DS supporting documents on file at the HO/ASD.

Research Airplane Committee. "A Report on the Conference on the Progress of the X-15 Project." Compilation of the Papers Presented at the Langley Aeronautical Laboratory. Langley VA, 25-26 October, 1956. Found in the X-15 files at the OH/ASD.

Richelson, Jeffery T. *America's Secret Eyes in Space*. New York: Harper & Row, Publishers, Inc, 1990.

Ritland, Major General O. J. *Los Angeles Times,* 1960.

------. Deputy to the Commander for Manned Spaceflight. "Gemini-Dyna-Soar Task Groups." Letter to Commander, SSD. Andrews AFB MD, 31 January, 1963. Found in the DS supporting document son file at the HO/ASD.

------. "Response to Secretary McNamara's 15 March 1963 Questions." Letter to Commander, Manned Space Flight, HQ AFSC. Andrews AFB MD, 22 May, 1963. Found in the DS supporting document son file at the HO/ASD.

Roy Johnson, Director ARPA. "Reconnaissance Satellites and Manned Space Exploration." Wright-Patterson AFB OH, 28 February, 1958. Found in the DS supporting documents on file at the OH/ASD.

Rubel, John H., Deputy Director of DDR&E. *Missiles and Rockets*, 5 March 1962.

Scientific Advisory Board Ad Hoc Committee to Study Advanced Weapons Technology and Environment. "Report of the SAB Ad Hoc Committee to Study Advanced Weapons Technology and Environment." SAB Report. Washington, D.C., 9 October, 1957. Found in the Ballistic Missile Division documents on file at HD/SSD.

Sandstrom, R. J., Vice President, Engineering, Bell Aircraft Corporation. "Proposed Glide Bomber Study." Letter to HQ WADC (Attn: Chief, Weapon System Division)17 April 1952.

Sänger-Bredt, Irene. "The Silver Bird Story: A Memoir." In *Essays of the History of Rocketry and Astronautics: Proceedings of the Third Through the Sixth History Symposia of the International Academy of Astronautics*, edited by R. Cargill Hall, 195-228. Washington, D.C.: NASA, 1977.

------. "The Silver Bird Story: A Memoir." In *History of Rocketry and Astronautics*. Vol. 7, Part 1 of *AAS History Series*, edited by R. Cargill Hall, 195-228. San Diego CA: American Astronautical Society Publications, 1986.

Sänger, Eugene, and Irene Bredt. *Uber Einen Rakentenantrieb Fur Fernbomber, Deutsche Luftfahrtforschung*. UM 3538. Translated by Bureau of Aeronautics Naval Technical Information Branch, United States Navy. Ainring: DFS, 22 September 1944.

Schriever, General Bernard A., "Manned Space Program." Letter to Major General Marvin Demler, Commander, Research and Technology Division. Andrews AFB MD, 16 December, 1963. Found in the DS supporting documents on fila at the HO/ASD.

------. *New York Times*, 8 October 1961.

------. "X-20 Program Management." Letter to Commander, SSD. Andrews AFB MD, 9 May, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "X-20 Program." Letter to Commander, ASD. Andrews AFB MD, 31 July, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "The USAF and Space." *Air Force and Space Digest*, May 1964, 161-62.

Schriever, Lieutenant General Bernard A., ARDC Commander. "Management of Dyna-Soar Project." Letter to Lieutenant General S.E. Anderson, AMC Commander. Wright-Patterson AFB OH, 5 December, 19959. Found in the DS supporting documents on file at the HO/ASD.

Schriever, Major General Bernard A. "The USAF Ballistic Missile Program." *Air University Review*, Summer 1957, 8.

Scoville, Lieutenant Colonel. "Events Concerning the X-20 Cancellation." Memo. Washington, D.C., No Date, 1963. Found in the DS supporting documents on file at the HO/ASD.

Seaberg, J. D., Major. "Trip Report to Bell Aircraft Company." WCOWB/WADC Trip Report on the November 1952 Visit to Bell Aircraft Company. Wright-Patterson AFB OH, 20-21 November, 1952. Found in the DS Antecedents supporting documents on file at the OH/ASD.

Seaberg, John D.. Letter to John L. Sloop, NASA HQ. Wright-Patterson AFB OH, 25 June, 1976. Found in the personal files of William E. Lamar.

Secretary of the Air Force. TWX to HQ AFSC. Washington, D.C., 11 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

Sessums, Major General John W., Jr. "Dyna-Soar Program." Letter to Lieutenant General R. C. Wilson, Deputy Chief of Staff, Development, Air Force HQ. Washington, D.C., 11 July, 1958. Found in the DS supporting documents on file at HO/ASD.

Space Systems Division. *Partial System Package Plan, Military Orbital Development System (MODS), System Number 648C.* Los Angeles CA: Space Systems Division, 1962.

------. *Partial System Package Plan, Program 287, Supplement I (Blue Gemini).* Los Angeles CA: Space Systems Division, 1962.

Stennis, Senator John, Chairman. *Congressional Record.* Volume 107, Part 17, p. 21252. Washington, D.C.: GPO, 1961.

Swofford, Lieutenant General R. P., Jr. "Selection of Contractor for WS 464L (Dyna-Soar) Development." Letter to Commander, ARDC. Andrews AFB MD, 25 June, 1958. Found in the DS supporting documents on file at the HO/ASD.

Teller, Edward. *Report of the Teller Ad Hoc Committee.* Wright-Patterson AFB OH: HQ ARDC, 1957.

Terhune, Brigadier General C. H., Jr. "Dyna-Soar Booster Evaluation." Letter to Det 1, HQ ARDC. Los Angeles CA, 13 August, 1959. Found in the DS supporting document on file at the HO/ASD.

Tosti, Colonel C. R., Executive Secretary. "65th Meeting, DSMG." DSMG Minutes. Washington, D.C., 12 July, 1963. Found in the DS supporting documents on file at the HO/ASD.

Trenholm, J. B., Assistant Director. "X-20 System Package Program." Letter to Lieutenant Colonel C. L. Scoville, Director, Military Space Program, HQ AFSC. Wright-Patterson AFB OH, 21 November, 1963. Found in the DS supporting documents on file at the HO/ASD.

U.S. Arms Control and Disarmament Agency. *Documents and Disarmament 1961.* Washington, D.C.: GPO, 1962.

------. *Documents and Disarmament 1962.* Washington, D.C.: GPO, 1963.

U.S. Congress. House. Hearings Before the Subcommittee on Manned Spaceflight of the Committee on Science and Astronautics. *Agreement Between the NASA and* *the DOD Concerning the Gemini Program, January 1963*. 88th Congress, 1st Session. Washington, D.C.: GPO, 1963.

------. Hearings Before the House DOD Subcommittee on Appropriations. *The Ballistic Missile Program*. 85th Congress, 1st Session. Washington, D.C.: GPO, 1957.

------. Hearings Before the House Subcommittee on DOD Appropriations. *DOD Appropriation Bill, 1962*. House Report 574. 87th Congress, 1st Session. Washington, D.C.: GPO, 1961.

------. *DOD Appropriations for 1957*. 88th Congress, 2nd Session, Part 4. Washington, D.C.: GPO, 1956.

------. Hearings Before the Subcommittee of the Committee on Appropriations. *DOD Appropriations for 1959*. 85th Congress, 2nd Session. Washington, D.C.: GPO, 1958.

------. Hearings Before the Subcommittee of the Committee of Appropriations, House of Representatives *DOD Appropriations for 1960,*. 86th Congress, 1st Session, Part 5. Washington, D.C.: GPO, 1959.

------. Hearings Before the House Subcommittee on DOD Appropriations. *DOD Appropriations for 1961*. 86th Congress, 2nd Session. Washington, D.C.: GPO, 1960.

------. Hearings Before a Subcommittee on Appropriations. *DOD Appropriations for 1963*. 87th Congress, 2nd Session, Part 5. Washington, D.C.: GPO, 1963.

------. Hearings Before a Subcommittee of the Committee on Appropriations. *DOD Appropriations for 1964*. 88th Congress, 1st Session. Washington, D.C.: GPO, 1963.

------. *Military Aid and Supply Programs in Western Europe*. House Report 1371, 90th Report by the Committee on Government Operations. 85th Congress, 2nd Session. Washington, D.C.: GPO, 1959.

------. Hearings Before The Committee on Armed Services. *Military Posture Briefings*. 87th Congress, 2nd Session. Washington, D.C.: GPO, 1962.

------. Hearings Before the Committee on Science and Astronautics. *Missile Development and Space Sciences*. 86th Congress, 1st Session. Washington, D.C.: GPO, 1959.

------. *Organization and Management of Missile Programs*. House Report 1121. 86th Congress, 1st Session. Washington, D.C.: GPO, 1959.

------. Hearings Before the Select Committee on Astronautics and Space Exploration. *Problems of Congress Formulating Outer Space Legislation.* Memo from Eileen Galloway to Representative J. W. McCormick. 85th Congress, 2nd Session. Washington, D.C.: GPO, 1958.

------. *Report to the House Committee on Science and Astronautics*. DOD Directive 5160.32. 87th Congress, 1st Session. Washington, D.C.: GPO, 1962.

------. Hearings Before the Committee on Science and Astronautics. *Space Posture*. 87th Congress, 1st Session. Washington, D.C.: GPO, 1961.

------. Hearings Before the Committee on Science and Astronautics *Space Posture..* 88th Congress, 1st Session. Washington, D.C.: GPO, 1963.

------. *Space, Missile, and the Nation*. House Report 2092. 86th Congress, 2nd Session. Washington, D.C.: GPO, 1961.

------. Hearings Before the Subcommittee for Special Investigations of the Committee on Armed Services. *Weapon System Management and Team System Concept in Government Contracting,* 86th Congress, 1st Session. Washington, D.C.: GPO, 1959.

------. Hearings Before the House Subcommittee on DOD Appropriations. *DOD Appropriations for 1962*. 87th Congress, 1st Session. Washington, D.C.: GPO, 1961.

------. Armed Services Committee. Hearings on Military Posture *House Report 9751..* 87th Congress, 1st Session. Washington, D.C.: GPO, 1961.

------. House Committee on Astronautics and Space Exploration. *Aeronautic al and Astronautical Events of 1961*. House Report. 87th Congress, 1st Session. Washington, D.C.: GPO, 1962.

------. *Astronautics and Its Applications*. Staff Report. 85th Congress, 1st Session. Washington, D.C.: GPO, 1958.

------. *Review of the Space Program*. 86th Congress, 2nd Session. Washington, D.C.: GPO, 1960.

------. House Select Committee on Astronautics and Space Exploration. *HR 1758*. 85th Congress, 2nd Session. Washington, D.C.: GPO, 1959.

------. Report 1758. *The National Space Program*. 85th Congress, 2nd Session. Washington, D.C.: GPO, 1958.

U.S. Congress. Senate. Hearings Before the Preparedness Investigations Subcommittee on Armed Services. *Inquiry Into Satellite and Missile Programs*. 85th Congress, 1st and 2nd Sessions. Washington, D.C.: GPO, 1957.

------. Hearings Before the Preparedness Investigation Committee on Armed Services. *Inquiry Into Satellite and Missile Programs,* 85th Congress, 1st and 2nd Sessions, Part 1. Washington, D.C.: GPO, 1958.

------. Hearings Before the Subcommittee on the Government Organization for Space Activities of the Committee on Aeronautics and Space Sciences. *Investigation of Governmental Organization for Space*. 86th Congress, 1st Session. Washington, D.C.: GPO, 1958.

------. Hearings Before the Committee on Armed Services. *McNamara Testimony*. 88th Congress, 1st Session. Washington, D.C.: GPO, 1963.

------. Hearings Before the Committee on Military Procurement. *Military Procurement Authorization 1964*. 88th Congress, 1st Session. Washington, D.C.: GPO, 1963.

------. Hearings Before the NASA Authorizations Subcommittee of the Committee on Aeronautics and Space Science *NASA 1965 Authorizations*.. 88th Congress, 2nd Session. Washington, D.C.: GPO, 1964.

------. Hearings Before the NASA Authorizations Subcommittee of the Committee on Aeronautics and Space Sciences. *NASA Authorization for Fiscal Year 1960*. 86th Congress, 1st Session. Washington, D.C.: GPO, 1958.

------. Hearings Before the Committee on Aeronautical and Space Sciences. *NASA Authorizations for FY 1963*. 87th Congress, 1st Session. Washington, D.C.: GPO, 1962.

------. *Study of Airpower, Hearings Before the Subcommittee on the Air Force of the Committee on Armed Services*. 84th Congress, 2nd Session, Part 2. Washington, D.C.: GPO, 1956.

------. Hearings Before the Permanent Subcommittee on Investigations of the Committee on Government Operations *TFX Contract Investigation.*. 88th Congress, 1st Session. Washington D.C.: GPO, 1962.

------. Report of the NACA Special Committee on Space Technology. *Recommendations to NASA for a National Space Program.* 86th Congress, 1st Session. Washington, D.C.: GPO, 1958.

------. Military Affairs Committee. *Department of Armed Services, Department of Military Security: Hearings.* 79th Congress. 1st Session. Washington, D.C.: GPO, 1945.

USAF Flight Dynamics Laboratory. "Advanced Technology Program: Technical Development Plan for Aerothermodynamic/Elastic Structural Systems Tests (ASSET)." Wright-Patterson AFB OH, 9 September, 1963. Found in the ASSET supporting documents on file at the HO/ASD.

"USAF Pushes Pied Piper Space Vehicle." *Aviation Week*, 14 October 1957, 27.

von Kármán, Dr. Theodore H. *Where We Stand: A Report Prepared for the Scientific Advisory Group.* Washington, D.C.: United States Army Air Force, August, 1945.

------. editor. *Science, the Key to Air Supremacy.* Vol. 1 of *Toward New Horizons.* Washington, D.C.: United States Army Air Force, 1945.

------. *The Wind and Beyond: Theodore von Kármán, Pioneer in Aviation and Pathfinder in Science.* Toronto, 1967.

Wright Air Development Center. "Work Requirements for a Preliminary Feasibility Study for an Advanced Long Range Bombing and Reconnaissance Weapon System." Department of Defense (DD) Form 613, Research and Development Report Card. Wright-Patterson AFB OH, 26 September, 1952. Found in the Dyna-Soar [hereafter cited as DS] Antecedents supporting documents on file at the OH/ASD.

------. "RDZSXB-1-1420-E." TWX to HQ ARDC. Wright-Patterson AFB OH, 28 January, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "RDZSXB-30061-E." TWX to HQ ARDC. Wright-Patterson AFB OH, 20 January 1960, 1960. Found in the DS supporting documents on file at the HO/ASD.

Wall Street Journal. 20 October 1950.

Walter, William C. "Project Dyna-Soar: The Roots of Shuttle-A Memoir." IAA-92-0193, 1-24. 43rd Congress of the International Astronautical Federation. Washington, D.C.: International Astronautical Federation, 28 August-5 September, 1992.

------. "Visit to HQ Air Force on Project Dyna-Soar." Trip Report. Washington, D.C., 21 October, 1957. Found in the DS supporting documents on file at the OH/ASD.

Washington Evening Star. 7 September 1951.

Washington Post. 12 October 1951; 11 January 1961.

White, General Theodore D. "Air and Space Indivisible." *Air Force*, March 1958.

Wilson, Lieutenant General R. C., Deputy Chief of Staff. "Dyna-Soar Funding." Letter to Lieutenant General S. E. Anderson, ARDC Commander. Andrews AFB MD, 12 August, 1958. Found in the DS supporting documents on file at the HO/ASD.

------. "Dyna-Soar Program." Letter to Major General John W. Sessums, Jr., Vice Commander ARDC. Andrews AFB MD, 23 July, 1958. Found in the DS supporting documents on file at the HO/ASD.

WSPO, Directorate of Systems Management, WADD. "Dyna-Soar Step II and Step II Funding." Wright-Patterson AFB OH, 2 August, 1960. Found in the DS supporting documents on file at the HO/ASD.

------. "WWZRM-8-1041-E." TWX to HQ ARDC. Wright-Patterson AFB OH, 23 August, 1960. Found in the DS supporting documents on file at the HO/ASD.

Yearbook of the United Nations,1963. Washington, D.C., 1963.

York, Herbert F., Director of Defense Research and Engineering. "Saturn, Dyna-Soar Propulsion." Memo to the Secretary of the Air Force and ARPA. Washington, D.C., 27 July, 1959. Found in the DS supporting documents on file at the HO/ASD.

------. *The Advisors: Oppenheimer, Teller, and the Superbomb*. San Francisco: W. A. Freeman, 1976.

Zuckert, E. M., Secretary of the Air Force. Interview edited by Larry McQuade and Ned Trapnell. Washington, D.C., 27 June-11 July, 1964.

------. "Dyna-Soar Termination." Memo to the Chief of Staff, Air Force. Washington, D.C., 12 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

------. "Manned Military Space Program." Memo to the Secretary of Defense. Washington, D.C., 4 December, 1963. Found in the DS supporting documents on file at the HO/ASD

------. "Manned Military Space Program." Memo to the Secretary of Defense. Washington, D.C., 5 December, 1963. Found in the DS supporting documents on file at the HO/ASD.

Secondary

Air Force Ballistic Missile Division. *Chronology of Early Air Force Man-in-Space Activity, 1955-1960.* Los Angeles CA: Space Systems Division, 1965.

Alexander, Charles C. *Holding the Line: The Eisenhower Era, 1952-1961.* Bloomington IN: Indiana University Press, 1975.

Anderson, Frank W., Jr. *Orders of Magnitude: A History of NACA and NASA.* 2nd ed. Washington, D.C.: NASA History Office, 1981.

Baals, Donald D., and William R. Corliss. *Wind Tunnels of NASA.* Washington, D.C.: NASA, 1981.

Baucom, Donald R. "Air Force Images of Research and Development and Their Reflections in Organizational Structure and Management Policies." Ph.D. Dissertation. Norman Oklahoma: University of Oklahoma, 1976.

Beard, Edmund. *Developing the ICBM: A Study in Bureaucratic Politics.* New York: Columbia University Press, 1976.

Berger, Carl. *The Air Force in Space Fiscal Year 1961.* USAF Historical Liaison Division Office: Office of Air Force History, 1966.

------. *The Air Force in Space, Fiscal Year 1962.* Washington, D.C.: USAF Historical Division Liaison Office, 1966.

Bilstein, Roger E. *Flight in America: From the Wrights to the Astronauts*. Baltimore MD: Johns Hopkins University Press, 1984.

Bloomfield, Lincoln. "Prospects for Law and Order." In *Outer Space, Prospects for Man and Society*. Englewood Cliffs, NJ: Prentice-Hall, 1962.

Bobkov, Valentin. "Unknown Spacecraft." In *History of the Soviet Space Program*. In *What's New in Life, Science, and Technology: Space Program and Astronomy Series*, edited by I. B. Afanasyev. Moscow: JRPS-USP-92-003, 13 December, 1991.

Bowen, Lee. *An Air Force History of Space Activities, 1945-1959*. Washington, D.C.: USAF Historical Division Liaison Office, 1964.

------. *The Threshold of Space: The Air Force in the National Space Program, 1945-1959*. Washington, D.C.: USAF Historical Division Liaison Office, 1960.

Bright, Charles D. *The Jet Makers*. Lawrence KS: Regents Press of Kansas, 1978.

Bruce, Robert V. *Lincoln and the Tools of War*. Chicago IL: University of Illinois Press, 1989.

Builder, Carl H. *The Icarus Syndrome*. New Brunswick NJ: Transaction Publishers, 1994.

Bamford, James. *The Puzzle Palace*. Boston: Houghton Mifflin, 1982.

Burrows, William E. *Deep Black*. New York: Random House, 1986.

Cantwell, Gerald T. *The Air Force in Space, Fiscal Year 1963*. USAF Historical Division Liaison Office: GPO, 1966.

------. *The Air Force in Space, Fiscal Year 1964*. USAF Historical Liaison Office: GPO, 1967.

Clements, Walter C. *Outer Space and Arms Control*. Cambridge MA: MIT Press, 1966.

Covault, Craig. "USAF Plans Manned Military Exercises on Space Shuttle." *Aviation Week and Space Technology*, 4 January 1988, 38.

Crickmore, Paul. *Lockheed SR-71 Blackbird*. London, England: Osprey Publishing Limited, 1986.

Daniels, George H. "Science, Scientism, and Planned Progress: The Uses of Science in Progressive Ideology." In *Science in American Society, A Social History*, 288-315. New York: Knopf, 1971.

Dehaven, Ethal M. *The Evolution of USAF Weapons Acquisition Policy, 1945-1961.* Washington, D.C.: Air Force Systems Command Historical Study, 1962.

Dreyup, Felicia Johnson. *Arms Makers in the Connecticut Valley*. Northampton MA, 1948.

Dupree, A. Hunter. "The Great *Instauration* of 1940: The Organization of Research for War." In *Twentieth Century Sciences*, edited by Gerald Holton, 445-54. New York: Norton, 1972.

------. *Science in the Federal Government.* Cambridge MA: Belknap Press of Harvard University Press, 1957.

Friedman, Robert Marc. *Appropriating The Weather.* Ithaca NY: Cornell University Press, 1989.

Futrell, Robert F. *Ideas, Concepts, Doctrine: A History of Basic Thinking in the United States Air Force, 1907-1964.* Maxwell AFB AL: Air University Press, 1974.

Geiger, Clarence J. *History of the X-20 Dyna-Soar.* Wright-Patterson AFB OH: Air Force Systems Command, 1963.

------. *Termination of the X-20A Dyna-Soar.* Wright-Patterson AFB OH: Air Force Systems Command, 1964.

Gielhoed, E. Bruce. *Charles E. Wilson and Controversy at the Pentagon, 1953-1957.* Detroit, 1979.

Gorn, Michael H. *Harnessing the Genie: Science and Technology Forecasting for the Air Force, 1944-1986.* Washington, D.C.: Office of Air Force History, 1988.

------. *The Universal Man: Theodore von Kármán's Life in Aeronautics.* Washington, D.C.: Smithsonian Institution Press, 1992.

------. *Vulcan's Forge: The Making of an Air Force Command for Weapons Acquisition, 1950-1985.* Andrews AFB MD: Office of History, Air Force Systems Command, 1989.

Gray, George C. *Frontiers of Flight: The Story of NACA Research*. New York: Knopf, 1948.

Green, Constance M., and Milton Lomask. *Vanguard: A History*. Washington, D.C.: GPO, 1970.

Greenberg, Daniel S. *The Politics of Pure Science*. New York: New American Library, 1967.

Greene, Warren E. *The Development of the SM-68 Titan*. Norton AFB CA: Historical Office Deputy Commander for Aerospace Systems, 1962.

Greun, Adam. "History of the Space Station, 1923-1972," Chapter 5, "MOL." Unpublished Doctorial Dissertation. Washington, D.C., 26 April, 1989.

Griffith, Robert. "Dwight D. Eisenhower and the Corporate Wealth." *American Historical Review* 87 (February 1982): 87-122.

Hall, R. Cargill. "Early U.S. Satellite Proposals." In *The History of Rocket Technology*, edited by Eugene M. Emme, 69-93. Detroit: American Astronautical Society, 1964.

------. "Earth Satellites: A First Look by the U.S. Navy." In *History of Rocketry and Astronautics*. Vol. 7, Part 1 of *AAS History Series*, 253-79. San Diego CA: American Astronautical Society Publications, 1986.

Hallion, Richard P., editor. *The Hypersonic Revolution: Eight Case Studies in the History of Hypersonic Technology*. Vol. 1. Wright-Patterson AFB OH: Aeronautical Systems Division, 1987.

------. *On the Frontier: Flight Research at Dryden, 1946-1981*. Washington, D.C.: NASA, 1984.

------. "Saga of the Rocket Ships." *Air Enthusiast*, March-June 1978, 90-91.

Hanle, Paul A. *Bringing Aerodynamics to America*. Cambridge MA: MIT Press, 1982.

Hansen, James R. Book Review of Robert Marc Friedman, *Appropriating the Weather* (Ithaca NY: Cornell University Press, 1989). *Isis* 81, 2 (1990): 382-83.

------. *Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917-1958*. Washington, D.C.: NASA History Office, 1987.

------. *Spaceflight Revolution: NASA Langley Research Center, From Sputnik to Apollo.* Washington, D.C.: NASA History Office, 1995.

Hilsman, Roger. *To Move a Nation*. New York: Doubleday, 1964.

Hindle, Brook. *The Pursuit of Science in Revolutionary America, 1735-1789*. Chapel Hill NC: University of North Carolina Press, 1956.

Hintz, Marvin E. *Chronology of the Arnold Engineering Development Center.* Tullahoma TN: HQ Arnold Engineering Development Center Historical Office, No Date.

Houchin, Roy F., II. "A Unit History of the 94th Pursuit Squadron, 5 March 1917 to 5 May 1918, with Emphasis on the Importance of Technology." M.A. Thesis. Bowling Green KY: Western Kentucky University, 1981.

Houston, Robert S. *Development of the X-15 Research Aircraft, 1954-1959*. Vol. 3 of *History of Wright Air Development Center, 1958*. Wright-Patterson AFB OH: Office of Information Services, 1959.

Jordan, John. *Machine Age Ideology*. Chapel Hill NC: University of North Carolina Press, 1994.

Kaplan, Fred. *The Wizards of Armageddon*. New York: Simon and Schuster, 1983.

Karr, Erica M. "Father of Dyna-Soar Awaits Air Force Decision." *Missiles and Rockets*, 4 May 1959, 29-31.

Kaufmann, William W. *The McNamara Strategy*. New York: Harper & Row, 1971.

Kirpil, Anatoliy, and Olga Okara. "Designer of Space Planes: Vladimer Chelomey Dreamed of Creating a Space Fleet of Rocket Planes." *JPRS-USP-94-006*, 9 August 1994, 14-16.

Klass, Philip J. *Secret Sentries in Space*. New York: Random House, 1971.

Launius, Roger D, and Howard E. McCurdy. "Johnson, Project Apollo, and the Politics of Space Program Planning." Chapter 3 of "Presidential Leadership, False Hopes, and the Decline of the U.S. Space Program." Unpublished manuscript, 1995.

Ley, Wiley. *Rockets, Missiles, and Space Travel*. New York: Viking Press, 1961.

May, Ernest. *Lessons of the Past: The Use and Misuse of History in American Foreign Policy*. New York: Oxford University Press, 1973.

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

Misenko, Albert, and Philip H. Pollock. *Engineering History from McCook Field to the Aeronautical Systems Division*. Wright-Patterson AFB OH: OH/ASD, 1978.

Neufeld, Jacob. *The Development of Ballistic Missiles in the United States Air Force, 1945-1960*. Washington, D.C.: Office of Air Force History, 1990.

------. editor. *Reflections on Research and Development in the United States Air Force: An Interview with General Bernard A. Schriever and Generals Samuel C. Phillips, Robert T. Marsh, James H. Doolittle, and Dr. Ivan A. Getting*. Conducted by Dr. Richard H. Kohn. Washington, D.C.: Center for Air Force History, 1993.

Nevin, Allen. *Kennedy, The Strategy for Peace*. New York: New York Publishing, 1960.

Newkirk, Dennis. "Soviet Space Planes." *Spaceflight* 32 (October 1990): 350-55.

------. Unpublished file notes from various Soviet sources acquired by Newkirk after the publication of his 1990 Article. Material sent to the author in April 1994.

Ordway, Frederick I., and Mitchell R. Sharpe. *The Rocket Team*. New York: Thomas Y. Crowell Publishers, 1979.

Peebles, Curtis. *Guardians: Strategic Reconnaissance Satellites*. Novato CA: Presido Press, 1987.

------. "Project BOMI." *Spaceflight* 22 (July-August 1980): 270-72.

Perry, Robert L. *Origins of the USAF Space Program, 1945-1956*. Wright-Patterson AFB: Office of History, Air Force Systems Command, 1961.

Petrakov, V. M. "Two Projects of V. M. Myasishchev." *Journal of the British Interplanetary Society* 47 (September 1994): 345-92.

Prados, John. *The Soviet Estimate: U.S. Intelligence Analysis and Russian Military Strength*. New York: Dial Press, 1982.

Ranelagh, John. *The Agency: The Rise and Decline of the CIA from Wild Bill Donovan to William Casey*. New York: Simon and Schuster, 1986.

Reeves, Richard. *President Kennedy: Profile of Power*. New York: Simon and Schuster, 1993.

Roland, Alex. *Model Research: A History of the National Advisory Committee for Aeronautics, 1915-1958*. Washington, D.C.: NASA History Office, 1985.

------. *Underwater Warfare in the Age of Sail*. Bloomington IN: University of Indiana Press, 1978.

Rosenberg, David A. "American Atomic Strategy and the Hydrogen Bomb Decision." *Journal of American History* 66 (June 1979):68-84.

Rosenberg, Max. *The Air Force in Space, 1959-1960*. USAF Historical Division Liaison Office: Office of Air Force History, 1962.

Rudenko, Mikhail. "Star Wars: History of the 'Death' of a Unique Spaceplane." *JPRS-USP-93-005*, 5 October 1993, 32-34.

Schwiebert, Ernest G. *Air Force Response to the Soviet Threat*. Wright-Patterson AFB: ARDC, 1960.

------. *A History of USAF Ballistic Missiles*. New York: Praeger Press, 1965.

Self, Mary R. *History of the Development of Guided Missiles, 1946-1950*. Wright-Patterson AFB: Air Material Command Historical Study, 1951.

Shapley, Deborah. *Promise and Power: The Life and Times of Robert McNamara*. Boston: Little, Brown, and Company, 1993.

Sigethy, Robert. "The Air Force Organization for Basic Research, 1945-1970: A Study in Change." Ph.D. Dissertation. American University, 1980.

Smith, Bruce L. R. *The RAND Corporation*. Cambridge MA: Harvard University Press, 1966.

Smith, Merritt Roe. *Harpers Ferry Armory and the New Technology*. Ithaca NY: Cornell University Press, 1977.

Stanley, Capt. Dennis J, and Capt. John J. Weaver. *Air Force Command for R&D, 1949-1976*. Andrews AFB MD: AFSC Office of History, 1976.

Stares, Paul B. *The Militarization of Space: U.S. Policy 1945-1984*. New York: Cornell University Press, 1985.

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

Strum, Thomas A. *The USAF Scientific Advisory Board: Its First Twenty Years, 1944-1964*. Washington, D.C.: Office of Air Force History, 1986.

Susskind, Charles, and Arlene Inouye. "Technological Trends and National Policy, 1937: The First Modern Technology Assessment." *Technology and Culture* 18 (1977): 593-621.

Terry, Michael R. "Formulation of Aerospace Doctrine, 1955-59." *Air Power History* 38 (Spring 1991): 48-52.

Trewhitt, Henry L. *McNamara: His Ordeal in the Pentagon*. New York: Harper & Row, 1971.

Uyehara, C. H. "Dyna-Soar Antecedents." Unpublished Manuscript. OH/ASD: Wright-Patterson AFB OH, 1964.

Van Keuren, David K. "Science, Progressivism, and Military Preparedness: The Case for the Naval Research Laboratory, 1915-1923." *Technology and Culture* 33, 4 (1992): 711-36.

Vitelli, John, Captain. *The Start Program and The SV-5 Configuration*. Los Angeles CA: Satellite and Missile Systems Office, Office of Information, Historical Division [hereafter cited as SAMSO/HD], 1967.

Wagner, Frederick. *Submarine Fighter of the American Revolution*. New York: Dodd, Mead & Company, 1963.

Watson, George M. *The Office of the Secretary of the Air Force, 1947-1965*. Washington, D.C.: GPO, 1993.

Wattendorf, Frank L. *A Chronology of the Background and Early History of the Arnold Engineering Development Center, 1938-1949*. Tullahoma TN: Arnold Engineering Development Center, 1986.

Wolf, Richard I. *The United States Air Force: Basic Documents on Roles and Missions*. Washington, D.C.: GPO, 1987.

Woodbury, Robert J. "The Legend of Eli Whitney and the Interchangeability of Parts." *Technology and Culture* 1 (1960): 235-51.

Yergin, Daniel. *Shattered Peace: The Origins of the Cold War and National Security State*. Boston, 1977.