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(Narrative)

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HISTORY OF

THE X-20A DYNA-SOAR

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HISTORY OF

THE X-20A DYNA-SOAR

by

Clarence J. Geiger

Historical Division
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Aeronautical Systems Division

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October 1963

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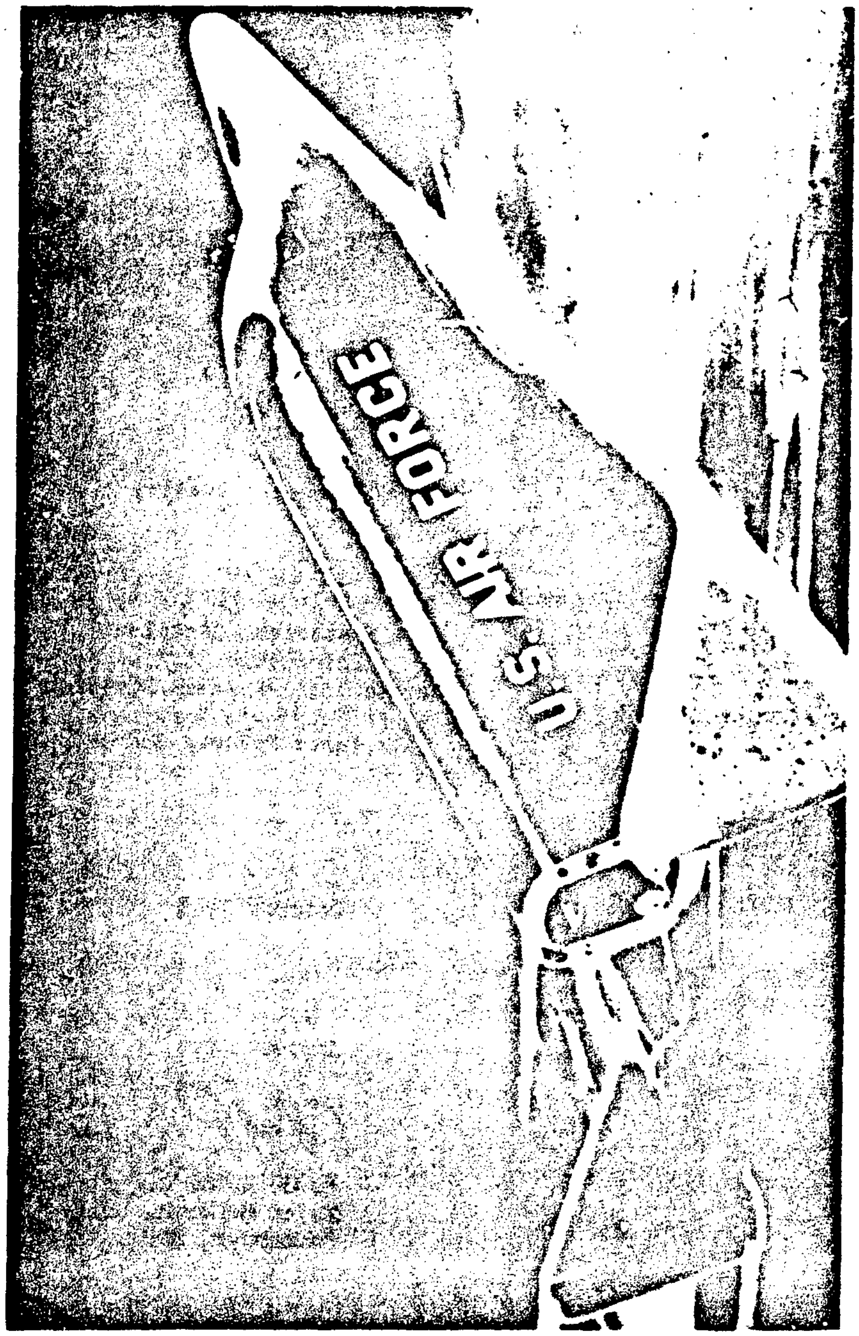

Frontispiece. The Dyna-Soar vehicle (artist's conception).

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Rather than offer a prolonged list of indebtedness, the author simply wishes to state his appreciation to the personnel of the Dyna-Soar System Program Office of the Aeronautical Systems Division. It is doubtful whether any other Air Force historian experienced such a high degree of cooperation as given by the Dyna-Soar office to this author. The task of accomplishing research in the files of a system program office certainly became a most pleasant and rewarding occasion. While responsibility for this history rests with the author, he would also like to thank his colleagues in the historical division for their immeasurable assistance in the preparation of this draft for publication.

September 1963 CLARENCE J. GEIGER

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CHRONOLOGY

1944	August		Drs. Eugen Sanger and Irene Bredt of the German air ministry completed their calculations for a manned, rocket bomber.
1945	January	24	The rocket development division of the German Army successfully launched, for the first time, an A-9 vehicle.
1946	May		RAND authorities determined that it was feasible to design a capsule with wings for manned space flight.
1952	April	17	The Bell Aircraft Company offered a proposal to the Wright Air Development Center for a manned bomber-missile, known as Bomi.
1954	April	1	The Air Force and the Bell Aircraft Company arranged a contract for the study of an advanced, bomber-reconnaissance weapon system.
1955	January	4	ARDC headquarters issued System Requirement 12, which called for studies of a reconnaissance aircraft or missile possessing a range of 3,000 nautical miles and capable of reaching 100,000 feet.
	May	12	Air Force headquarters announced General Operational Requirement 12 for a piloted, high-altitude, reconnaissance weapon system available by 1959.
	September	21	The Bomi contract of the Bell Aircraft Company was extended as a study for the Special Reconnaissance System 118P.
	December	19	The Air Force requested the aviation industry to investigate the feasibility of developing a manned, hypersonic, rocket-powered, bombardment and reconnaissance weapon system.
1956	March		The Research and Target Systems Division of ARDC headquarters completed an abbreviated development plan for a glide-rocket, research system, designated Hywards.
	March	20	The Air Force and Bell Aircraft Company completed negotiations for a study contract involving Reconnaissance System 459L, Brass Bell.

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1956	June	12	ARDC headquarters issued System Requirement 126, outlining the requirements for a rocket-bomber, named Robo.
	November	6	ARDC headquarters issued System Requirement 131, requesting information from Air Force agencies for the preparation of a Hywards abbreviated development plan.
1957		30	Air Force headquarters directed the Air Research and Development Command to formulate a development plan encompassing all hypersonic weapon systems.
	June	20	A committee, with representation from ARDC headquarters, the Wright Air Development Center, the Cambridge Air Force Research Center, and the Air Materiel Command, was formed to evaluate contractor studies on Robo.
	October	10	ARDC headquarters consolidated Hywards, Brass Bell, and Robo studies into a three-step abbreviated development plan for System 464L, Dyna-Soar.
	November	15	Air Force headquarters approved the abbreviated development plan for Dyna-Soar.
		25	Air Force headquarters issued Development Directive 94, which allocated $3 million of fiscal year 1958 funds for Dyna-Soar.
	December	21	ARDC headquarters issued System Development Directive 464L, directing the implementation of the Dyna-Soar program.
1958	May	20	The Air Force and the National Advisory Committee for Aeronautics signed an agreement for NACA participation in the Dyna-Soar program.
	June	16	The Air Force announced that the Boeing Airplane Company and the Martin Company had been chosen to compete, during a period of 12 to 18 months, for the Dyna-Soar contract.
	September	30	Air Force headquarters informed Detachment One of ARDC headquarters that the $10 million procurement fund for fiscal year 1959 had been canceled from the Dyna-Soar program.

[redacted]

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1958	November		The Dyna-Soar project office completed a preliminary development plan, involving a two-step program: the development of a research vehicle and then a weapon system.
1959	January	7	Deputy Secretary of Defense, D. A. Quarles reinstated the $10 million of fiscal year 1959 funds for the Dyna-Soar program.
	February	17	Air Force headquarters revised General Operational Requirement 12. Instead of a high-altitude reconnaissance system, ARDC was to develop a bombardment system.
	April	13	Dr. H. F. York, the Director of Defense for Research and Engineering, established the primary objective of the Dyna-Soar program as the suborbital exploration of hypersonic flight.
	May	7	ARDC headquarters issued System Requirement 201. The purpose of the Dyna-Soar vehicle was to determine the military potential of a boost-glide weapon system and provide research data on flight characteristics up to and including global flight.
	June		The Dyna-Soar source selection board completed its evaluation of the proposals of the Boeing Airplane Company and the Martin Company. The board recommended the development of the Boeing glider but also favored the employment of the orbital Titan C booster offered by Martin.
	November	1	In a development plan, the Dyna-Soar project office formulated a new three-step approach, involving the development of a suborbital glider, an orbital system, and an operational weapon system.
		9	The Secretary of the Air Force announced that the Boeing Airplane Company was the system contractor, while the Martin Company would be an associate contractor for booster development.
		24	Dr. J. V. Charyk, Assistant Secretary of the Air Force for Research and Development, directed a Phase Alpha study to determine the validity of the Dyna-Soar approach to manned, orbital flight.

[redacted]

1959	December	11	The Air Force and the Boeing Airplane Company completed contractual arrangements for the Phase Alpha study.
1960	January	27	The Vice Commander of the Wright Air Development Division directed the formation of an Air Force committee to evaluate the contractor studies for Phase Alpha.
	February	8	Lieutenant General B. A. Schriever, ARDC commander, and Lieutenant General S. E. Anderson, AMC commander, signed an agreement which delineated the responsibilities of BMD and AMC in the Dyna-Soar program.
	March		The Air Force committee concluded from the Phase Alpha study that a glider with medium lift-to-drag ratio, such as Dyna-Soar, would be the most feasible approach for an investigation of manned re-entry.
	April	1	The Dyna-Soar project office completed another development plan, detailing the three-step approach first offered in the November 1959 development plan.
		8	Professor C. D. Perkins, Assistant Secretary of the Air Force for Research and Development, approved the Phase Alpha results and the development plan and directed implementation of the suborbital Step I.
		11-14	The Air Force and the National Aeronautics and Space Administration held a joint conference at the Langley Research Center, Virginia, to provide industry and government agencies with a progress report concerning manned hypervelocity and re-entry vehicles.
		19	The Assistant Secretary of the Air Force for Materiel, P. B. Taylor, authorized the negotiation of fiscal year 1961 contracts for the Step I program.
		22	The Department of Defense endorsed the Dyna-Soar program and permitted the release of $16.2 million of fiscal year 1960 funds.
		27	The Air Force and the Boeing Airplane Company negotiated a letter contract for Step I of Dyna-Soar.

1960	June	8	The Air Force gave the Martin Company responsibility for the development of the Dyna-Soar booster airframe.
		9	The Air Force completed arrangements with the Aerospace Corporation to provide technical services for the Step I program.
		27	The Air Force authorized the Aero-Jet General Corporation to develop booster engines for the Dyna-Soar system.
	July	21	Air Force headquarters issued System Development Requirement 19, which sanctioned the three-step approach.
	August	4	ARDC headquarters directed that the conduct of flight testing be firmly placed in the control of the project offices.
	October	12	Air Force headquarters issued Development Directive 411, which gave approval to Step II and III studies.
			Air Force headquarters requested the project office formulate a "stand-by" plan for accelerating the orbital flight date of the Dyna-Soar program.
	November	28	The Assistant Secretary of the Air Force requested ARDC to examine the feasibility of employing Titan II instead of Titan I for Dyna-Soar suborbital flights.
	December		The Dyna-Soar office completed a "stand-by" plan which would accelerate the program by employing the same booster for both suborbital and orbital flights.
		6	ARDC headquarters issued a system study directive, which allotted $250,000 for a Step III study.
			The Air Force granted authority to the Minneapolis-Honeywell Regulator Company to develop the primary guidance subsystem.
		16	The Air Force completed negotiations with the Radio Corporation of America for the development of the communication and data link subsystem.

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1961 January 12 Air Force headquarters announced that Titan II would be the suborbital Step I booster.

February 3 Air Force headquarters informed the Dyna-Soar office that the fiscal year 1962 funding level had been set at $70 million.

14 The Air Force and the Boeing Airplane Company completed negotiations for Step IIA and IIB studies.

March 28 Air Force headquarters announced that the Department of Defense had decided to raise fiscal year 1962 funds for Dyna-Soar to $100 million.

April 24 Dr. J. V. Charyk, Under Secretary of the Air Force, authorized the negotiation of contracts for the entire Step I program.

26 The Dyna-Soar program office completed a system package program, further elaborating the three-step approach.

May 4 The Boeing Company offered a "streamline" approach for accelerating the Dyna-Soar program by the elimination of suborbital flights.

12 A Dyna-Soar technical evaluation board recommended the Martin C plan for a Step IIA booster.

29 The Space Systems Division completed two development plans for an Advanced Re-entry Technology program and a SAINT II program.

July 11 The Dyna-Soar Directorate of the Space Systems Division recommended employment of the Phoenix A388 space launch system for the Step IIA booster.

August The Dyna-Soar program was placed under the jurisdiction of the Designated Systems Management Group of Air Force Headquarters.

General B. A. Schriever, AFSC commander, directed a study for a Manned, Military, Space, Capability Vehicle.

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1961	September	11-22	Air Force and NASA officials conducted a mock-up inspection of the Dyna-Soar system at the Boeing Company facilities in Seattle, Washington.
		28	The Air Force completed the study of the Manned, Military, Space, Capability Vehicle.
	October	7	The Dyna-Soar program office completed an abbreviated development plan for a Dyna-Soar military system.
		13	The Department of Defense approved the Titan III as the space launch system for the Air Force.
	November	16	The Deputy Commander for Aerospace Systems completed a development plan for the Dyna-Soar program, which characterized the program as a manned, orbital research system.
	December	11	Air Force headquarters approved the November 1961 development plan.
		27	Air Force headquarters issued System Program Directive 4, which formalized the objectives of the November 1961 development plan.
1962	January	8	AFSC headquarters halted any further consideration of a Step III study.
		31	General B. A. Schriever, AFSC commander, rescinded the 4 August 1960 test policy and directed that Air Force test wings and centers prepare and implement test plans and appoint local test directors for the conduct of AFSC flight tests.
	February	21	Air Force headquarters amended System Development Requirement 19, by deleting referances to sub-orbital flight and the development of military subsystems.
		23	Secretary of Defense, Robert S. McNamara, officially limited the objective of the Dyna-Soar program to the development of an orbital, research system.

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1962	May	14	The Dyna-Soar program office completed a new system package program, which included multi-orbital flights.
	June	26	The Department of Defense officially designated the Dyna-Soar glider as the X-20.
		30	The Boeing Company completed the Step IIA and IIB studies at area 93
	July	13	Air Force headquarters informed ARDC headquarters that the Department of Defense had given qualified approval of the May 1962 system package program.
	October	10	The Dyna-Soar program completed a system package program, which made X-20 flight dates compatible with projected Titan IIIC schedules.
		15	Air Force headquarters issued System Program Directive 9, authorizing research and development of Titan III, System 624A.
		16	The function of the ASD Field Test Office was transferred to the 6555th Aerospace Test Wing of the Ballistic Systems Division.
	November		The Department of Defense set $130 million for fiscal year 1963 and $125 million for 1964 as the allotment for the Dyna-Soar program.
		5-7	The Dyna-Soar Symposium was held at Wright Field to insure dissemination of information to industry and government agencies concerning progress in Dyna-Soar technology.
		26	The X-20 office completed the "Westward-Ho" plan, which proposed consolidation of the flight control centers at Edwards Air Force Base.
	December	19	The Vice Commander of AFSC directed the establishment of a manned, space flight, review group to examine all aspects of the X-20 test program.
1963	January	11	The Dyna-Soar program completed a system package program, which incorporated the "Westward-Ho" proposal.

1963	January	18	The Secretary of Defense directed a review of the Dyna-Soar program.
		19	The Secretary of Defense directed a review of the Titan III program and the Gemini program of NASA.
		21	The Department of Defense and the National Aeronautics and Space Administration completed an agreement for defense department participation in the Gemini program.
	February	26	Headquarters of the Air Force Systems Command completed a position paper on the Dyna-Soar program, recommending continuation of the approved program.
	March	15	The Secretary of Defense directed the Air Force to conduct a comparison of the military potentials of Dyna-Soar and Gemini.
		30	Lieutenant General H. M. Estes, AFSC vice commander, forwarded four funding alternatives for the X-20 program to Air Force headquarters.
	April	12	USAF headquarters approved $130 million and $135 million as the most feasible funding level for the Dyna-Soar program in fiscal years 1963 and 1964.
	May	9	General Schriever assigned responsibility for X-20 orbital test direction to the Space Systems Division and placed the flight control center at Satellite Test Center, Sunnyvale, California.
		10	Officials of the Space Systems Division and the Aeronautical Systems Division completed their joint response to Secretary McNamara's request for the military potentialities of Dyna-Soar and Gemini.
		22	Lieutenant General O. J. Ritland, Deputy to the Commander for Manned Space Flight, AFSC headquarters, forwarded the X-20 and Gemini comparison to Air Force headquarters with the recommendation that the Dyna-Soar program be continued.

1963	May	27	Based on an anticipated funding level of $130 million for fiscal year 1963 and $135 million for 1964, the Dyna-Soar office completed a system package program which acknowledged a two month delay in the flight schedules.
	June	8	The Secretary of the Air Force approved the 27 May system package program.
	July	3	AFSC headquarters informed the X-20 office that the Department of Defense would only allow $125 million for fiscal year 1964.
		31	General Schriever assigned responsibility for X-20 air-launch program and pilot training to the Space Systems Division.

CHAPTER I

SEVEN FROM PEENEMUNDE

By March 1945, the Allies had overrun the possible launching areas for the A-4 rocket, commonly known as the V-2. Germany had been denied further employment of its more advanced vengeance weapon. Awaiting the end and under military guard, Lieutenant General Walter R. Dornberger, director of guided missile development for the German ministry of munitions, retired on 6 April with his Peenemunde band of rocket experts to the recesses of southern Germany. The A-4 had prematurely reached operational status in September 1944, and nearly 3,000 missiles were fired against targets. Further development of this and other advanced rocket weapons, however, was hopeless.[1] While employed too late to alter the apparent outcome of the war, the A-4 not only radically changed the concept of weapon delivery but offered the promise of rapidly extending the speed, range, and altitude of manned flight.

The first application of the A-4 rocket engine, capable of delivering over 50,000 pounds of thrust, to the problem of extending the regime of piloted flight was the formulation of the boost-glide concept. Here, a winged-vehicle would be propelled by a rocket booster to a sufficient altitude where, after fuel in the rocket stages had been expended, the craft would perform a gliding flight and then execute a conventional landing. The first intense effort at the refinement of this concept began in 1943, under the direction of General Dornberger, at the German Army's research facilities in the east sector of Peenemunde.

Dr. Wernher von Braun, Dornberger's assistant in charge of planning and design, reasoned that by merely attaching wings to the A-4 airframe, the range of this vehicle, now designated the A-9, could be extended from 230 to 360 miles. The director of preliminary planning went further and considered the possibility of placing the A-9 vehicle on a proposed A-10 booster, capable of producing 440,000 pounds of thrust and accelerating the craft to a velocity of 4,000 feet per second. With this arrangement, the A-9 could traverse a distance of 3,000 miles in 17 minutes. Further in the future, the rocket expert planned a multi-stage engine which could boost the A-9 to orbital velocities.

By mid-1943, preliminary designs had been completed, trajectories calculated, guidance systems investigated, and wind tunnel data gathered for the development of the A-9. Priority, however, demanded full effort on the A-4, and General Dornberger halted the work on the A-9. Late in 1944, greater range for the A-4 was demanded and development of the A-9 was resumed. After two unsuccessful launchings, this advanced vehicle reached a height of 50 miles and a speed of 4,000 feet per second on 24 January 1945.[2]

Independent of the Peenemunde group, Dr. Eugen Sanger and his assistant, Dr. Irene Bredt, were pursuing similar investigations for the German air ministry's Research Establishment for Gliders. By August 1944, they had completed their elaborate calculations for a manned, rocket bomber. The winged-rocket was to have a length of 92 feet, a span of 50 feet, and a takeoff weight of 110 tons. Unlike von Braun, Sanger preferred horizontal launch. For 11 seconds, a rocket sled would propel the bomber along tracks, two miles in length, until a takeoff velocity of 1,640 feet per second was attained. Under power of its own rocket engine, the vehicle would then climb to an altitude varying from 30 to 60 miles. At the end of ascent, the bomber would proceed in an oscillating, gliding flight, conceivably circumnavigating the Earth.

Sanger was intent on explaining the military value of his proposed system and detailed possible modes of attack. To achieve a strike on a specific point, the vehicle would be accelerated only until it acquired enough velocity to reach the target. After releasing its bomb, the vehicle would turn at the lowest possible speed, ignite its engine, and then return to its original base. For greater distances and bomb loads, the possession of an auxiliary landing site near the target was necessary. If such a site were not available, the rocket bomber would have to be sacrificed. An attack on a larger area, however, did not necessitate a low velocity over the target, and, consequently, there was more likelihood that the bomber could circumnavigate the globe.

The drawbacks to Sanger's proposal were obvious, and, consequently, the German military did not give serious consideration to the rocket bomber. The difficulties inherent in turning the rocket bomber at hypersonic speeds only increased the desirability for an antipodal landing site. To depend on the possibility of possessing friendly landing areas so near a target was unrealistic. Even if a fleet of rocket bombers could circle the Earth, a bomb capacity of about 8,000 pounds per vehicle, as estimated by Sanger, could not have changed the course of conflict.[3]

Apparently Russian military officials obtained copies of Sanger's analysis at the end of the war and became interested in the possibilities of boost-glide flight. In 1958, an article which appeared in a Soviet aviation journal referred to a Russian glide-bombing system, capable of attaining an altitude of 295,000 feet and striking a target at a distance of 3,500 nautical miles. Later, an American aviation periodical reported that Russian scientists were developing an antipodal, glide-missile, designated the T-4A. By March 1960, the Assistant Chief of Staff for Intelligence, USAF headquarters, estimated that the Soviets were at least conducting research directed towards the development of a boost-glide vehicle. Such a system could lead to the development of a craft capable of performing reconnaissance and bombing missions. Air Force intelligence analysts believed that limited flight tests of the manned stage could begin in 1962 and an operational system could be available by 1967.[4]

Soon after the war, American military officials also exhibited interest in the possibilities of a boost-glide vehicle. In 1946, the Army Air Force, under a contract with the Douglas Aircraft Company, sheltered a group of American scientists and specialists in various social science areas in an effort to provide analyses and recommendations relating to air warfare. One of the first studies completed under the new Project RAND centered on the design of an orbital vehicle.

Basing their analysis on the technological developments of the Peenemunde scientists, RAND experts considered that it was possible, by employing either a four-stage, alcohol-oxygen, or a three-stage, hydrogen-oxygen booster, to place a 500 pound capsule in orbit at an altitude of 300 miles. The initial objective was to provide an orbiting, scientific laboratory, nevertheless, RAND authorities stated that it was feasible to design a capsule with wings for future manned flight.[5] In 1948, RAND made a few more studies investigating the technological difficulties involved in flight beyond the atmosphere; however, the next step was taken by the Bell Aircraft Company.

Dr. von Braun did not become associated with any American efforts in refining the boost-glide concept but, from 1945 through 1950, served as a technical adviser for the Army Ordnance Department at the White Sands Proving Grounds, New Mexico. Dornberger, on the other hand, was held in England until 1947 when he became a consultant on guided missiles for the Air Materiel Command at Wright-Patterson Air Force Base, Ohio. In 1950, he left the Air Force and became a consultant for Bell Aircraft.

Perhaps the German missile expert was influential in persuading this contractor to undertake a study of boost-glide technology, for, on 17 April 1952, Bell officials approached the Wright Air Development Center (WADC) with a proposal for a manned bomber-missile, abbreviated to Bomi. Bell's glide-vehicle was to be boosted by a two-stage rocket and was to be capable of operating at altitudes above 100,000 feet, at speeds over mach 4.0, and at a range of 3,000 nautical miles. A month later, Bell submitted a proposal to Wright center for the initiation of a feasibility study. The contractor believed that the study would cost $398,459 and would take 12 months.[6]

By 28 November, the Air Research and Development Command (ARDC) headquarters had completed a review of the Bomi project. While Bell's proposal duplicated parts of the Atlas intercontinental ballistic missile and the Feedback satellite reconnaissance programs, command headquarters considered that some phases of Bomi would advance the Air Force's technical knowledge. Consequently, ARDC headquarters requested WADC to evaluate the proposal with the view of utilizing the concept both as a manned bomber and as a reconnaissance vehicle.[7]

Wright center officials completed their evaluation by 10 April 1953 and listed several reasons for not accepting the Bell proposal. A range of 3,000 nautical miles was too short for intercontinental operations. It was difficult to conceive how the vehicle could be adequately cooled, nor was there sufficient information concerning stability, control, and aeroelasticity at the proposed speeds. Furthermore, Bell's estimated lift-to-drag ratio was far too optimistic. Since it was to operate under an extreme environment, there was also the question of the value of providing a piloted vehicle. Before undertaking such a project, Wright engineers emphasized that the cost and military worth of such a system first had to be established. Center officials added that some doubt existed concerning the ability of the contractor to complete the program successfully.[8]

Bell Aircraft, however, was persistent, and, on 22 September, its representatives briefed ARDC headquarters on the Bomi strategic weapon system. Brigadier General F. B. Wood, Deputy Chief of Staff for Development, did think the proposal "somewhat radical" but stated that it could not be considered "outside the realm of possibilities." General Wood then requested WADC to give further consideration to Bell's proposal.[9] Apparently, Wright center officials reconsidered their first evaluation of Bomi, for, in their reply to ARDC headquarters on 23 November, they assumed a more favorable position.

Wright engineers considered that the Atlas ballistic missile and the Navaho cruise missile programs offered more promise of successful development than Bomi. The Bell proposal, however, appeared to present a reconnaissance ability far in advance of the Feedback program. Furthermore, Wright officials reasoned that the Bomi vehicle would provide a test craft for several unexplored flight regimes and would offer a guide for the development of manned, hypersonic, military systems. Because of the lack of information, Wright authorities did not recommend the the initiation of development but thought that the potential reconnaissance value of Bomi necessitated a two-year study program. Specifically, Wright officials recommended that Bell be offered a $250,000 contract for one year with the possibility of extending the study for an additional year. This investigation should determine whether the piloted, Bomi vehicle was more advantageous than an unmanned version and whether a reconnaissance mission would compromise the strategic striking ability of the system.[10]

[redacted]

ARDC headquarters agreed and approved Wright center's recommendation. Brigadier General L. I. Davis, acting Deputy Chief of Staff for Development, emphasized that the strategic requirements for an intercontinental vehicle, with a range up to 25,000 nautical miles, should be considered. General Davis stated that development of a program such as Bomi would not be undertaken until other contractors could offer competitive concepts. In accordance, the acting deputy chief of staff requested that the Boeing Airplane Company include in its efforts for Project MX-2145 (Design Studies for an Advanced Strategic Weapon System) investigations of a manned, glide-rocket system.[11]

Boeing had undertaken MX-2145 in May 1953 in order to determine the characteristics of a high performance bomber which could succeed the B-58 Hustler and be capable of delivering nuclear weapons over intercontinental ranges by 1960. Later, as directed by ARDC headquarters, Boeing briefly considered the possibility of a manned, reconnaissance glide-rocket. The contractor regarded the method of traveling an intermediate distance and then reversing direction to return to the point of origin as impractical. Rather, Boeing emphasized that it would be more feasible to orbit the Earth. The contractor, however, pointed to the difficulties of devising structures to withstand high temperature and equipment for reconnaissance. Yet, because of the military potential of such a system, the contractor thought that further investigations were indicated.[12]

On 1 April 1954, Wright center completed a contract with the Bell Aircraft Corporation for a design study of an advanced, bomber-reconnaissance

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weapon system. The contractor was to define the various problem areas and detail the requirements for future programs. Bell had to focus on such problems as the necessity for a manned vehicle, the profiles of possible missions, performance at high temperatures, and the feasibility of various guidance systems.[13]

Bell Aircraft now envisaged a three-stage system, with each stage riding pickaback. This system would total more than 800,000 pounds. Bomi, now designated as MX-2276, would be launched vertically, and the three rocket engines would be fired simultaneously, delivering 1.2 million pounds of thrust. Bell proposed manning the booster stage in order to achieve recovery by use of aerodynamic surfaces. The third-stage would also be piloted and would carry navigation, reconnaissance, and bombardment equipment. Bomi would be capable of reaching an altitude of 259,000 feet, attaining a speed of 22,000 feet per second, and possessing a range of 10,600 nautical miles

The contractor believed that a piloted system such as Bomi held several advantages over an unmanned version. Reliability of the system would be increased, bombing precision augmented, and reconnaissance information easily recovered. Furthermore, operational flexibility would be enhanced with the possibility of selecting alternate targets. Unmanned instrumentation certainly could not provide for all the necessary contingencies.[14]

With the completion of the initial study in May 1955, the contract expired, but Bell continued its efforts without government funds or direction. On 1 June, WADC personnel discussed with the contractor the possibility of officially extending its work. The purpose of the Air Force in considering an extension was to investigate the feasibility of adapting the Bomi concept to Special Reconnaissance System 118P.

On 4 January 1955, ARDC headquarters had issued System Requirement 12, which called for studies of a reconnaissance aircraft or missile possessing a range of 3,000 nautical miles and an operational altitude of more than 100,000 feet. Wright center officials established System 118P, and several contractors investigated the adaptability of boost-glide rockets and vehicles using air-breathing engines to the system requirement. To bring Bell into these efforts, ARDC headquarters gave assurance, in June, that $125,000 would be released for the purpose of extending Bell's Bomi contract, and by 21 September 1955, contract negotiations were completed. Bell's efforts would continue.[15]

At the request of the Assistant Secretary of the Air Force for Research and Development, Trevor Gardner, personnel from the Bombardment Aircraft Division of ARDC headquarters and Bell Aircraft gave several presentations to ARDC and USAF headquarters in November, where the Bomi concept was received with approval.[16]* Meanwhile, officials from the laboratories of Wright center, the laboratories of the National Advisory Committee for Aeronautics (NACA), and the Directorate of Weapon Systems in ARDC headquarters had evaluated the results of the Bomi study and had drawn several conclusions.

*On 1 August 1955, the management of weapon system development was transferred from the Wright Air Development Center to ARDC headquarters. Detachment One of the Directorate of Systems Management, which included the Bombardment Aircraft Division, however, was located at Wright-Patterson Air Force Base.

Representatives from the three organizations thought that Bell's concept was theoretically practicable and promising, and that the Bomi program should be continued to determine the feasibility of such a weapon system. Emphasis, however, should be placed on a test program to validate Bell's analysis. The members considered that the most advantageous procedure for Bomi would be a three-step program with the development of a 5,000 nautical mile, a 10,000 nautical mile, and a global system.[17]

By 1 December 1955, Bell had completed its final engineering report for the supplementary contract and had expended a total of $420,000 for the Bomi studies. For System 118P, Bell's design had included a two-stage rocket to boost a vehicle to 165,000 feet at a velocity of mach 15. The contractor, however, was once again out of funds. Brigadier General H. M. Estes, Jr., Assistant Deputy Commander for Weapon Systems, ARDC headquarters, estimated that about $4 million more would be required for the next 12 to 18 months. General Estes then requested the Deputy Commander for Weapon Systems at ARDC headquarters to allocate $1 million for fiscal year 1956 and to grant authority for the continuation of the program.[18]

While the question of future funding was being debated, officials from the New Development Weapon Systems Office of ARDC headquarters and Bell Aircraft visited Langley Air Force Base, Virginia, in December 1955, to obtain the views of NACA on the Bomi concept. The advisory committee had first become interested in the boost-glide concept when it undertook a preliminary study in 1953 to determine the feasibility of manned, hypersonic flight. On 30 September 1955, Dr. I. H. Abbott, Assistant

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Director for Research, NACA, thought that more data was required before a development program could be initiated for Bomi. Dr. Abbott hoped that the Air Force would continue to inform NACA on the future progress of the program in order that its laboratories could contribute to the research program. The conference in December resulted in an invitation to NACA for participation in the validation testing for Bomi.[19]

Early in January 1956, the Intelligence and Reconnaissance Division of ARDC headquarters informed the New Development Weapon Systems Office that $800,000 had been allocated for continuation of Bomi. The Air Force, however, considered that the Bell program should now be directed towards the fulfillment of the General Operational Requirement 12, which had been issued on 12 May 1955. This directive called for a piloted, high-altitude, reconnaissance weapon system which was to be available by 1959. Accordingly, the Air Force concluded a contract with Bell on 20 March 1956, totaling $746,500, for Reconnaissance System 459L, commonly known as Brass Bell. In October, the contract was extended to 31 August 1957, bringing total expenditures to approximately $1 million. Later in 1956, Bell was awarded an additional $200,000 and four more months to complete its work.[20]

By December 1956, Bell Aircraft had conceived of a manned, two-stage system which would be propelled over 5,500 nautical miles at a velocity of 18,000 feet per second to an altitude of 170,000 feet by Atlas thrust chambers. With the addition of another stage, Bell engineers reasoned that the range could be extended to 10,000 nautical miles with a maximum speed of 22,000 feet per second.[21]

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While the Air Force had channeled Bell's work towards the eventual development of a boost-glide, reconnaissance system, it had not abandoned the application of this concept to the development of a bombardment vehicle. On 19 December 1955, the Air Force had sent a request to the aircraft industry for a study which would incorporate analytical investigations, proposed test programs, and design approaches for a manned, hypersonic, rocket-powered, bombardment and reconnaissance weapon system. Boeing, the Republic Aircraft Company, the McDonnell Aircraft Corporation, the Convair Division of the General Dynamics Corporation, Douglas, and North American Aviation responded to the request. Study contracts, amounting to $860,000 were awarded to the latter three for investigations extending from May through December 1956. Later, the Martin Company, Lockheed Aircraft, and Bell joined in the study. By the end of fiscal year 1957, an additional $3.2 million was expended by Boeing, Convair, North American, Republic, Douglas, and Bell from their own funds.[22]

On 12 June 1956, ARDC headquarters outlined the conditions for the rocket-bomber study, now designated as Robo, in its System Requirement 126. The purpose of the study was to determine the feasibility of a manned, hypersonic, bombardment and reconnaissance system for intercontinental operation by 1965. The main requirement of the proposed system was the ability to circumnavigate the globe and yet operate at a minimum altitude of 100,000 feet. Furthermore, the vehicle would not only have to perform strategic strike missions but, in addition, fulfill a reconnaissance role. The contractors would also have to determine the effects of carrying weapons, ranging in weight from 1,500 to 25,000 pounds, on vehicle design and investigate the feasibility of launching air-to-surface missiles.[23]

The importance of advanced systems such as Brass Bell and Robo was given added emphasis by ARDC commander, Lieutenant General T. S. Power, at his conference on "radical" configurations, held on 15 February 1956. General Power stated that the Air Force should stop considering new and novel configurations and should start developing them. Speeds to any conceivable extent and operation of manned, ballistic rockets beyond the atmosphere should be investigated.[24]

Encouraged by General Power's statement, Major G. D. Colchagoff of the Research and Target Systems Division, ARDC headquarters, considered that one of the promising proposed programs was the manned, glide-rocket, research system. This was to be a vehicle similar to Brass Bell and Robo and would be used to obtain scientific data rather than to fulfill a military role. The research and target division prepared an abbreviated development plan for the test system and submitted it to Air Force headquarters in March. On 29 June, headquarters approved the proposal but requested a full development plan.[25] Research and target managers, however, had already encountered funding difficulties.

In April 1956, the research and target division had estimated that $4 million was required for the manned glide-rocket, and a total of $33.7 million was needed for the research-vehicle programs, which included the X-13, the X-14, the XB-47D, the X-15, and a vertical-takeoff-and-landing (VTOL) aircraft. Air Force headquarters, however, had set a ceiling of $8.5 million for all of these programs. The research and target division then undertook negotiations with the Air Materiel Command to determine a method of funding to alleviate this deficiency. If this attempt failed, the division warned USAF headquarters that the Air Force would not have a research-vehicle program.[26]

Air Force headquarters, however, drastically reduced the budget for fiscal year 1957, allocating no funds for the manned glide-rocket. General Power warned that this reduction would postpone his bold research program for at least one year. He cautioned headquarters that this action would seriously jeopardize America's qualitative lead over Russia.[27]

In spite of inadequate funding, ARDC issued System Requirement 131 on 6 November 1956, which requested information from the ARDC director of systems management, Wright center, the flight test center and the Cambridge research center for the preparation of an abbreviated system development plan. The manned, glide-rocket, research program was now titled Hypersonic Weapons Research and Development Supporting System (Hywards) and was classified as System 455L. By 28 December, the ARDC Directorate of Systems Plans had completed a development plan for Hywards.[28]

The purpose of the Hywards vehicle was to provide research data on aerodynamic, structural, human factor, and component problems and was to serve as a test craft for development of subsystems to be employed in future boost-glide systems. The research and target division considered three propulsion choices as satisfactory for boosting Hywards. The 35,000 pound thrust chambers, employing fluorine-ammonia fuel, which Bell had under development, was one possibility. The 55,500 and 60,000 pound thrust sustainer engines for the Atlas and Titan systems comprised another. The 50,000 pound thrust XLR-99 engine, employed in the X-15 vehicle, was the third option. One of these rocket systems would propel the Hywards craft to a velocity of 12,000 feet per second and an altitude of 360,000 feet. The initial flight test program was to employ the air-drop technique, similar to the X-15 launch, while later testing would use a rocket-boosted, ground-launch method. The research and target division emphasized that by appropriate modifications to Hywards, increased velocities and orbital flight could be attained to provide continuing test support for the Air Force's technological advances.[29]

On 27 February 1957, the development plans for both Hywards and Brass Bell were presented to USAF headquarters, where it was decided that the two programs were complementary, and, therefore, should be consolidated. Funding, however, proved more difficult. For fiscal year 1958, ARDC headquarters had requested $5 million for Hywards and $4.5 million for Brass Bell. Air Force headquarters, however, reduced these requests to a total of $5.5 million. Lieutenant General D. L. Putt, Deputy Chief of Staff for Development, USAF headquarters, hesitated endorsing the boost-glide programs. The lack of Air Force funds necessitated giving priority to the advanced satellite reconnaissance system, 117L, rather than to Hywards or Brass Bell. Furthermore, the X-15 program would provide a more dependable source of research data than the boost-glide programs. Major General R. P. Swofford, Director of Research and Development, USAF headquarters, did recommend that $1 million be allocated for the boost-glide systems, but, on 30 April, Air Force headquarters informed ARDC headquarters that the two development plans were disapproved and that a new plan, encompassing all hypersonic weapon systems, should be prepared. 30

Pefore the new development plan for Brass Bell and Hywards was completed, additional investigations for the Robo program were accomplished. On 20 June 1957, an ad hoc committee, consisting of representatives from ARDC headquarters, Wright Air Development Center, the Cambridge Air Force Research Center, and the Air Materiel Command, was formed to evaluate the Robo studies of the contractors. Advisory personnel from the Strategic Air Command, the National Advisory Committee for Aeronautics, and the Office of Scientific Research were also present.

During the first three days of the conference, the contractors working on System Requirement 126 presented their proposals, most of which centered on the feasibility of manned vehicles. Both Bell and Douglas favored a three-stage, boost-glide vehicle, the former employing fluorine and the latter, an oxygen propellant. The Convair Division also proposed a three-stage system, using fluorine fuel, but its concept differed from the previous two in that a control rocket and turbojet engine were placed in the glider. While North American advanced a two-stage vehicle, using conventional rocket fuel, Republic advocated an unmanned vehicle, powered by a hypersonic cruise, ramjet engine, and boosted by a single-stage rocket. Republic's proposal also involved an unmanned, satellite, guidance station, which was to be placed in orbit by a three-stage booster. Finally, Boeing favored an unmanned version and advanced an intercontinental glide-missile. In the opinion of Boeing officials, a manned vehicle would involve a longer development cycle and would not possess any great advantage over a missile.

After the presentation of the contractors' proposals, the committee spent the next two days evaluating the concepts. While Wright officials thought that the boost-glide concept was feasible and would offer the promise of an operational weapon system by 1970, they also pointed to several problems confronting the Air Force. The details of configuration design were yet unknown. The status of research in the area of materials was not sufficiently advanced. Lack of hypersonic test facilities would delay ramjet development until 1962. Rocket engines were not reliable enough to allow an adequate safety factor for manned vehicles during launch. Finally, center officials pointed to the difficulty of providing a suitable physiological environment for a piloted craft.

Officials of the Cambridge Research Center focused on a different set of problems. All the proposals employed an inertial, autonavigating system, and Cambridge officials pointed out that these systems required detailed gravitational and geodetical information in order to strike a target accurately. The effect of the Earth's rotational motion became extremely important at hypersonic speeds, and, consequently, this factor would have to be considered in determining the accuracy of the guidance systems. Research center scientists also emphasized that an ion sheath would be created as the vehicle penetrated the atmosphere during re-entry; this phenomenon would hinder communication. There were other difficulties that required investigation. The thermal properties of the atmosphere would have to be studied in order to determine the extent of aerodynamic heating. Adequate data on the effect of wind turbulence and the impact of meteor dust on the vehicle would have to be determined. Officials of the Cambridge center added one more problem: the presence of ionization trails, infrared radiation, and vehicle contrails could facilitate hostile detection of the vehicle.

It was apparent to the representatives of the Air Materiel Command that the development of either a manned or unmanned system would be feasible only with increased and coordinated efforts of six to eight years of basic research. More detailed knowledge was required of the system design in order that a determination could be made of various logistical problems and the complexity of the launching area. Viewing the development costs for the ballistic missile programs, materiel officials estimated that the cost for Robo would be extremely high. In order that the Robo program could be continued, air materiel officials recommended that the participating contractors be given specific research projects. A contracting source for the conceptual vehicle should then be chosen, and, after approximately six years, competition for the weapon system development should be held.

After surveying the contractors' proposals and the analyses of Wright center, the materiel command, and the Cambridge center, the ad hoc committee concluded that a boost-glide weapon system was technically feasible, in spite of the numerous problems inherent in the development of such a system. With moderate funding, an experimental vehicle could be tested in 1965, a glide-missile in 1968, and Robo in 1974. The committee emphasized that the promise of boost-glide vehicles to be employed either for scientific research or as weapon systems was necessity enough for the undertaking. The members of the committee went beyond the scope of the Robo proposals and recommended that ARDC headquarters submit a preliminary development plan to USAF headquarters, covering the entire complex of boost-glide vehicles.[31]

By 10 October 1957, the Director of Systems Plans, ARDC headquarters, had completed consolidating the details of the Hywards, Brass Bell, and Robo programs into a three-step, abbreviated, development plan for the new Dyna-Soar (a compound of dynamic soaring) program. Like Hywards, the first phase of System 464L involved the development of a manned, hypersonic, test vehicle which would obtain data in a flight regime significantly beyond the reach of the X-15 and would provide a means to evaluate military subsystems. To avoid further confusion between the purpose of Dyna-Soar and the X-15 vehicle, the directorate made a clear distinction between a research vehicle and a conceptual test vehicle. Both vehicles were designed to obtain flight data in a regime which had not been sufficiently well defined; however, the latter was to obtain information for the development of a specific system. The initial objectives of the Step I vehicle would be a speed of approximately 18,000 feet per second and altitudes of 350,000 feet and would be attained by use of one of the three engines considered for Hywards.

The Brass Bell program assumed the position of Step II in the Dyna-Soar plan. A two-stage rocket booster would propel the reconnaissance vehicle to a speed of 18,000 feet per second and an altitude of about 170,000 feet. The vehicle would then glide over a range of 5,000 nautical miles. The system would have to be capable of providing high quality photographic, radar, and intelligence information. The vehicle would also have to possess the ability of performing strategic bombing missions. The Director of Systems Plans considered that the liquid rocket Titan sustainer appeared usable; however, investigations under Step I could prove the fluorine engine more valuable.

Step III incorporated the Robo plans, and encompassed a more sophisticated vehicle which would be boosted to 300,000 feet and 25,000 feet per second and would be capable of orbital flight. Like the earlier phase, this vehicle would be able to execute bombardment or reconnaissance missions.

Because of insufficient data, the directorate reasoned that the Dyna-Soar program could not be immediately initiated. A two-phase program for preliminary investigations had to come first. Phase one would involve validation of various assumptions, theory, and data gathered from previous boost-glide studies, provide design data, and determine the optimum flight profile for the conceptual vehicle. The second part would refine vehicle design, establish performance, and define subsystems and research instrumentation. While this two-phase preliminary program would consume 12 to 18 months, preliminary studies for the Brass Bell and Robo phases of Dyna-Soar could be started. Following this procedure, flight testing at near satellite speeds for the conceptual test vehicle would begin in 1966. The estimated operational date for Dyna-Soar II was set in 1969, and for Dyna-Soar III in 1974.

The Director of Systems Plans argued that the hypersonic, boost-glide vehicle offered a considerable extension of speed, range, and altitude over conventional Air Force systems. Furthermore, this concept represented a major step towards manned, space flight. It could not be safely assumed, the systems plans directorate reasoned, that the intercontinental ballistic missile would destroy all the required targets in the decade of the 1970's. Difficulties in penetrating hostile territory by air-breathing vehicles further enhanced the necessity for a manned, boost-glide vehicle. Additionally, the proposed reconnaissance ability of Dyna-Soar could provide more detailed and accurate intelligence data than other Air Force reconnaissance systems then under development. The director warned that time could not be economically bought. If the boost-glide weapon system were necessary, it was imperative to initiate the Dyna-Soar program by allowing a funding level of $3 million for fiscal year 1958.[32]

On 17 October 1957, Lieutenant Colonel C. G. Strathy of the Research and Target Systems Division presented the Dyna-Soar plan to Air Force headquarters. Brigadier General D. Z. Zimmerman, Deputy Director of Development

Planning, USAF headquarters, gave enthusiastic endorsement but thought that ARDC headquarters should take a more courageous approach. Command headquarters, he stated, should immediately consider what could be accomplished with greater funding than had been requested. Also present at the briefing was Dr. J. W. Crowley, Associate Director for Research of NACA. He pointed out that the national advisory committee was strongly in favor of initiating the conceptual vehicle program as a logical extension of the X-15 program. He emphasized that his organization was directing its research towards the refinement of the boost-glide concept and was planning new facilities for future research.[33]

Brigadier General H. A. Boushey, Deputy Director of Research and Development, USAF headquarters, informed ARDC headquarters, on 15 November, that the Dyna-Soar abbreviated development plan had been approved. General Boushey's office then issued, on 25 November, Development Directive 94, which allocated $3 million of fiscal year 1958 funds for the hypersonic, glide-rocket weapon system. The boost-glide concept offered the promise of a rapid extension of the manned flight regime, and, following General Zimmerman's reasoning, the deputy director stated that the philosophy of minimum risk and minimum rate of expenditure must be abandoned. If the concept appeared feasible after expenditure of fiscal year 1958 and 1959 funds, the boost-glide program should definitely be accelerated. Not certain of the feasibility of piloted flight, Air Force headquarters directed that the study of manned and unmanned reconnaissance and bombardment weapon systems should be pursued with equal determination. A decision on whether the vehicle was to be piloted would be made in the future and based on substantial analysis. Finally, USAF headquarters stressed that the only objective of the conceptual test vehicle was to obtain data on the boost-glide flight regime. Early and clear test results from this system must be obtained.[34]

While Dr. Sanger had elaborated the theoretical foundation, Dornberger's Peenemunde group demonstrated the practicability of boost-glide flight by launching a winged-precursor, the A-9. The Air Force, however, refined the concept with the Bomi, Brass Bell, Robo, and Hywards study programs. These steps advanced the proposal towards a clearly delineated development program for an orbital, military vehicle—Dyna-Soar.

CHAPTER I

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CHAPTER II

SYSTEM 464L

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. During the existence of System 464L, however, officials in the Department of Defense subjected the program to severe criticism. The necessity of orbital flight and the feasibility of a boost-glide weapon system were points frequently questioned. By November 1959, the project office had to undertake an exacting investigation of the Dyna-Soar approach to manned, space flight. Certainty of program objectives had momentarily disappeared.

On 21 December 1957, ARDC headquarters issued System Development Directive 464L, which stipulated that the mission of the conceptual test vehicle, Dyna-Soar I, was to obtain data on the boost-glide flight regime in support of future weapon system development. Headquarters suggested that a system development plan for Dyna-Soar I and the recommended weapon system programs be completed on 31 October 1958 and set July 1962 as the date for the first flight of the conceptual test vehicle. Finally, ARDC headquarters approved immediate initiation of the program by directing the source selection process to begin.[1]

By 25 January 1958, a task group of the source selection board had screened a list of 111 contractors to determine potential bidders for

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the Phase I design. The working group considered that Bell, Boeing, Chance-Vought Aircraft, Convair, General Electric Company, Douglas, Lockheed, Martin, North American, and Western Electric Company would be able to carry out the development. Later, the list was amended to include McDonnell Aircraft, Northrop Aircraft, and Republic Aviation.[2]

The source selection board had received, by March 1958, proposals from nine contractor teams. Essentially, two approaches were taken in considering the development of Dyna-Soar I. In the satelloid concept, a glider would be boosted to an orbital velocity of 25,500 feet per second to an altitude of 400,000 feet, thereby achieving global range as a satellite. In the flexible boost-glide proposal, however, the projected vehicle would follow a glide-trajectory after expenditure of the booster. With a high lift-to-drag ratio at a velocity of 25,000 feet per second and an altitude of 300,000 feet, the glider could circumnavigate the Earth.

Three contractors offered the first approach, the satelloid concept, as 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 feet per second and an altitude of 400,000 feet. Lockheed considered a 5,000 pound glider similar in design to that of Republic. This vehicle could operate as a satelloid, however, the contractor suggested a modified Atlas booster which lacked sufficient thrust for global range. A 15,000 pound vehicle similar to the X-15 craft comprised the proposal of North American. The booster was to consist of a one-and-a-half stage liquid propellant unit with an additional stage in the glider. Operated by a two-man crew, the vehicle was also to have two, small, liquid engines for maneuvering and landing. The glider was to be propelled to a velocity of 25,600 feet per second and an altitude of 400,000 feet and would operate as a satelloid.

Six contractors concentrated on the flexible 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 proposed, instead, the employment of a modified Atlas unit. A delta-wing glider, weighing 11,300 pounds, was recommended by Convair. 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 joined to propose a two-man, delta-wing vehicle, weighing 13,300 pounds, which would be propelled by a modified Titan engine. Employing Minuteman solid propellant units, 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.

The task group of the source selection board, after reviewing the proposals, pointed out that with the exception of the North American vehicle all of the contractors' proposed configurations were based on a delta-wing design. The size of the proposed vehicles was also small in comparison with current fighter aircraft such as the F-106. McDonnell and Republic offered vehicles which could carry the biggest payload, yet they in turn required the largest boosters. At the other extreme was Boeing's proposal which could carry only 500 pounds, including the weight of the pilot. The task group also emphasized that of the three contractors proposing the satelloid concept Lockheed's vehicle fell short of a global range. Of the six contractors offering the flexible boost-glide approach, only the Martin-Bell team and Boeing proposed a first-step vehicle capable of achieving orbital velocities. The other four considered a global range in advanced versions.[3]

By the beginning of April, the working group had completed its evaluation of the contractors' proposals, and, on 16 June 1958, Air Force headquarters announced that the Martin Company and the Boeing Airplane Company both had been selected for the development of Dyna-Soar I.[4] Major General R. P. Swofford, Jr., then Acting Deputy Chief of Staff for Development, USAF headquarters, clarified the selection of two contractors. 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. General Swofford anticipated that $3 million would be available from fiscal year 1958 funds and $15 million would be set for 1959. The decision as to whether Dyna-Soar I would operate as a boost-glide or a satelloid system was left open, as well as the determination of a piloted or unmanned system. The acting deputy directed that both contractors should proceed as far as possible with available funds towards the completion of an experimental tes. vehicle. The design, however, should approximate the configuration of a Dyna-Soar weapon system.[5]

Apparently some questioning concerning the validity of the Dyna-Soar program occurred at Air Force headquarters, for, on 11 July, Major General J. W. Sessums, Jr., Vice Commander of ARDC, stated to Lieutenant General R. C. Wilson, USAF Deputy Chief of Staff for Development, that Air Staff personnel should stop doubting the necessity for Dyna-Soar. Once a new project had been sanctioned by headquarters, General Sessums considered, support should be given for its completion.[6] In reply, General Wilson assured General Sessums that the Air Staff held the conviction that Dyna-Soar was an important project. However, due to the interest of the Advanced Research Projects Agency (ARPA) and the National Aeronautics and Space Administration (NASA) and their undetermined responsibilities in the development of systems such as Dyna-Soar, the Air Force firmly had to defend its projects to the Department of Defense.* General Wilson closed by reassuring General Sessums of his full endorsement of the Dyna-Soar program.[7]

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*Previously, considerable discussion within the Air Force had taken place concerning the role which the National Aeronautics and Space Administration, earlier designated the National Advisory Committee for Aeronautics, was going to play in the Dyna-Soar program. On 31 January 1958, Lieutenant General D. L. Putt, Deputy Chief of Staff for Development, USAF headquarters, asked NACA to join with the Air Force in developing a manned, orbiting, research vehicle. He further stated that the program should be managed and funded along the lines of the X-15 program. It appeared that General Putt was proposing a Dyna-Soar I program under the direction of NACA. ARDC headquarters strongly recommended against this contingency on the grounds that Dyna-Soar would eventually be directed towards a weapon system development. By 20 May, General T. D. White, Air Force Chief of Staff, and Dr. H. L. Dryden, NACA director, signed an agreement for NACA participation in System 464L. With the technical advice and assistance of NACA, the Air Force would direct and fund Dyna-Soar development. On 14 November 1958, the Air Force and NASA reaffirmed this agreement.[8]

While the Dyna-Soar program had the verbal support of USAF headquarters, Lieutenant General S. E. Anderson, ARDC commander, considered that the program required additional funds. He reminded General Wilson that ARDC headquarters, with the efforts of only one contractor in mind, had requested $32.5 million for fiscal year 1959. The Air Staff had limited this amount to $15 million for the contributions of both Boeing and Martin. Consequently, $52 million was now required for the 1959 Dyna-Soar program. The ARDC commander emphasized that if System 464L were to represent a major step in manned, space flight, then the delay inherent in the reduced funding must be recognized and accepted by Air Force headquarters.[9] General Wilson agreed with General Anderson's estimation and stated that the approved funding level for fiscal year 1959 would undoubtedly delay the program by one year. The stipulated $18 million for both fiscal years 1958 and 1959, although a minimum amount, would permit the final contractor selection. General Wilson did assure the ARDC commander that the Air Staff would try to alleviate the situation and thought there was a possibility for increasing fiscal year 1959 funding.[10]

Major General V. R. Haugen, Assistant Deputy Commander for Weapon Systems, Detachment One, 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 the developmental test program and cause excessive design modification. General Haugen strongly urged the augmentation of fiscal year 1959 funding to $52 million. Besides this, it was important that the full release of the planned $15 million be immediately made.[11]

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On 4 September, Colonel J. L. Martin, Jr., Acting Director of Advanced Technology, USAF headquarters, offered additional clarification of the funding situation to Detachment One. He stated that the two separate efforts by Boeing and Martin should only be maintained until study results pointed to a single, superior approach. It was possible for this effort to be terminated within 12 months. Colonel Martin pointed out that the Air Staff was aware that the $18 million level would cause delays; these funds, however, would provide the necessary information for contractor selection. He did announce that release of the $15 million had been made. Lastly, Colonel Martin directed that the term "conceptual test vehicle" would no longer be used to refer to Dyna-Soar I and, in its place, suggested the words "experimental prototype."[12]

The Dyna-Soar project office replied that the competitive period could be terminated by April instead of July 1959; however, additional funding could be effectively utilized.[13] These efforts to increase the Dyna-Soar allotment had no effect, for, on 30 September 1958, USAF headquarters now informed Detachment One that the $10 million procurement funds for fiscal year 1959 had been canceled. All that remained for development of Dyna-Soar was $3 million from fiscal year 1958, with $5 million for 1959. In his 12 August letter to General Anderson, General Wilson mentioned the possibility of increased funding for fiscal year 1959. Apparently a figure of $14.5 million was being considered; however, Air Force headquarters also informed ARDC that this proposed increase would not be made. Headquarters further directed that expenditure rates by the contractors be adjusted in order that the $8 million would prolong their efforts through 1 January 1959.[14]

From 20 through 24 October 1958, Mr. W. E. Lamar, in the Deputy for Research Vehicles and Advanced Systems, and Lieutenant Colonel R. M. Herrington, Jr., chief of the Dyna-Soar project office, briefed Air Force headquarters on the necessity of releasing funds for the Dyna-Soar program. The discussions resulted in several conclusions. The objectives of the program would remain unchanged, but further justification would have to be given to Department of Defense officials. The position of NASA in the program was reaffirmed, and it was further stipulated that ARPA would participate in system studies relating to Dyna-Soar.[15] These decisions, however, did not offer immediate hope for increased funding.

Early in November 1958, Colonel Herrington and Mr. Lamar briefed officials of both ARDC and USAF headquarters on the question of Dyna-Soar funding. General Anderson, after hearing the presentation, stated that he supported the program but thought that references to space operation should be deleted in the presentations to the Air Staff. Later, during a briefing to General Wilson, USAF officials decided that suborbital aspects and possibilities of a military prototype system should be emphasized. With the sanction of the Air Force Vice Chief of Staff, General C. E. LeMay, the Dyna-Soar presentation was given to Mr. R. C. Horner, the Air Force Assistant Secretary for Research and Development. The latter emphasized that if a strong weapon system program were offered to Department of Defense officials, Dyna-Soar would probably be terminated.

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Rather, Secretary Horner suggested that the program be slanted towards the development of a military, research system. He stated that a memorandum would be sent to the defense secretary requesting release of additional funds for Dyna-Soar.[16] While Colonel Herrington and Mr. Lamar achieved their funding objectives, it was also apparent that the final goal of the Dyna-Soar program—the development of an operational weapon system—was somewhat in jeopardy.

In accordance with ARDC System Development Directive 464L, the Dyna-Soar project office had completed, in November, a preliminary development plan which supplanted the abbreviated plan of October 1957. Instead of the three-step approach, the Dyna-Soar program would follow a two-phase development. Since the military test vehicle would be exploring a flight regime which was significantly more severe than that of existing Air Force systems, the first phase would involve a vehicle whose function was to evaluate aerodynamic characteristics, pilot performance, and subsystem operation. Dyna-Soar I was to be a manned glider with a highly-swept, triangular-planform wing, weighing between 7,000 and 13,000 pounds. A combination of Minuteman solid rockets could 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 rocket such as the Titan system, a 13,000 pound vehicle could be propelled to a similar speed and height. The project office stipulated that a retro-rocket system to decelerate the glider and an engine to provide maneuverability for landing procedures would be necessary.

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Assuming a March 1959 approval for the preliminary development plan, the Dyna-Soar office reasoned that the air-drop tests could begin in January 1962, the suborbital, manned, ground-launch tests in July 1962, and the first, piloted, global flight in October 1963. While this first phase was under development, weapon system studies would be conducted concurrently, with the earliest operational date for a weapon system set for 1967. This Dyna-Soar weapon could perform reconnaissance, air defense, space defense, and strategic bombardment missions.[17] The problem of obtaining funds to continue the program, not an outline of Dyna-Soar objectives, was still, however, of immediate importance.

On 4 December 1958, the Secretary of the Air Force requested the Secretary of Defense to release $10 million for the Dyna-Soar program. Apparently the defense department did not act immediately, for, on 30 December, Air Force headquarters informed Detachment One that release of these funds could not be expected until January 1959.[18] The project office urgently requested that procurement authorizations be immediately issued.[19] Finally, on 7 January, the Deputy Secretary of Defense, D. A. Quarles, issued a memorandum to the Secretary of the Air Force, which approved the release of $10 million for the Dyna-Soar program. The deputy secretary emphasized that this was only an approval for a research and development project and did not constitute recognition of Dyna-Soar as a weapon system. The stipulated increase of $14.5 million was not to be released until a decision was made concerning the Boeing-Martin competition.[20]

Air Force headquarters, on 14 January 1959, requested the Dyna-Soar office to provide a detailed program schedule. Concerning the Dyna-Soar I military test system, 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 further directed that the competitive period for the contractors would end by 1 April with a final selection announced by 1 July 1959. While emphasis on a weapon system would be minimized, joint Air Force and ARPA weapon system studies would proceed under separate agreement with Dyna-Soar contractors. The project office was also directed to consider two other developmental approaches. The first would assume that Dyna-Soar objectives had definitely been changed to center on a research vehicle, similar to the X-15 craft, and planning 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, and a funding total of $650 million extending from fiscal year 1961 through 1967 would be assumed. The next day, Air Force headquarters partially revised its directions by stipulating that the source selection process should be completed by 1 May 1959.[21]

On 6 February 1959, the Dyna-Soar project office pointed out that the 1 May date was impracticable, but the office did anticipate a presentation on source selection to the Air Council by 1 June. The project office went on to emphasize that the funding forecasts were incompatible with the flight dates which had been specified to the contractors. It was apparent to the project office that only heavy expenditures during the beginning of phase two could result in the questioned flight dates. The Dyna-Soar office, consequently, requested Air Force headquarters to provide a more realistic funding schedule.[22]

In mid-February, the Dyna-Soar office further clarified its position. The approval of only $5 million in development funds for fiscal year 1959 (the release of $10 million had been for procurement), instead of a revised request of $28 million, had a serious effect on the program by reducing the applied research and development program. Furthermore, the project office had originally requested $187 million for fiscal year 1960, an estimate that was predicated on more extensive effort during fiscal year 1959 than was actually taking place under the reduced funding level. Air Force headquarters had only projected $35 million for fiscal year 1960. The result would be a prolongation of the program.[23] This statement of the project office had some impact on headquarters, for, on 17 February, the Air Staff requested the project office to provide additional information on the program based on fiscal year 1960 funding levels of either $50 million or $70 million.[24]

The depreciation of Dyna-Soar as a weapon system by the defense department, as exemplified by the Secretary Quarles' memorandum of 7 January, did not alter the necessity, in the opinion of the Air Force, for a boost-glide weapon. On 17 February 1959, Air Force headquarters revised its General Operation Requirement 92, previously issued on 12 May 1955. Instead of referring to a high-altitude reconnaissance system, the Air Force now concentrated on a bombardment system. USAF headquarters stated that this system, capable of target destruction, was expected to operate at the fastest attainable hypersonic speed, within and above the stratosphere, and could complete at least one circumnavigation of the Earth. This projected system would be capable of operation from 1966 to 1970.[25]

On 13 April 1959, Dr. H. F. York, Director of Defense for Research and Engineering, firmly established the objectives for Dyna-Soar I. The primary goal was the non-orbital exploration of hypersonic flight up to a velocity of 22,000 feet per second. Launched by a booster already in production or planned for the national ballistic missile and space programs, the vehicle would be manned, maneuverable, and capable of controlled landings. Secondary objectives were the testing of military subsystems and the attainment of orbital velocities. The Department of Defense instructed that the accomplishment of these last objectives should only be implemented if there were no adverse effects on the primary objective. The additional $14.5 million was now authorized for fiscal year 1959, giving a total of $29.5 million for that year. The Department of Defense inquired whether this figure plus a proposed $35 million for fiscal year 1960 would be sufficient to carry out the program. If the Air Force did not consider this feasible, then an alternate program should be submitted for review.[26]

Command headquarters was not in accord with these directions. In an effort to fulfill the conditions established by General Operational Requirement 92, the research and development command issued, on 7 May 1959, ARDC System Requirement 201. The Dyna-Soar I vehicle was to be a military test system developed under the direction of the Air Force with technical assistance from the National Aeronautics and Space Administration. The purpose of this system would be to determine the military potential of a boost-glide weapon system and provide research data on flight characteristics up to and including global flight. Concurrently, studies would be made concerning a weapon system based on this type of hypersonic vehicle. Headquarters then directed its Detachment One to prepare a development plan for Dyna-Soar by 1 November 1959.[27*]

Major General Haugen, in reply to the directions of Dr. York, "strongly recommended" that the attainment of orbital velocities and the testing of military subsystems should be a primary, not a secondary objective. He further stated that Dyna-Soar was the only manned vehicle program which could determine the military potential in the near-space regime. It was "extremely important," the systems management director stated, that the accomplishment of the Dyna-Soar mission not be compromised by restrictions which limited safety, reliability, and growth potential in deference to short-term monetary savings.[28]

General Haugen's organization then drew up a position paper substantiating these recommendations. The directorate firmly believed that both the primary and secondary objectives had to be achieved. Concentration on the first set of objectives would prevent investigation of re-entry from

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[*]By January 1959, the preliminary development plan of November 1958 had been forwarded to ARDC and USAF headquarters, however, apparently neither headquarters gave it official sanction.

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orbit and the adequate testing of military subsystems. The directorate then recommended a program involving the fabrication 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 modification of this program to conform with only the primary objectives would reduce the cost by $110 million, it would seriously lessen the possibility of evolving a weapon system from Dyna-Soar I.[29]

Excluding $18 million expended during contract competition, the Deputy Chief of Staff for Development in Air Force headquarters established, on 28 May, $665 million as the maximum total of the Dyna-Soar program. For planning purposes $77 million was set for fiscal year 1960.[30] On 11 June 1959, the Air Force Council considered this last figure to be excessive, and the deputy chief of staff had to recant: $35 million was to be used in place of the $77 million.[31]

During a briefing on 23 June 1959, officials of the project office and Dr. J. V. Charyk, Assistant Secretary of the Air Force for Research and Development, further discussed the questions of Dyna-Soar funding and objectives. Apparently, Dr. Charyk, at this point, was not in full agreement with Dr. York's position. The assistant secretary considered that the over-all purpose of the program was to exploit the potentialities of boost-glide technology, and, consequently, he implied that orbital velocities should be attained early in the program. For fiscal year 1960, he favored $77 million instead of $35 million but raised the

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question of how much a total funding level of $300 million to $500 million would compromise the program.* Dr. Charyk then reported to the project officials that Dr. York appeared quite concerned over the effort necessary for modification of a proposed Dyna-Soar booster.[32]

The Air Force source selection board had already appraised the Boeing and Martin proposals. Although both contractors offered similar delta-wing designs, they differed in their selection of boosters. While Boeing only considered an orbital Atlas-Centaur combination, Martin officials offered a surborbital Titan A (later renamed the Titan I) and an orbital Titan C. The board deemed the Boeing glider superior but also recommended use of Martin's orbital booster. The Secretary of the Air Force, J. H. Douglas, did not agree. Development of a new booster, capable of orbital velocities, was clearly not in accord with Dr. York's direction. The secretary recommended further study of the configuration and size of the vehicle to determine whether the glider could be modified to permit compatibility with a basic, suborbital, Titan system. Furthermore, Secretary Douglas was concerned about the total cost of the program. He did not think that funding should be increased by attempting to configure a vehicle which conformed to an anticipated 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. Accordingly, USAF headquarters directed Detachment One to examine

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*The documentary source, as cited in reference 32, for Dr. Charyk's comments referred to the $77 million and $35 million as projected figures for fiscal year 1959. Placed in context of the funding discussions concerning the Dyna-Soar program, these estimates obviously applied to fiscal year 1960 and not 1959.

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the possibilities for a lighter vehicle and to analyze a development program based on a total cost of not more than $500 million.[33]

Designation of the booster, management of booster development and procurement, and most important, the purpose of the program, were problems that became intertwined in the series of discussions following Secretary Douglas' instructions. After a 14 July meeting with Dr. Charyk, General Boushey, Colonel W. L. Moore, Jr., and Lieutenant Colonel Ferer, General Haugen directed systems management to prepare a presentation designed to answer the questions raised by Secretary Douglas and also to outline the participation of the Ballistic Missiles Division (BMD) in the Dyna-Soar program.* After reviewing this briefing on 22 July 1959, Lieutenant General B. A. Schriever, now ARDC commander, instructed General Haugen's directorate to prepare a detailed management plan for booster development.[34]** Dr. York, however, on 27 July, placed a new complication in this planning effort by requesting the Air Force secretary and the director of ARPA to investigate the possibility of a common development of a Dyna-Soar booster and a second stage for the Saturn booster of NASA. The Director of Defense for Research and Engineering stated that no commitments for the propulsion system would be made until this proposal had been considered. Dr. York apparently had in mind reviving consideration of the Titan C for System 464L and modifying this booster for use in the Saturn program.[35]

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*Colonel Moore succeeded Colonel R. M. Herrington, Jr., as chief of the Dyna-Soar Weapon System Project Office early in July 1959.

**On 10 March 1959, Lieutenant General S. E. Anderson, previously ARDC commander, became commander of the Air Materiel Command. Lieutenant General B. A. Schriever, on 25 April 1959, assumed command of ARDC.

On 28 and 29 July, General Haugen and Brigadier General O. J. Ritland, BMD commander, completed a tentative agreement concerning the management of Dyna-Soar booster development. During a series of meetings on 11 and 13 August, however, General Schriever and General Anderson, AMC commander, could not agree on a method of booster procurement. With the exception of the parts pertaining to BMD participation in the Dyna-Soar program, Mr. Lamar then gave the Dyna-Soar presentation to Dr. Charyk, with Generals Wilson, Ferguson, and Haugen attending. After preliminary data was given on Titan C and the Saturn second stage, Dr. Charyk was asked to recommend to the defense department that a contractor source selection be made for Dyna-Soar. He declined: subcontractor selection had not been adequately competitive and the proposed Dyna-Soar funding was too high.[36]

By the middle of August, the Ballistic Missiles Division had completed its evaluation of possible Dyna-Soar boosters. Largely because of serious stability and control problems, an Atlas-Centaur combination was rejected in favor of the Titan C. Concerning Dr. York's proposal, west cost officials believed that it was impractical to employ a precisely identical booster stage for both the Dyna-Soar and Saturn projects. Since Titan C was essentially a cluster of four LR87-AJ-3 engines, ballistic division engineers did recommend employing two of these propulsive units as a Saturn second stage.[37] Discussions between Dr. Charyk, Dr. York, and ballistic division officials concerning selection of the Dyna-Soar booster followed. Finally, while a booster was not designated, Dr. Charyk, Generals Wilson, Ferguson, and Boushey

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decided, on 25 September, that Titan C would not be employed in the program.[38]

On 23 September, Lieutenant General W. F. McKee, AMC vice commander, took up the question of booster procurement and proposed to General Schriever a management plan, based on discussions between ARDC and AMC personnel, for the Dyna-Soar program. Because of the wide participation of government agencies and industry, control of Dyna-Soar had to be centralized in a specific organization. While the system was to be procured under two contracts, one for the glider and one for the propulsion unit, the contractor responsible for the manufacture of the vehicle would be given responsibility for integration of the entire system and would act as weapon system contractor. Over-all 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 of the materiel command, General McKee suggested that the aeronautical center negotiate the two contracts, utilizing the experience available at the ballistic center. The Aeronautical Systems Center, however, would delegate authority to the ballistic center to contractually cover engineering changes. This delegation would be limited to actions not affecting over-all cost, compatibility between booster and vehicle, and system performance. General McKee closed by recommending that ARDC and AMC forward a message to Air Force headquarters outlining this proposal.[39]

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General Schriever, on 2 October, informed AMC officials that he agreed with General McKee's proposed message to USAF headquarters. He did wish to point out, however, that the plan did not adequately reflect the increased role that ARDC agencies at Wright Field were intending to play. General Schriever further stated that ARDC was going to establish a single agency for all booster research and development which would incorporate the use of BMD and BMC.[40] General Anderson replied that he did not understand the ARDC commander's statement concerning increased management responsibility of Wright agencies. He stated that the AMC plan stressed this aspect. General Anderson further emphasized that the materiel command recognized BMD's technical responsibility for the Dyna-Soar booster and had agreed to delegate necessary procurement authority. The AMC commander did not think it was necessary, however, to delegate authority to negotiate contracts. This authority, along with over-all technical management should rest in the ARDC and ASC weapon system project offices.[41]

On 29 October, General Boushey re-examined the Dyna-Soar requirements established by the 13 April memorandum of Dr. York. Orbital flight and testing of military subsystems could only be permitted, Dr. York insisted, if these efforts did not adversely affect the central objective of non-orbital, hypersonic flight. General Boushey reiterated the opinion of USAF headquarters; both sets of objectives should be definitely achieved. Assuming a total funding of $665 million, ARDC was directed to formulate a two-phase development approach for a 9,000 to 10,000 pound glider.[42]

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By 1 November 1959, the Dyna-Soar office completed an abbreviated development plan in fulfillment of ARDC System Requirement 201. 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. The project office anticipated 19 air-drop tests to begin in April 1962; the first of eight unmanned, suborbital flights to occur in July 1963; and the first of eight piloted, suborbital launches to take place in May 1964. The first, manned, global flight of Step II was scheduled for August 1965. To accomplish this program, the project office estimated the development cost to total $623.6 million from fiscal year 1960 through 1966.[43] On 2 November, the Weapons Board of Air Force headquarters approved the revised Dyna-Soar plan. The Air Council, in addition to sanctioning the three-step program, also approved of an ARDC and AMC arrangement concerning booster procurement.[44]

Generals Schriever and Anderson, on 4 November, forwarded a joint ARDC and AMC letter to USAF headquarters. After detailing the essentials of the program, the two commanders outlined their agreement on booster procurement: the project office would utilize the "experience" of the ballistic division in obtaining a booster for Dyna-Soar. They further stated that the proposed program would make full use of existing national

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booster programs, essentially satisfying Dr. York's requirement, and would also attain Air Force objectives by achieving orbital velocities. General Schriever and General Anderson closed by urging the source selection process to be completed.[45]

Following this advice, the Secretary of the Air Force, on 9 November 1959, announced the Dyna-Soar contracting sources. The Boeing Airplane Company had won the competition and was awarded the systems contract. The Martin Company, however, was named associate contractor with the responsibility for booster development.[46] On 17 November, Air Force headquarters directed the research and development command to implement Step I and to begin planning for Step II of the Dyna-Soar program.[47] Three days later, Dr. Charyk gave the Air Force authority to negotiate Step I contracts for fiscal year 1960. There was, however, an obstruction. The assistant secretary instructed the Deputy Chief of Staff for Development that, prior to obligating any funds for the Dyna-Soar program, now designated System 620A, Dr. Charyk's office would have to be given financial plans and adequate work statements. No commitments could be made before the Air Force had a concise understanding of the direction of the project.[48]

In an effort to obtain approval to obligate funds for fiscal years 1959 and 1960, General Boushey and some of his staff met with Dr. Charyk on 24 November, and Dr. Charyk made it clear that he did not wish to release any funds for Dyna-Soar at that time. Instead, he was going to institute Phase Alpha, the purpose of which would be to examine the step-approach,

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the proposed booster, the vehicle size, and the flight test objectives. Dr. Charyk stated that no funds would be obligated until the Alpha exercise was completed. Once Dyna-Soar was implemented, the assistant secretary wanted to review the program step-by-step and release funds as the program proceeded.[49] To cover the work carried on under Phase Alpha, the Air Force released a total of $1 million. Pending further approval by Dr. Charyk, obligations could not exceed this amount.[50]

CHAPTER II

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38. Ltr., Brig. Gen. H. A. Boushey, Dir., Adv. Tech., DCS/Dev., Hqs. USAF to Hqs. ARDC, 29 Oct. 1959, subj.: Required Action on Dyna-Soar, Doc. 83.

39. Ltr., Lt. Gen. W. F. McKee, Vice Cmdr., AMC to Cmdr., ARDC, 23 Sept. 1959, subj.: The Dyna-Soar Program, Doc. 78.

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42. Ltr., Brig. Gen. Boushey to Hqs. ARDC, 29 Oct. 1959, subj.: Required Action on Dyna-Soar, Doc. 83.

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45. Ltr., Lt. Gen. B. A. Schriever, Cmdr., ARDC and Lt. Gen. S. E. Anderson, Cmdr., AMC to Hqs. USAF, 4 Nov. 1959, subj.: Dyna-Soar Selection, Doc. 84.

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47. TWX, AFDAT-90938, Hqs. USAF to Cmdr., ARDC, 17 Nov. 1959, Doc. 90.

48. Memo., Dr. J. V. Charyk, ASAF/Res. & Dev. to DCS/Dev., Hqs. USAF, 20 Nov. 1959, subj.: D&F 50-11-284 Dyna-Soar program, Doc. 92.

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CHAPTER III

ALPHA TO ONE

Before the Dyna-Soar Weapon System Project Office could undertake the suborbital Step I of the program, the Air Force had to institute Phase Alpha and appraise the Dyna-Soar approach to eventual manned, orbital flight. Early in December 1959, the Aero and Space Vehicles Panel of the Scientific Advisory Board offered some recommendations concerning the objectives of this study. The panel pointed to the inadequacy of technical knowledge in the areas of aerodynamics and structures and, consequently, considered that development test programs to alleviate these deficiencies should be formulated during the study. Concerning the entire program, the scientific advisory group strongly supported the Dyna-Soar approach. While the program could be severely limited by a restricted budget and the absence of a high military priority, the Aero and Space Vehicles Panel insisted that Dyna-Soar was important because, if properly directed, it could yield significant information in the broad research areas of science and engineering.[1]

Dr. J. V. Charyk, Assistant Secretary of the Air Force for Research and Development, concurred with the position of the panel. In Alpha, emphasis would be placed on the identification and solutions of technical problems, and the objective of Step I would be the development of a test vehicle rather than a weapon system. Dr. Charyk then authorized the release of an additional $2.5 million for this study.[2]

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On 11 December 1959, the Air Force and the Boeing Airplane Company had already signed a contract for the Alpha study, but the Air Force was undecided as to which contractors or Air Force agencies would provide Boeing with booster analyses. By the end of January 1960, the Dyna-Soar office recommended that the Ballistic Missile Division and the Space Technology Laboratories provide the booster studies. Since Alpha had to be completed in March 1960, the project office did not consider that there was sufficient time to complete a contract with Martin for the Alpha study.[3] The Aeronautical Systems Center objected and maintained that the existing contracts with Boeing could not be extended to allow participation in booster studies.[4] Command headquarters disagreed and resolved the issue on 3 February: the Ballistic Missiles Center would arrange contracts with the space laboratories and the Martin Company and the Aeronautical Systems Center would extend the Boeing contract.[5]

Booster information for Alpha was not the only problem; ARDC headquarters still had to settle the question of booster procurement for the entire Dyna-Soar program. Lieutenant General B. A. Schriever, Commander of ARDC, and Lieutenant General S. E. Anderson, Commander of AMC, had apparently delineated the authority of their respective commands in their 4 November 1959 letter, but a formal agreement had not been reached. Early in December 1959, General Schriever had completed an agreement within his command which assigned technical responsibility for booster development to the Ballistic Missiles Division. General Schriever hoped that General Anderson also intended to delegate commensurate contractual authority to the Ballistic Missiles Center.[6] General Anderson

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was essentially in agreement with General Schriever's position, but he objected to an agreement made between the ARDC project office and the ballistic division without participation of AMC elements. Consequently, the air materiel commander urged that the two commands complete a joint agreement concerning the development of the Dyna-Soar booster.[7]

On 8 February 1960, Generals Schriever and Anderson reached such an understanding which detailed the position of the west coast complex in the Dyna-Soar program. While management and financial authority for the entire program rested in the weapon system project office, the ballistic division and center, with the approval of the system office, would define the statements of work and complete contractual arrangements for the booster development. All changes in the booster program which significantly altered performance, configuration, cost, or schedules, however, would necessitate concurrence of the project office.[8]

In the middle of January 1960, Brigadier General H. A. Boushey, Assistant for Advanced Technology in Air Force headquarters, gave more specific instructions concerning the direction of the Phase Alpha study. The objective of this review was to examine selected configurations for controlled, manned re-entry, to determine the technical risks involved in each, and to define a development test program for Step I.[9] In order to evaluate the efforts of Boeing, Martin, the ballistic division, and the space laboratories in this study, Colonel W. R. Grohs, Vice Commander of the Wright Aeronautical Development Division (WADD), then directed the formation of an ad hoc committee.[10*]

*With the formation of the Wright Air Development Division, on 15 December 1959, the management of weapon system development was transferred from ARDC headquarters to the Wright complex.

This group was established early in February with representation not only from the Wright division but also from the Air Force Flight Test Center, the Air Force Missile Test Center, the Air Materiel Command, and the National Aeronautics and Space Administration. The central objective of this committee was to determine the kind of research vehicle the Air Force required to solve the problems involving manned re-entry from orbital flight. Consequently, the ad hoc committee contracted with several companies, which were placed under the direction of Boeing, to investigate the potentialities of several categories of configurations. Variable geometric shapes such as the drag brake of the AVCO Manufacturing Corporation, a folding-wing glider of Lockheed Aircraft, and an inflatable device of Goodyear Aircraft were all examined. The committee also analyzed ballistic shapes such as a modified Mercury Capsule of McDonnell and lifting body configurations offered by the ad hoc committee itself and General Electric. Finally, gliders with varying lift-to-drag ratios were also proposed by the committee, Bell Aircraft, Boeing, and Chance-Vought Aircraft.

After examining these various configurations, the ad hoc group concluded that the development and fabrication of a ballistic shape or a lifting body configuration with a lift-to-drag ratio up to 0.5 would only duplicate the findings of the National Aeronautics and Space Administration in its Mercury program. Conversely, a glider with a high lift-to-drag ratio of 3.0 would not only provide a maximum amount of information on re-entry but would also demonstrate the greatest maneuverability in the atmosphere and allow the widest selection of landing sites. Such a glider, however, presented the most difficult design problems. Consequently, the ad hoc committee decided that a medium lift-to-drag glider, in the range of 1.5 to 2.5, offered the most feasible approach for advancing knowledge of re-entry problems.[11]

At the end of March 1960, the Aero and Space Vehicles panel again reviewed the Dyna-Soar program with emphasis on the results of the Alpha study. If the overriding requirement were to orbit the greatest weight in the shortest development time, the panel reasoned that the modified ballistic approach was preferable. However, the members noted that gliders would advance technical knowledge of structures and would provide the greatest operational flexibility. The vehicles panel further emphasized the importance of attaining early orbital flight and, consequently, suggested a re-examination of the need for a sub-orbital Step I and more precise planning for the orbital Step II.[12]

The Dyna-Soar glider, as conceived by the Alpha group and the project office, was to be a low-wing, delta-shape vehicle, weighing about 10,000 pounds. To undergo the heating conditions during re-entry, the framework was to be composed of Rene' 41 braces which would withstand a temperature of 1,800 degrees Fahrenheit. The upper surface of the glider was to be fabricated of Rene' 41 panels, where the temperature was expected to range from 500 to 1,900 degrees. The lower surface was to be a heat shield, designed for a maximum temperature of 2,700 degrees and was to consist of molybdenum sheets attached to insulated Rene' 41 panels. The leading edge of the wings would have to withstand similar heat conditions and was to be composed of coated molybdenum segments.

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The severest temperature, ranging from 3,600 to 4,300 degrees, would be endured by the nose cap, which was to be constructed of graphite with zirconia rods.[13]

In conjunction with the ad hoc group, the Dyna-Soar project office completed, by 1 April 1960, a new development plan which further elaborated the three-step program presented in the November 1959 approach. Step I was directed towards the achievement of four objectives: exploration of the maximum heating regions of the flight regime, investigation of maneuverability during re-entry, demonstration of conventional landing, and evaluation of the ability of man to function usefully in hypersonic flight. While Step I was limited to suborbital flight, the purpose of Step IIA was to gather data on orbital velocities and to 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 systems. While Step IIB would provide an interim military system capable of reconnaissance and satellite inspection missions, the objective of Step III was a fully operational weapon system.

Whereas the last two steps were only outlined, the main consideration of the project office was the suborbital Step I. In order to demonstrate the flying characteristics of the glider up to speeds of mach 2, the Dyna-Soar office scheduled a program* of 20 air-drop tests from a B-52 carrier to begin in July 1963. Beginning in November 1963, five unmanned flights were

*For the air-drop program, the Dyna-Soar office was considering employment of either the XLR-11 or the AR-1 liquid rocket engines to propel the glider to specified speeds. Late in 1960, however, the project office decided to use a solid acceleration rocket not only for abort during launch but also for the air-drop tests.

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to be conducted to Mayaguana in the Bahama Islands and Fortaleza, Brazil, with velocities ranging from 9,000 to 19,000 feet per second. Eleven piloted flights, scheduled to start in November 1964, would then follow, progressively increasing the velocity to the maximum 19,000 feet per second and employing 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 that $74.9 million would be required for fiscal year 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.[14]

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 Schriever, Anderson, and Boushey, and the Strategic Air Panel and the Weapons Board of Air Force headquarters. On 8 April, Dyna-Soar representatives explained the program to the Assistant Secretary of the Air Force for Research and Development, now Professor C. D. Perkins, and received his approval to begin work on the suborbital Step I.[15] On 19 April, the Assistant Secretary of the Air Force for Materiel, P. B. Taylor authorized negotiations of fiscal year 1961 contracts for this phase of the program.* The Department of Defense, on 22 April, endorsed the new program and permitted

*On 24 April 1961, Dr. Charyk, then Under Secretary of the Air Force, permitted contractual arrangements for the entire Step I program rather than for only particular fiscal years.

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the release of $16.2 million of fiscal year 1960 funds.[16] Consequently, on 27 April, the Air Force completed a letter contract with the Boeing Airplane Company as system contractor. Source selection procedures had previously been initiated for the award of two associate contracts. On 6 December 1960, the Air Force granted authority to the Minneapolis-Honeywell Regulator Company for the primary guidance subsystem, and, on 16 December, the Air Force gave responsibility to the Radio Corporation of America for the communication and data link subsystem.*

Air Force headquarters, on 21 July 1960, further recognized the three-step program by issuing System Development Requirement 19. With the segmented approach, the Air Force could develop a manned glider capable of demonstrating orbital flight, maneuverability during hypersonic glide, and controlled landings. Furthermore, Dyna-Soar could lead to a military system able to fulfill missions of space maneuver and rendezvous, satellite inspection, and reconnaissance. Headquarters looked forward to the first manned, suborbital launch which was to occur in 1964.[17]

While the Step I program was approved and funded, the Dyna-Soar project office firmly thought that studies for the advanced phases of the program should also be initiated. In early August 1960, the project office recommended to ARDC headquarters that $2.32 million should

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*The Air Force granted three other associate contracts for the Dyna-Soar program. On 8 June 1960, the Martin Company received responsibility for the booster airframe, while, on 27 June, the Air Force authorized the Aero-Jet General Corporation to develop the booster engines. Previously, on 9 June, the Air Force made arrangements with the Aerospace Corporation to provide technical services for the Step I program.

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be made available through fiscal year 1962 for this purpose. If these funds were released 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.[18] Later in the month, the Dyna-Soar office again reminded command headquarters of the urgency in releasing these funds.[19]

The apparent source of delay was that the authority to negotiate contracts, issued by Assistant Secretary Taylor on 19 April 1960, referred specifically to Step I of the program. Colonel E. A. Kiessling, Director of Aeronautical Systems in ARDC headquarters, met with Professor Perkins on 22 and 23 September, and the assistant secretary agreed that this authority did not prohibit Step II and III studies. The restraint only applied to the expenditure of fiscal year 1961 funds for the purchase of equipment for the advanced phases.[20*] This decision was confirmed on 12 October when Air Force headquarters approved Steps II and III studies by issuing Development Directive 411.[22**] ARDC headquarters then issued, on 6 December,

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*Colonel T. T. Omohundro, Deputy Director for Aeronautical Systems, ARDC headquarters, informed the Dyna-Soar office, on 4 October 1960, that Air Force headquarters would probably have to issue a new authority to negotiate contracts for Step II and III studies before funds could be released. Apparently, Colonel Kiessling had not told his deputy of Professor Perkins' previous decision.[21]

**On 14 February 1961, the Air Force and Boeing complete contract for Step IIA and IIB studies with an effective date of 9 November 1960. Boeing was allotted $1.33 million and given until 30 June 1962 to complete the studies. With the assumption that a new orbital booster would provide Step II propulsion, Boeing concluded that it was feasible for the Dyna-Soar glider to perform military missions such as reconnaissance, satellite interception and inspection, space logistics, and bombardment. The last mission, however, the contractor considered could be performed with less expense by intercontinental ballistic missiles.[23]

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a system study directive for Step III and allotted $250,000 for this work.[24] By the middle of 1961, however, it was questionable whether the Air Force would continue the three-step approach. The Air Staff consequently postponed the Step III investigation, and, early in 1962, command headquarters canceled the study.[25]

In the April 1960 development plan, the Dyna-Soar office had proposed the employment of Titan I as the Step I booster. The first stage of this system was powered by the LR87-AJ-3 engine, capable of developing 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 Dyna-Soar glider to a velocity of 19,000 feet per second on a suborbital flight from Cape Canaveral to Fortaleza, Brazil. Professor Perkins, however, considered this booster marginal for Step I flights and, on 28 November 1960, requested the Air Force to examine the feasibility of employing Titan II for the suborbital step and a combination Titan II first stage and a Centaur-derivative upper stage for the orbital phase.[26] The Titan II was a two-stage liquid rocket and, unlike the Titan I, employed hypergolic, storable propellants. The first stage consisted of an XLR87-AJ-5 engine, capable of producing 430,000 pounds of thrust, while the second stage was an XLR91-AJ-5 unit, capable of delivering 100,000 pounds of thrust.

Late in December 1960, Mr. R. C. Johnston of the Dyna-Soar office and Major G. S. Halvorsen of the Ballistic Missiles Division presented the advantages of Titan II to ARDC headquarters, and the proposal to employ the advanced Titan received the endorsement of General Schriever. A presentation to Air Force headquarters followed. Assistant Secretary Perkins appeared satisfied with the recommendation but stated that Department of Defense approval would probably not be given unless the booster change was considered in conjunction with an anticipated funding level of $70 million for fiscal year 1962, instead of the requested $150 million.[27]

A few days later, the project office protested the $70 million level and insisted that it would result in serious delays to the program. Regardless of the funding arrangements, the Dyna-Soar office urged approval of Titan II.[28] Colonel Kiessling concurred with this position and appealed to USAF headquarters. Even with the proposed low funding level, the Director of Aeronautical Systems stated, employment of the Titan II promised a substantially improved Dyna-Soar program and this booster change should be immediately approved.[29]

Mr. Johnston and Major Halvorsen again went to Air Force headquarters. After receiving the approval of Major General M. C. Demler, Director of Aerospace Systems, the Dyna-Soar representatives informed the Strategic Air Panel of the attributes of Titan II. Discussion of the panel 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 apparent inadequate funding level for fiscal year 1962. In spite of some doubts, the panel approved ths proposed booster for Dyna-Soar I and further recommended that approximately $150 million should be allocated for fiscal year 1962.[30]

At the request of Assistant Secretary Perkins, General Demler had prepared a summary on the advantages of Titan II over the earlier version. The Director of Aerospace Systems insisted that Titan I was barely sufficient for achieving the objectives of Step I and, furthermore, could not be modified to provide orbital velocities for the glider. The April 1960 development plan had stipulated that with Titan I the first unmanned ground-launch would occur in November 1963, while employment of the more powerful Titan II would only push this date back to January 1964. General Demler pointed out that if the program were limited to $70 million, October 1964 would be the date for the first unmanned ground-launch with Titan I, while December 1964 would be the date for Titan II. The aerospace director estimated that with a $150 million level for fiscal year 1962, the development of Titan II would cost an additional $33 million, while the cost would still be $26 million with the $70 million funding level. General Demler considered that the total booster cost for Step I and II employing the Titan I and then a Titan II-Centaur combination would be $320.3 million. If Titan II were immediately used for Step I, the booster 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 only amounted to $4.2 million. The conclusion was obvious; however, General Demler refrained from making recommendations.[31]

Following the briefing to the Strategic Air Panel, Mr. Johnston and Major Halvorsen gave the Titan II presentations to the Weapons Board. The members were familiar with the logic of General Demler's summary, and, while expressing interest in the early attainment of orbital flight, they endorsed the change to Titan II. The board recommended that Air Force headquarters immediately instruct ARDC to adopt the new booster.[32]

However, Major General V. R. Haugen and Colonel B. H. Ferer, both in the office of the Deputy Chief of Staff for Development, decided to seek the approval of the Department of Defense. The Titan II presentations were then given to Mr. J. H. Rubel, Deputy Director of Defense for Research and Engineering. While reiterating the necessity of a $70 million budget, Mr. Rubel, agreed to the technical merits of Titan II. On 12 January 1961, Air Force headquarters announced approval of this booster for Step I flights.[33]

During these discussions over Titan II, it was apparent that the Department of Defense was seriously considering limiting the fiscal year 1962 figure to $70 million. This financial restriction was confirmed on 3 February, when Air Force headquarters directed the Dyna-Soar office to reorient the Step I program to conform with this lower funding level.[34] By the end of the month, the project office and the Dyna-Soar contractors had evaluated the impact of this reduction on the program. It was clear that flight schedules would be set back almost one year.[35]

Apparently Department of Defense officials relented, for, on 28 March 1961, Air Force headquarters announced that the fiscal year 1962 level would be set at $100 million. The following day, Colonel W. L. Moore, Dyna-Soar director, and his Deputy Director for Development, W. E. Lamar, reported on the status of the program to Air Force headquarters. Both Dr. Charyk and Major General Haugen directed that the program be established on a "reasonable" funding level. Colonel Moore noted that a definition of this statement was not offered.[36] Finally, on 4 April, headquarters of the Air Force Systems Command (AFSC) officially instructed

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the program office to redirect Dyna-Soar to a $100 million level for fiscal year 1962.[37*]

By 26 April 1961, the Dyna-Soar office had completed a system package program. This plan further elaborated the familiar three-step approach. Step I would involve suborbital missions of the Dyna-Soar glider boosted by the Titan II. For the research and development of this program, the Dyna-Soar office stated that $100 million was required for fiscal year 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. If these funds were allotted, the first air-drop would take place in January 1964, the first unmanned ground-launch in August 1964, and the first manned ground-launch in April 1965.

The objective of Step IIA was to demonstrate orbital flight of the Dyna-Soar vehicle on around-the-world missions from Cape Canaveral to Edwards Air Force Base. The program office proposed the testing, on these flights, of various military subsystems such as weapon delivery and reconnaissance subsystems. Because of high cost, the Dyna-Soar office did not recommend the evaluation of a space maneuvering engine, space-to-earth missiles, or space-to-space weapons during Step IIA flights.

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*On 1 April 1961, the Air Research and Development Command, by acquiring the procurement and production functions from the Air Materiel Command, was reorganized as the Air Force Systems Command. At Wright-Patterson Air Force Base, the Wright Air Development Division combined with the Aeronautical Systems Center to become the Aeronautical Systems Division (ASD).

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For fiscal years 1963 through 1968, the program office estimated that this phase of Step II would total $467.8 million and, assuming the selection of the orbital booster by the beginning of fiscal year 1962, reasoned that the first manned, orbital flight could be conducted in April 1966.

In Step IIB, the Dyna-Soar vehicle would 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, however, it did anticipate a Step IIB vehicle operating by October 1967. The program office looked further in the future and maintained that $250,000 would be necessary for each fiscal year through 1964 for studies on a Step III weapon system, which could be available by late 1971.[38]

In the April 1961 system package program, the Dyna-Soar office outlined an extensive Category I program, consisting of structural and environmental, design, and aerothermodynamic testing, which was necessary for the development of the glider. In order to verify information obtained from this laboratory testing, the system office recommended participation in another test program which would place Dyna-Soar models in a free-flight trajectory.[39] The first approach which the Dyna-Soar office considered was System 609A of the Ballistic Missiles Division.

During the March 1960 review, the Aero and Space Vehicles Panel emphasized the difficulty in predicting behavior of structures utilizing coated heat shields and recommended Dyna-Soar participation in the 609A program.[40] The system office agreed and decided to place full-scale sections of the glider nose on four hyper-environmental flights.[41*] Although subsequent planning reduced the number to two flights, command headquarters refused to release funds for such tests, and, consequently, Colonel Moore terminated Dyna-Soar flights in the System 609A test program on 5 October. The project director gave several reasons for this decision: low probability of obtaining sufficient data with only two flights, insufficient velocity of the boosters, and high cost for Dyna-Soar participation.[43]

Air Force headquarters was concerned over this cancellation and emphasized to ARDC headquarters that the absence of a free-flight test program for Dyna-Soar failed to carry out assurances previously given to the Department of Defense.[44] The National Aeronautics and Space Administration had another approach which it had been proposing since May 1960. Dyna-Soar models constructed by both NASA and the Air Force would be placed on RVX-2A re-entry vehicles and boosted by Atlas or Titan systems. Project office engineers could thereby obtain data on

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*Models of the AVCO drag brake were also scheduled to ride 609A launches. In February 1960, Air Force headquarters had transferred the management of this project from the Directorate of Advanced Systems Technology, WADD, to the Dyna-Soar Weapon System Project Office. In March, the Air Force granted AVCO a study contract, and, in July, ARDC headquarters approved a development program for the drag brake. Air Force headquarters was reluctant to authorize funds, and the program was terminated in December. Nevertheless, in February 1961, Major General J. R. Holzapple, WADD Commander, reinstated research on certain technical areas of the drag brake program.[42]

heat transfer and aerodynamic characteristics. By November 1960, the Dyna-Soar office was seriously considering verification of laboratory data by this RVX-2A program.[45]

In May 1961, Major General W. A. Davis, ASD Commander, emphasized to AFSC headquarters the requirements for RVX-2A tests: funds and space on Titan II launches.[46] After two more appeals by the program office, Major General M. F. Cooper, Deputy Chief of Staff for Research and Engineering, gave the position of AFSC headquarters. Placing a re-entry vehicle with Dyna-Soar models on the Titan II would impose several limitations on the test schedule of the booster, requiring several modifications to the airframe and the launch facilities. General Cooper further stated that the $10 million estimated by NASA officials for the RVX-2A program would necessitate approval by Air Force headquarters. Consequently, General Cooper intended to incorporate this program in a future Dyna-Soar development plan. The RVX-2A proposal was included in a 7 October 1961 plan for the development of a Dyna-Soar weapon system; however, this program did not receive the approval of USAF headquarters.[48] The attempt by the Dyna-Soar office to provide a specific program for free-flight verification of its laboratory test data ended at that point.

The April 1961 system package program also reflected changes in the Dyna-Soar flight plan. While 20 air-drop tests were still scheduled, only two unmanned ground-launches, instead of the previously planned four, were to be conducted. On the first flight, the Titan II would accelerate the glider to a velocity of 16,000 feet per second, reaching Santa Lucia. During the second unmanned launch, the vehicle would

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attain a velocity of 21,000 feet per second and land near Fortaleza. Twelve manned flights were then planned with velocities ranging from 16,000 to 22,000 feet per second. If the two additional vehicles for unmanned launches were not expended, additional piloted flights would then take place.[50]

The scheduling of flights to Fortaleza, however, was becomming academic. As early as June 1960, Air Force headquarters notified ARDC headquarters that the State Department was concerned over the problem of renewing an agreement with Brazil for American military use of its territory.[51] This subject reappeared in May 1961 when the acting Director of Defense for Research and Engineering, J. H. Rubel, informed the Department of the Air Force that discussions with State Department officials indicated the difficulty, if not the impossibility, of obtaining a landing site for Dyna-Soar in Brazil.[52] Unless Air Force headquarters would tolerate increased costs, reduced flight test objectives, or employment of a new booster, the Dyna-Soar office thought that a landing field in Brazil was essential. The program office stated that employment of alternative landing sites would seriously affect the conduct of Category II flights and would probably prevent attainment of important research objectives.[53] Although Dr. Brockway McMillan, Assistant Secretary of the Air Force for Research and Development, reiterated this position to the Department of Defense, the subject of a Fortaleza landing site did not assume a greater significance because the Air Force was already seriously questioning the need for suborbital flight.[54]

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From January 1960 through April 1961, the Dyna-Soar program office had defined the three-step program and had implemented the suborbital phase. While Air Force headquarters had approved the April 1960 development plan, it had not sanctioned the more detailed April 1961 system package program. The reason for this suspended action was apparent. The Dyna-Soar office was engaged in a study which promised to eliminate suborbital flight, accelerate the date for the first manned orbital launch, and, consequently, radically alter the three-step approach.

CHAPTER III

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CHAPTER IV

REDIRECTION

When Brigadier General M. B. Adams, Deputy Director of Systems Development in Air Force headquarters, forwarded Development Directive 411 in October 1960, he initiated a series of studies which eventually resulted in a redirection of the Dyna-Soar program. General Adams instructed the Air Research and Development Command to formulate a "stand-by" plan for achieving orbital flight with the Step I glider at the earliest possible date.[1] In December, the Dyna-Soar office was ready with such a proposal. By merging Steps I and IIA into a continuous development and employing an orbital booster for both suborbital and orbital flights, the time for the first, manned, orbital launch could be accelerated by as much as 17 months over the three-step schedules.[2]

Depending on either a March 1961 or a November 1961 approval date, Dyna-Soar officials estimated that by using a Titan II in combination with a Centaur derivative, the program would cost either $726 million or $748 million. If Saturn C-1 was designated, the figures would be $892 million or $899 million. The total, however, for a separate suborbital Step I and an orbital Step IIA would approximate $982.6 million. This financial difference between "stand-by" and the three-step approach stemmed from the employment of the same booster for both suborbital and orbital flights. The Dyna-Soar office favored this accelerated approach and recommended that ARDC headquarters immediately approve "stand-by."[3] Command headquarters did not agree and

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took the position that "stand-by" would only be approved when the international situation necessitated a higher priority and additional funds for Dyna-Soar.[4]

The logic of employing the same booster for Steps I and IIA pointed to a further conclusion. On 4 May 1961, Boeing officials proposed another plan for acceleration. This "streamline" 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 the first unmanned, orbital flight to occur in April 1963, instead of August 1964 as scheduled in the three-step approach.[5]

Temporary subsystems would only decrease system reliability, the program office reasoned, and, consequently, Boeing's proposal was not entirely acceptable. Dyna-Soar officials considered that the key to accelerating the orbital flight date was not only the question of booster availability, but also the time required to develop the various glider subsystems. If funding for fiscal year 1962 were increased, it would be possible to accelerate the glider schedules and advance the orbital flight date.

By the end of June, the program office had refined Boeing's original plan. The first phase, "streamline," involved the development of an orbital research vehicle. The purpose of the second phase was the development and testing of military subsystems with the final phase resulting in an operational weapon system. Either a modified Saturn booster, a Titan II with a hydrogen-oxygen second stage, or a Titan II augmented by solid propellant engines, was acceptable for the "streamline" phase. The program office now estimated

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that this phase would cost a total of $967.6 million, with the first unmanned, orbital flight occurring in November 1963.[6]

While the Dyna-Soar office was considering ways to accelerate the orbital flight date of its glider, the newly established Space Systems Division (SSD) completed, on 29 May 1961, two development plans for demonstrating orbital and far-earth orbital flight of a lifting body design. Essentially, the objective of the Advanced Re-entry Technology program (ART) was to determine whether ablative or radiative heat protection was more feasible for lifting re-entry.[7] The second program advanced by SSD was a manned, satellite, inspector proposal, SAINT II.

The space division had under its cognizance a SAINT I program, the purpose of which was the development of an unmanned, prototype, inspector vehicle. The SAINT II proposal involved the development of a manned vehicle, capable of achieving precise orbital rendezvous and fulfilling space logistic missions. This lifting body would be able to maneuver during re-entry and accomplish conventional landing at a pre-selected site. Officials of the space division listed several reasons why the Dyna-Soar configuration could not, in their opinion, accomplish SAINT II missions. The re-entry velocity of Dyna-Soar could not be significantly increased because of the inadapability of this configuration to ablative heat protection. Furthermore, winged-configurations did not permit sufficient payload weights and incurred structural penalties to the booster. Finally, rendezvous and logistic missions would require prohibitive modifications to the Dyna-Soar glider.

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The proposed SAINT II demonstration vehicle was to be a two-man, lifting, re-entry craft, launched by a Titan II and Chariot combination. This Chariot upper stage would employ flourine and hydrazine propellants and would produce 35,000 pounds of thrust. The vehicle would be limited to 12,000 pounds, but, with approval of an Air Force space launch system, the weight could be increased to 20,000 pounds. Twelve orbital demonstration launches were scheduled, with the first unmanned flight occuring early in 1964 and the initial manned launches taking place later that year. From fiscal year 1962 through 1965 this program would require $413.9 million.[8]

After examining the space division proposal and the Dyna-Soar plan for acceleration, General B. A. Schriever, AFSC commander, deferred a decision on Dyna-Soar until the relationship between "streamline" and SAINT II was clarified. Moreover, further analysis of an orbital booster for Dyna-Soar would have to be accomplished.[9]

From 1 through 12 May 1961, a Dyna-Soar technical evaluation board, composed of representatives from the Air Force Systems Command, the Air Force Logistics Command (AFLC), and the National Aeronautics and Space Administration, had considered 13 proposals for orbital boosters from the Convair Division, the Martin Company and NASA. The evaluation board decided that the Martin C plan was the most feasible approach. The first stage of this liquid 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.[10]

The Dyna-Soar Directorate of the Space Systems Division, having the responsibility for developing boosters for System 620A, also made a recommendation on the Step IIA propulsion. On 11 July, Colonel Joseph Pellegrini informed the Dyna-Soar office that his directorate favored employment of the projected Space Launch System A388. This proposal was an outgrowth of an SSD study on a Phoenix series of varying combinations of solid and liquid boosters to be used in several Air Force space missions. Phoenix A388 was to have a solid first stage, which could produce 750,000 pounds of thrust, and a liquid propellant second stage, using the J-2 engine.[11]

On 3 and 4 August 1961, Colonel Walter L. Moore, Jr., director of the Dyna-Soar program, brought the "streamline" proposal before the Strategic Air Panel, the Systems Review Board, and the Vice Chief of Staff. The program director pointed out that 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 be accelerated but considerable financial savings would also accrue. Colonel Moore now estimated that the combined cost of Steps I and IIA was projected at $1.201 billion, while the figure for "streamline" would run $1.026 billion. The director concluded by emphasizing that Dyna-Soar provided the most effective solution to an Air Force, manned, space program, and "streamline" was the most expeditious approach to piloted, orbital flight.[12]

Officials from SSD and the Aerospace Corporation presented their considerations for a "streamline" booster. At this point, it was clear that previous SSD evaluations for a Step IIA booster were simply incorporated in the "streamline" analysis. The first choice of Aerospace and SSD officials was again their proposed Phoenix space launch system. Assuming a November 1961 approval date, Phoenix A388 allowed the first, unmanned launch to occur in July 1964, and, based on an 18-flight Dyna-Soar program, the cost for Phoenix development from fiscal year 1962 through 1966 would total $183.3 million. The second option was the Soltan, 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 and the cost would total $267.2 million, this booster was the third choice, largely because it was deemed less reliable. The space division representatives then concluded their part of the presentation by discussing the merits of ART and SAINT II.[13]

The Assistant Secretary of the Air Force for Research and Development, Dr. Brockway McMillan, was not as enthusiastic for acceptance of the Phoenix system. While he did not recommend use of the Saturn, Dr. McMillan thought that the Air Force should seriously consider the fact that the big NASA booster would provide the earliest launch date for Dyna-Soar. The assistant secretary believed, however, that an Atlas-Centaur combination would be the most feasible space launch vehicle for 10,000 pound payloads through 1965. After this time period, Dr. McMillan favored Soltan.[14]

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Prior to these briefings, General Schriever was already convinced that Dyna-Soar had to be accelerated. He further believed that the best selection for the booster was Phoenix A388.[15] On 11 August, he informed ASD, SSD and his Deputy Commander for Aerospace Systems, Lieutenant General H. M. Estes, Jr., that "streamline" had the approval of AFSC headquarters and had to be "vigorously supported" by all elements of the command. Yet, the acceleration of Dyna-Soar was not that simple. The AFSC commander was still concerned over the duplication of the manned, SAINT proposal and an orbital Dyna-Soar. He stated that these plans constituted a complex, and, at that point, an indefinable approach to military space flight which could not be presented to USAF headquarters. Consequently, General Schriever directed that a Manned, Military, Space, Capability, Vehicle study be completed by September. This proposed program would consist of "streamline," and a Phase Beta study which would determine vehicle configuration, boosters, military subsystems, and missions for an operational system which would follow Dyna-Soar. General Schriever also directed that the applied research programs of his command be reviewed to assure contributions to Dyna-Soar and far-earth orbital flights.[16]

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 acceleration.* He directed the three-step

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*In early April 1961, Lieutenant General R. C. Wilson, Deputy Chief of Staff for Development, appeared concerned with the management of Air Force

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approach to continue until the position of Dyna-Soar in a manned, military space program was determined. Within the confines of the $100 million fiscal year 1962 budget, the secretary stated that action could be taken to facilitate the transition from a Step I to a "streamline" program. Finally, he requested a study on various approaches to manned, military, orbital flight.[18]

Under the direction of General Estes, a committee was formed in mid-August 1961 with representation from the Air Force Systems Command, RAND, MITRE, and the Scientific Advisory Board for the purpose of formulating a manned, military, space plan. The work of the committee was completed by the end of September with diverse sets of recommendations.

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headquarters over the Dyna-Soar program. Although the Air Staff had devoted considerable attention to this program, it had not always been successful in affecting the decisions of the Secretary of the Air Force or the Secretary of Defense. General Wilson indicated to General C. E. LeMay, the Vice Chief of Staff, that this situation could be alleviated if the program were placed under the management of the Air Force Ballistic Missile and Space Committee. General LeMay, on 5 May, concurred and pointed out that the Department of the Air Force would have to place increasing emphasis on Dyna-Soar because it was a system leading to manned space flight. Dr. J. V. Charyk, the Air Force under secretary, disagreed and thought that since Dyna-Soar was primarily a research project, transfer of the management in the department should be deferred until a Dyna-Soar weapon system was under development. On 25 July, the Secretary of the Air Force replaced the ballistic and space committee with the Designated Systems Management Group. Composed of important officials in the Department of the Air Force, this group was to assist the Secretary of the Air Force in managing significant programs. By 1 August 1961, the Dyna-Soar program was listed as one of the systems under the jurisdiction of the designated management group.[17]

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One of the working groups, chaired by a representative from the Aerospace Corporation, favored terminating the Dyna-Soar program and redirecting Boeing's efforts to the development of a lifting body. Such an approach would cost $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, this group considered, was to implement "streamline," and initiate a Phase Beta. Such a program would be the most expensive, totaling $2.8 billion.[19]

The opposite position was assumed by a panel of Scientific Advisory Board members, chaired by Professor C. D. Perkins, which strongly supported the last alternative of the Aerospace group. The Perkins group thought that military applications of a lifting body approach did not offer more promise than Dyna-Soar. To emphasize this point, the group questioned the control characteristics of a lifting body design which could make the execution of conventional landings hazardous. The group further argued that "streamline" should be directed towards defining military space objectives and insisted that a Phase Beta and an applied research program should be undertaken before considering an advanced Dyna-Soar vehicle.[20]

General Estes reached his own conclusions about a manned, military, space study. "Streamline" should receive Air Force approval; however, it should have unquestionable military applications, namely satellite inspection and interception missions. The deputy commander doubted that a Dyna-Soar vehicle could accomplish far-earth orbital flights and undergo the resulting re-entry velocity, ranging from 35,000 to 37,000 feet per second, and, consequently, he firmly stated that a Phase Beta study, conducted by Boeing, was necessary to determine a super-orbital design for Dyna-Soar.[21]

Secretary of Defense Robert S. McNamara also made a pronouncement on Dyna-Soar. After hearing presentations on the program and the military, space proposal of SSD, the secretary seriously questioned whether Dyna-Soar represented the best expenditure of national resources.[22] From this encounter with the defense department, the Air Staff derived a concept which was to dominate the Dyna-Soar program. Before military applications could be considered, the Air Force would have to demonstrate manned, orbital flight and safe recovery.[23]

During a meeting of the Designated Systems Management Group in early October 1961, it was very clear that the Air Force had decided in favor of "streamline." The management group had severely criticized SAINT II, by insisting that the projected number of flight tests and the proposed funding levels were too unrealistic. As a result of this review, the Department of the Air Force prohibited further use of the SAINT designation.[24]

Dyna-Soar officials completed, on 7 October 1961, an abbreviated development plan for a manned, military, space, capability program. The plan consisted of "streamline"; a Phase Beta study, which would determine approaches to the design of a super-orbital Dyna-Soar vehicle; supporting technological test programs; and an applied research program. The objectives of the proposed Dyna-Soar plan were to provide a technological basis for manned, maneuverable, orbital systems; determine the optimum configuration for super-orbital missions, and demonstrate the military capability of both orbital and super-orbital vehicles.

The program office considered the Phoenix system acceptable but derived, instead, a new two-step program based on the employment of Titan III, which differed from Soltan by using two 120-inch diameter solid propellant engines. While Dyna-Soar I would encompass the "streamline" proposal, Dyna-Soar II would involve the development of a far-earth, orbital vehicle. The program office anticipated the first, unmanned, orbital flight in November 1964, and the first, piloted flight in May 1956. The next five flights would be piloted with the purpose of accomplishing multiorbital missions. The ninth flight test, occurring in June 1966, however, would be an unmanned exploration of super-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 considered that $162.5 million would be required for fiscal year 1962, $211.7 million for 1963, $167.4 million for 1964, $168.6 million for 1965, $99.0 million for 1966, $21.0 million for 1967, and $2.4 million for 1968. With $88.2 million expended prior to fiscal year 1962, these figures would total $921 million for the development of a manned, military, Dyna-Soar vehicle.[25]

On 15 October 1961, Colonel B. H. Ferer of the Dyna-Soar system staff office, USAF headquarters, requested W. E. Lamar, Deputy Director for Development in the Dyna-Soar office, to brief Dr. Brockway McMillan and a military, manned, spacecraft panel, convened to advise the Secretary of Defense. Mr. Lamar gave a comprehensive narrative of the history of Dyna-Soar and its current status to the assistant secretary. While Dr. McMillan approved the briefing as suitable for the spacecraft panel, he requested Mr. Lamar not to emphasize military applications at that time. The briefing to the panel followed, but Colonel Ferer once again called Lamar. The deputy for development was rescheduled to brief Dr. L. L. Kavanau, Special Assistant on Space in the Department of Defense. Dr. Kavanau appeared quite interested in the various alternatives to accelerating Dyna-Soar and finally stated that it was sensible to go directly to an orbital booster.[26]

Based on the October proposal, General Estes prepared another development plan for Dyna-Soar. This approach was presented in a series of briefings to systems command headquarters, the Air Staff, and, on 14 November, to the Designated Systems Management Group.[27] The central objective was to develop a manned, maneuverable vehicle, capable of obtaining basic research data, demonstrating re-entry, testing subsystems, and exploring man's military function in space. These objectives were to be achieved by adapting the Dyna-Soar glider to a Titan III booster, in place of the previously approved, suborbital Titan II.*

The Dyna-Soar office considered two alternate funding plans. Plan A adhered to the established $100 million ceiling for fiscal year 1962, set $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 ground-launch by November 1964. Plan B followed the ceilings of $100 million for fiscal year 1962 and $125 million for fiscal year 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 ground-launch. Regardless of which approach was taken, the proposed program would substantially accelerate the first, manned, orbital flight from 1967 to 1965.[29]

On 11 December 1961, Air Force headquarters informed the systems command that the Secretary of the Air Force had agreed to accelerate the Dyna-Soar program. The suborbital phase of the old three-step program was eliminated, and the central objective was the early attainment of

*While accepting the standard space launch concept, the Department of Defense decided against the employment of a Phoenix system and, on 13 October, informed Dr. McMillan that Titan III was to be the Air Force space booster.[28]

orbital flight, with the Titan III booster. Plan B of the November 1961 development plan was accepted, and $100 million for fiscal year 1962 and $125 million for 1963 was stipulated. Finally, the Air Staff instructed the Dyna-Soar office to present a new system package program to headquarters by early March 1962.[30]

Colonel Moore set the following tentative target dates to be considered in reorienting the program: the first air-launch in July 1964; the first, unmanned, orbital ground-launch in February 1965; and the first, manned, orbital ground-launch in August 1965. The program director commented that the advancement of the program to an orbital status represented a large step toward meeting the over-all objectives of Dyna-Soar.[31]

The program office then issued instructions to its contractors, the Boeing Company, the Minneapolis-Honeywell Regulator Company, and the Radio Corporation of America, pertaining to the redirected program. The tentative dates offered by Colonel Moore were to be used as guidelines for establishing attainable schedules. The Dyna-Soar glider was to be capable of completing one orbit with all flights terminating at Edwards Air Force Base, California. The system office informed the contractors that no requirements existed for maneuvering in space nor for the development of military subsystems. The contractors were to make only a minimum number of changes to the glider and the transition section in order to adapt the airframe to the Titan IIIC. To conform to budget restrictions, a serious reduction in program scope was 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 terminate in

April 1965. The first two ground-launches were to be unmanned, and the remaining eight were to be piloted.[32]

On 27 December 1961, the Deputy Chief of Staff for Systems and Logistics, USAF headquarters, issued System Program Directive 4, which reiterated the program objective announced in the November 1961 development plan. The deputy chief of staff emphasized the Air Force view that man would be required to perform missions essential to national security in space. The Dyna-Soar program would provide a vehicle which offered an economical and flexible means to return to a specific landing site, and, consequently, would fulfill a vital military need not covered in the national space program. The directive specified that Titan IIIC was to be the booster, and that only single orbits were contemplated for each ground-launch. Although Air Force headquarters chose the low funding level of Plan B, $100 million for fiscal year 1962 and $115 million for 1963, headquarters also insisted on the accelerated flight dates of Plan A.[*] The deputy chief of staff would accept later flight dates only if an examination by the systems command revealed the impossibility of achieving such a schedule. Lastly, a new system package program had to be completed by March 1962.[33**]

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*The flight schedule of Plan A in the November 1961 development plan stipulated April 1964 for the air-launch program, November 1964 for the unmanned ground-launch, and May 1965 for the manned ground-launch.

**Major General W. A. Davis, ASD commander, protested that the March 1962 date was an arbitrary limitation and did not allow the system office enough time to reshape the program. Air Force headquarters apparently received this recommendation favorably because, on 2 February 1962, the Deputy Chief of Staff for Systems and Logistics issued an amendment to the system program directive of 27 December 1961, extending the completion date of a new system package program to the middle of May 1962.[34]

To give further legal sanction to the redirected program, Air Force headquarters, on 21 February 1962, issued an amendment to the advanced development objective, dated 21 July 1960.* This amendment deleted references to suborbital flights and to the development of military subsystems. Air Force headquarters, however, did state that a reliable method for routine recovery of space vehicles would make military missions practical. The amendment further stipulated that the program was oriented to single orbital flights, with the first, unmanned ground-launch occurring in November 1964.[35]

In a memorandum of 23 February 1962, Secretary McNamara officially endorsed the redirection of the Dyna-Soar program. He directed the termination of the suborbital program and the attainment of orbital flight, by employment of the Titan IIIC booster. The funding level was limited to $100 million in fiscal year 1962 and $115 million in 1963. Finally, Secretary McNamara insisted on a redesignation of the Dyna-Soar program to a nomenclature more suitable for a research vehicle.[36]

By the end of February, a draft version of the system package program was completed, and, in the middle of March, the program office offered the preliminary outlines to AFSC and Air Force headquarters. The central point of this briefing was that the $115 million fiscal year 1963 ceiling

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*This advanced development objective had been previously designated System Development Requirement 19, issued on 21 July 1960.

would endanger the attainment of desired system reliability and would also limit the flight profile of the glider. As a result of these presentations, Air Force headquarters instructed the systems command to prepare a briefing for the Department of Defense.[37]

On 17 April, officials of the Dyna-Soar office made a presentation to Dr. Harold Brown, Director of Defense for Research and Engineering. The program office wanted approval of a $12.2 million increase for fiscal year 1963 and, also, an additional $16.7 million to realize an unmanned ground-launch date of May 1965. Dr. Brown offered to give both proposals further consideration and requested the Dyna-Soar office to present alternative funding levels to meet a May or July 1965 unmanned launch date.[38]

By 23 April 1962, the system package program was completed. The objective of the new Dyna-Soar program had been clearly announced by the November 1961 development plan and was reiterated in this more elaborate proposal. Dyna-Soar was a research and development program for a military, test system to explore and demonstrate maneuverable re-entry of a piloted, orbital glider which could execute conventional landing at a pre-selected site. For the Dyna-Soar office, the new program represented a fundamental step towards the attainment of future, piloted, military, space flight.

Prior to redirection in December 1961, the Dyna-Soar system office had final authority over the Step I booster being developed by the space division. Under the new program, however, the Dyna-Soar glider would only be one of the payloads for the standard space launch system, designated

624A. Titan IIIA formed the standard core and was essentially a modified Titan II with a transtage composed of an additional propulsive unit and a control module. This version of the standard launch system, although it had no assigned payload, as yet, was capable of placing 7,000 pounds into an orbit of 100 nautical miles. The Dyna-Soar glider, however, was scheduled to ride the Titan IIIC booster. This launch system was derived from the standard core with an attached first-stage of two, four-segment, solid, rocket motors, capable of delivering a total of 1,760,000 pounds of thrust.* The second and third stages were liquid propulsive units and would produce 474,000 and 100,000 pounds of thrust, respectively. Titan IIIC could place a maximum of 25,000 pounds in low-earth orbit, however, for the particular Dyna-Soar trajectory and conditions, the payload capability was 21,000 pounds.[40]

The flight test program was defined in three phases. One Dyna-Soar glider was now scheduled to accomplish 20 air-launches from a B-52C aircraft to determine glider approach and landing characteristics, obtain data on lift-to-drag ratio and flight characteristics at low supersonic velocities, and accumulate information on the operation of the glider 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.

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*Late in May 1962, the Assistant Secretary McMillan requested the Dyna-Soar office to investigate the impact of employing a five-segment Titan IIIC on the program. Although this change would necessitate glider modifications amounting to $5.4 million, the program office recommended that the five-segment configuration be selected for Dyna-Soar, and command headquarters concurred on 25 July.[39]

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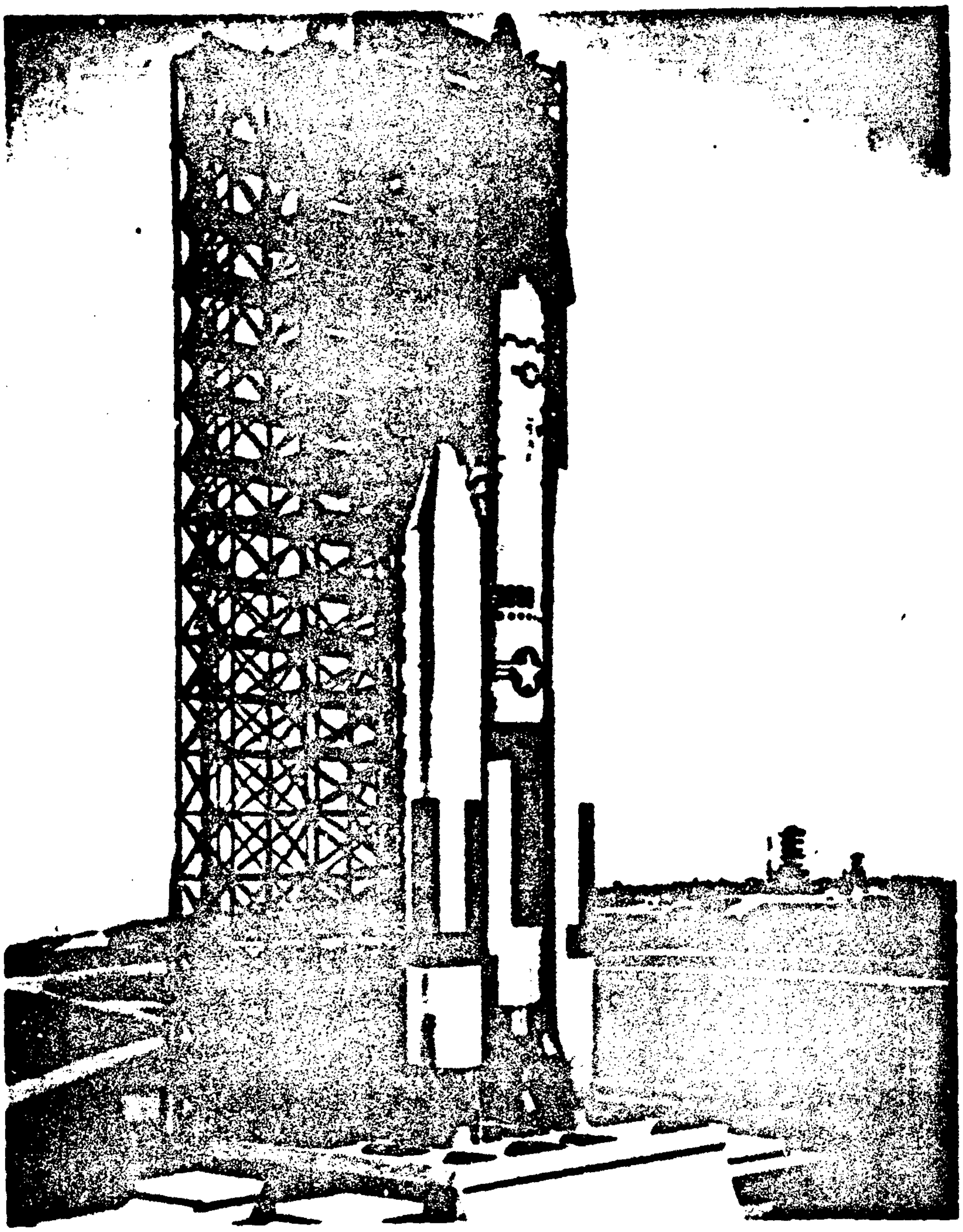

Figure 1. Titan IIIC and Dyna-Soar prior to launch (artist's drawing).

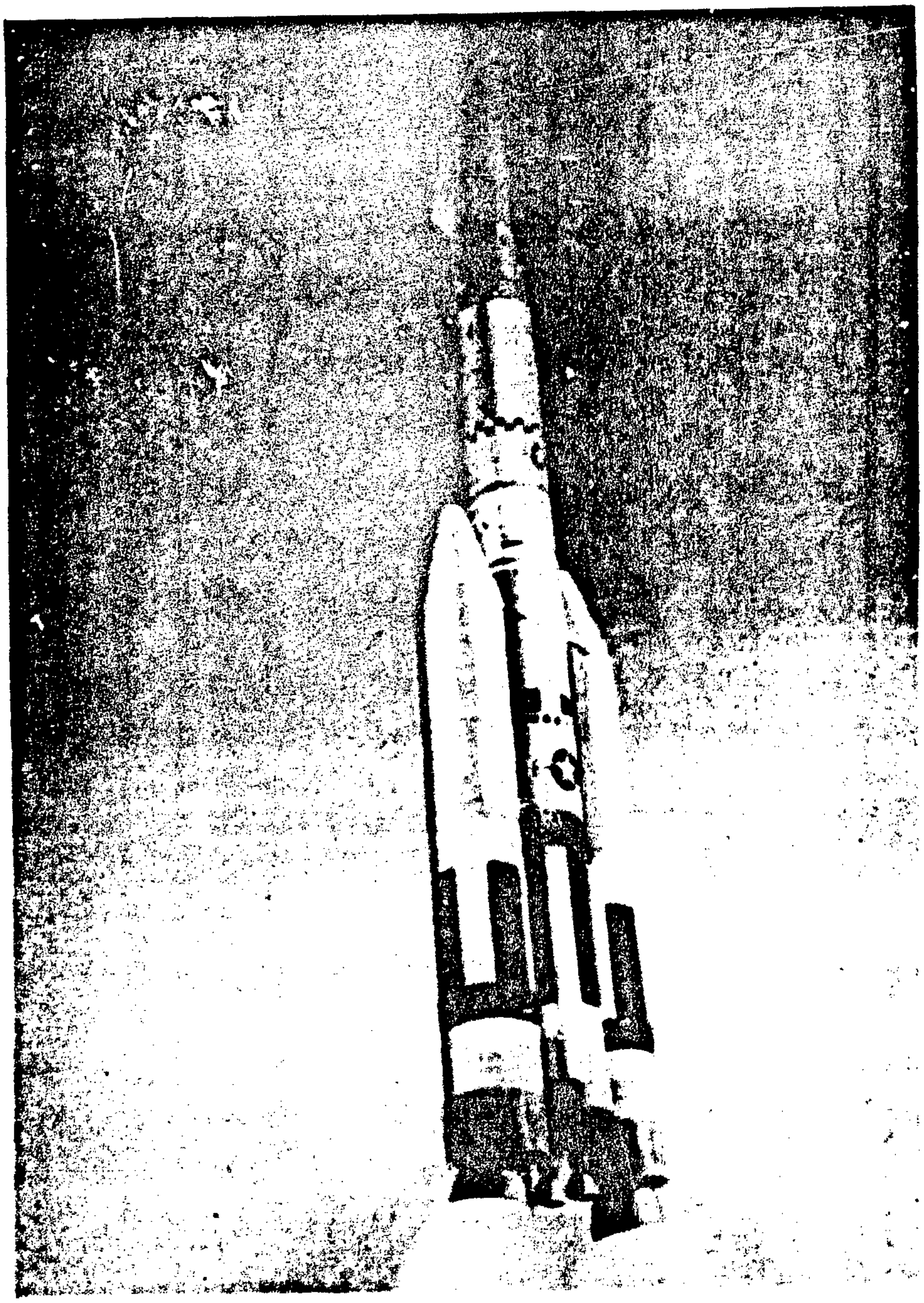

Figure 2. Dyna-Soar flight during solid-stage burning.

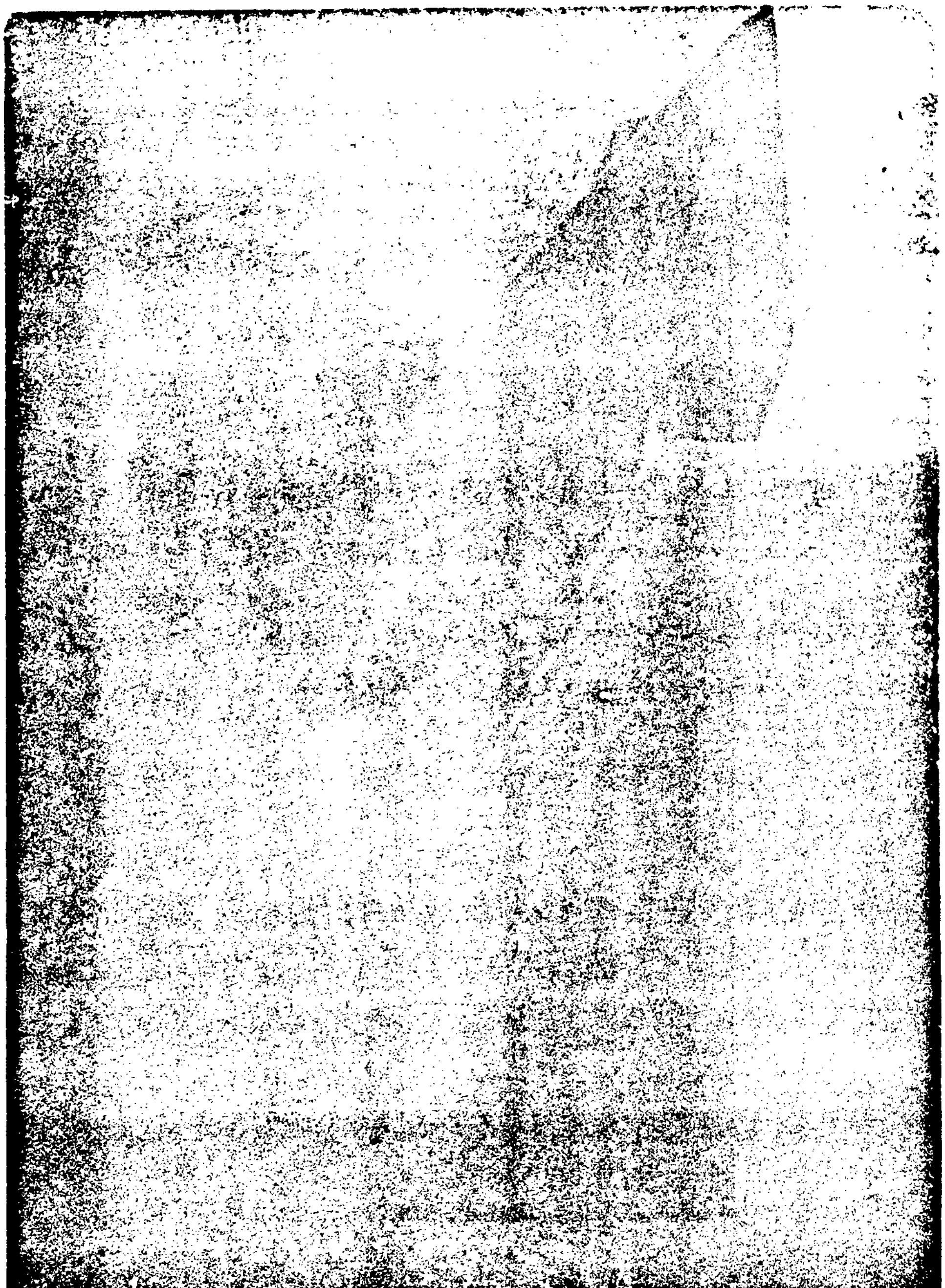

Figure 3. Second-stage ignition.

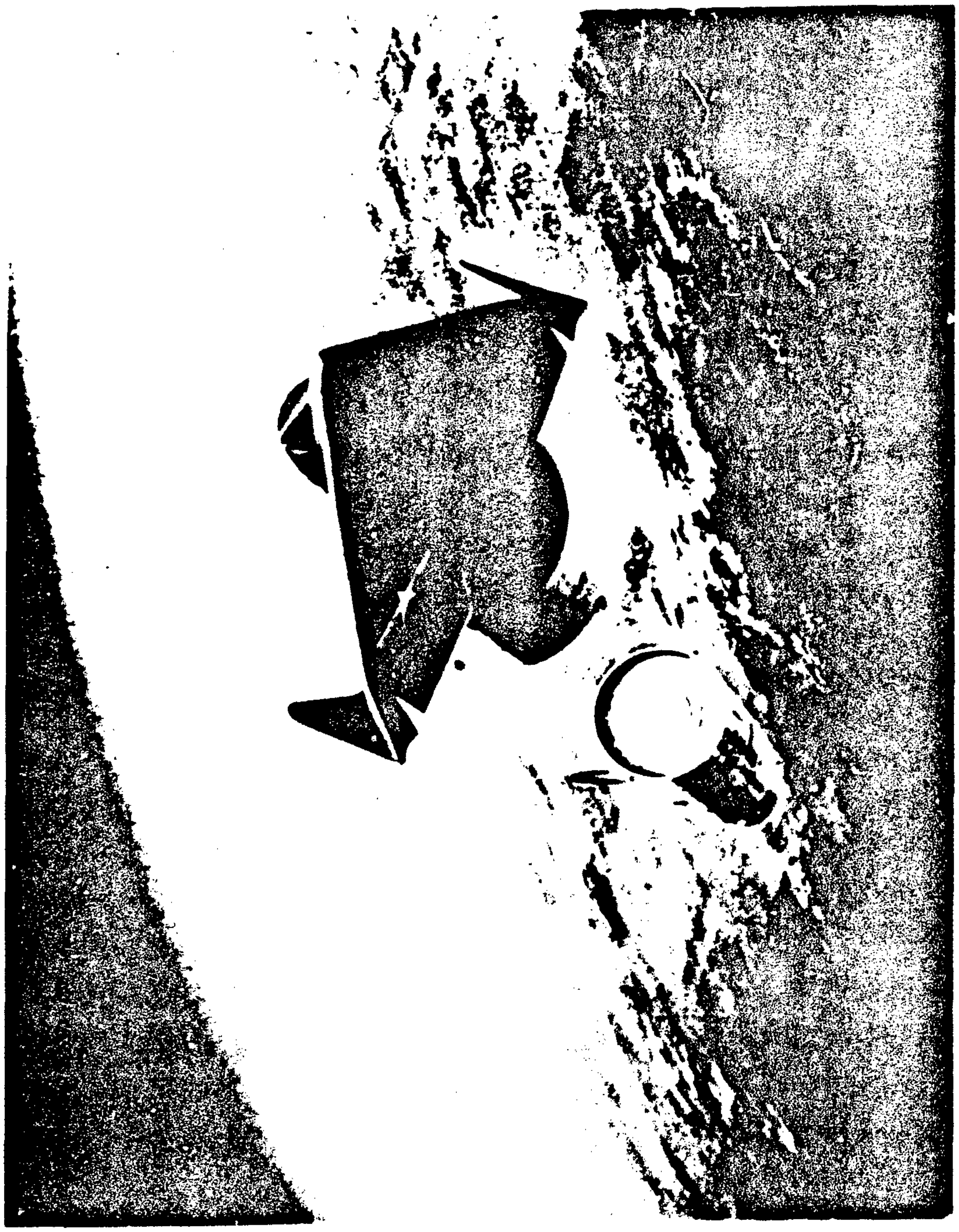

Figure 4. Transtage separation.

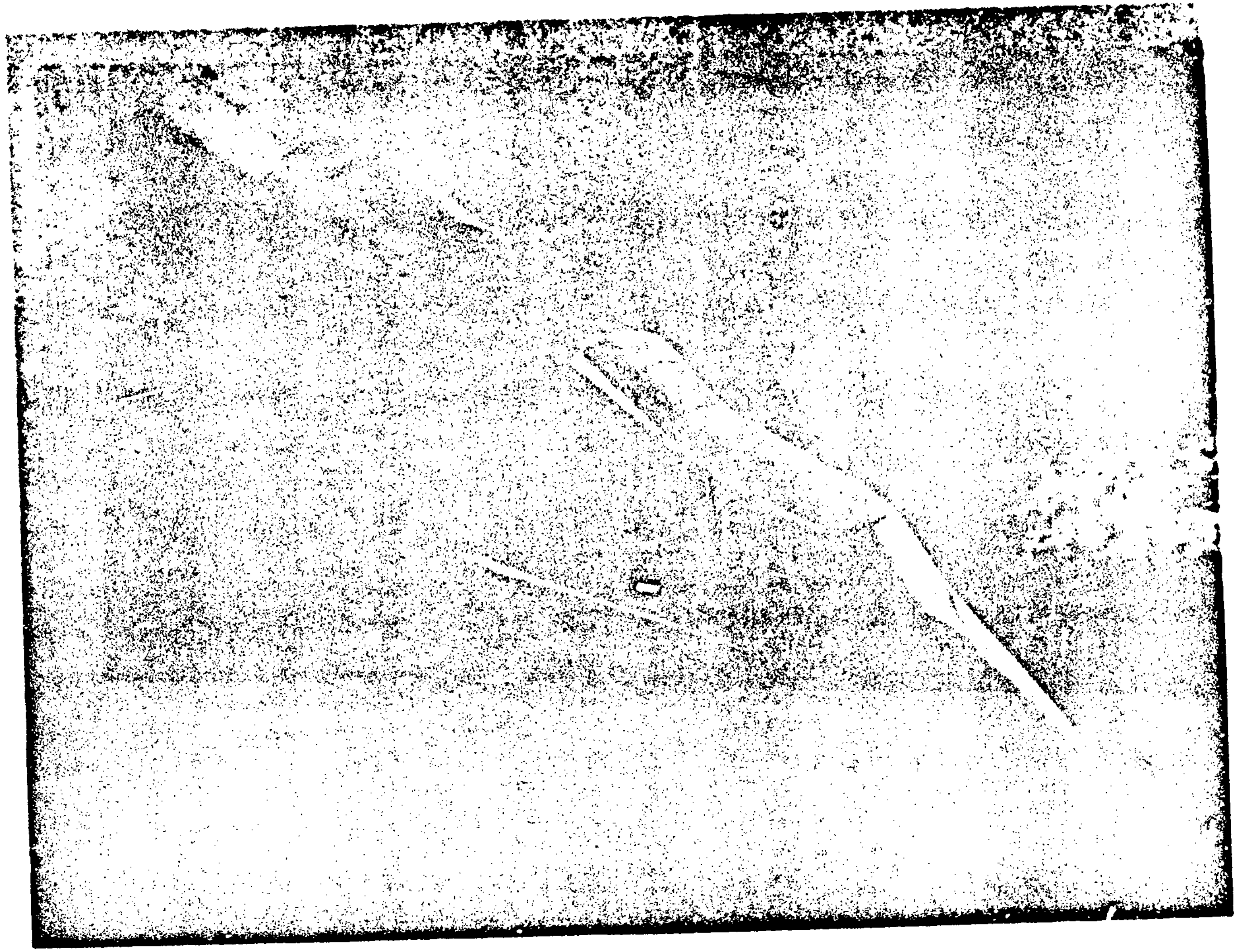

Figure 5. Transition section separation.

Figure 6. Beginning of re-entry glide.

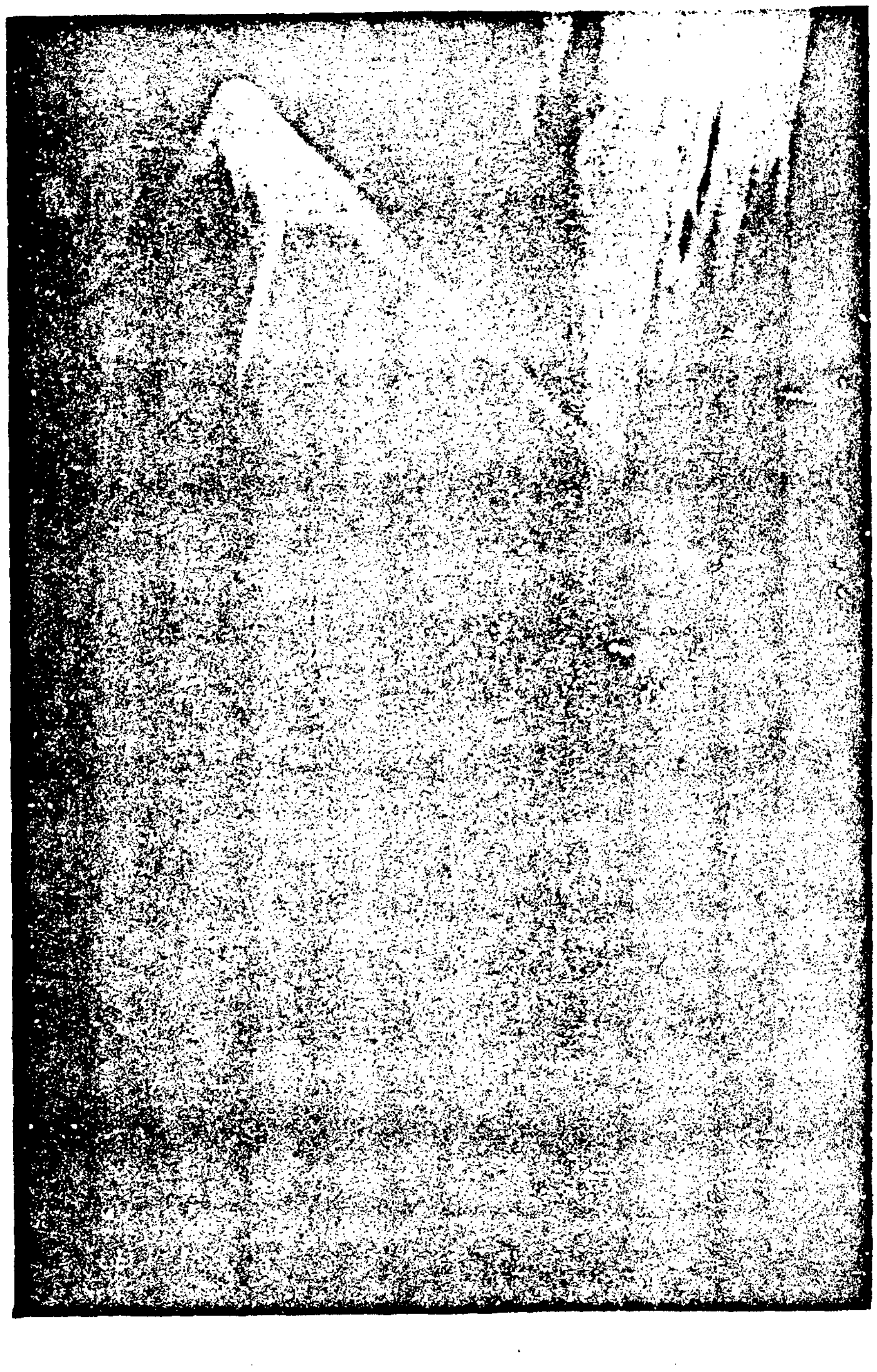

Figure 7. Re-entry glide during high temperature regime.

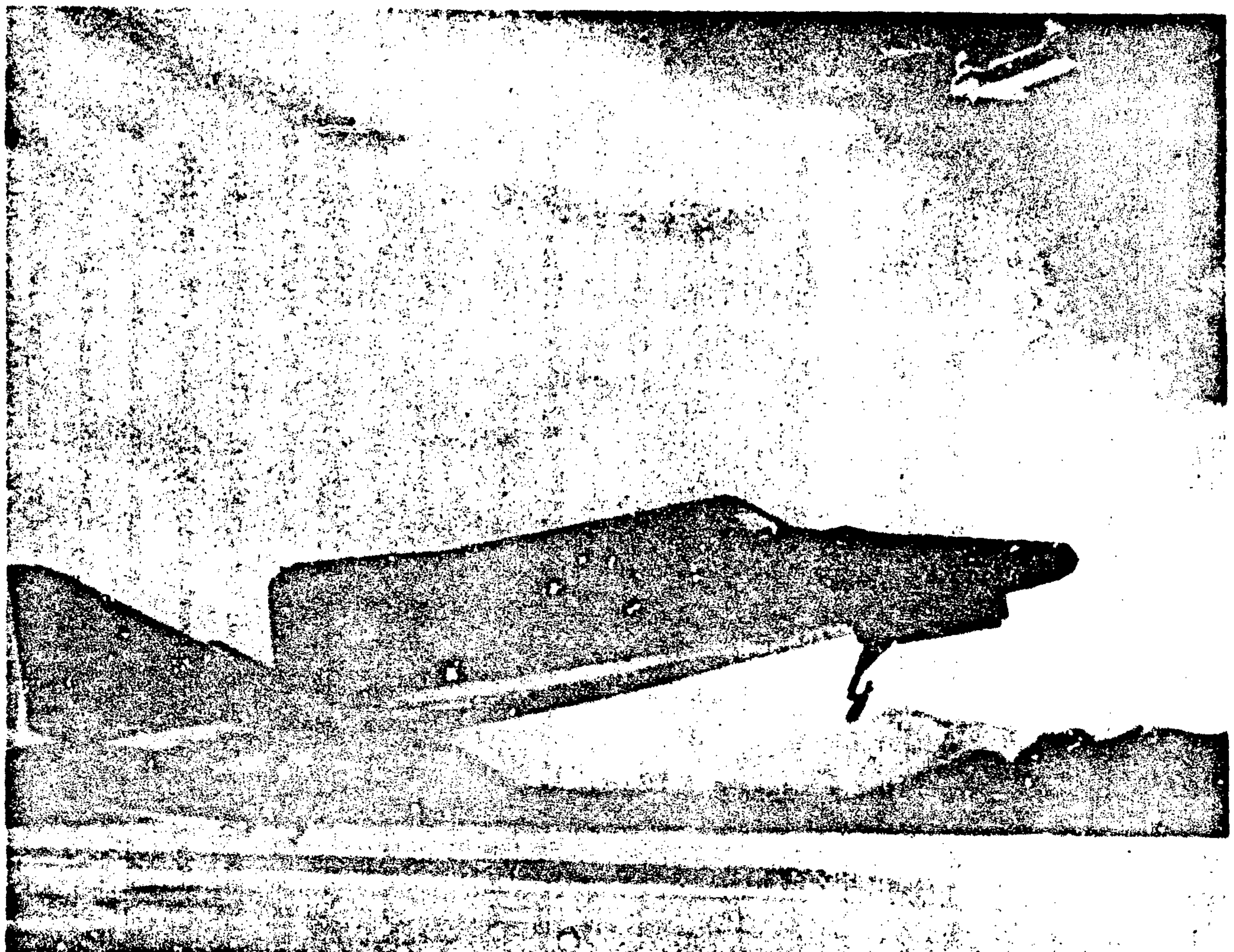

Figure 8. Landing.

Following the air-launch program, two, unmanned, orbital launches would occur. The purpose was to verify the booster-glider system as a total vehicle for piloted flight, and demonstrate glider-design for hypersonic velocities. The Titan IIIC would propel the glider to a velocity of 24,490 feet per second, and after fulfilling its orbital mission, the vehicle would land at Edwards Air Force Base by employment of the drone-landing techniques. Eight, piloted, orbital flights were to follow, further exploring and defining the Dyna-Soar flight corridor.

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 was to be conducted in May 1965, with the second, unmanned flight occurring in August 1965. The first, piloted flight was scheduled for November 1965 and the last, manned, orbital mission for the beginning of 1967. The Dyna-Soar office had hopefully attempted to obtain the earliest possible launch dates and still remain within the $115 million fiscal year 1963 ceiling set by USAF headquarters on 27 December 1961.[41]

On 25 April 1962, General Davis forwarded the system package program for the approval of AFSC headquarters. In line with Dr. 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 was required for fiscal year 1963 and $133.1 million for 1964. If the first, unmanned launch was to occur in July 1965, then $127.2 million was needed for fiscal year 1963 and $133.1 million for 1964.[42*]

*General Davis also pointed out that the Pacific Missile Range of the Department of the Navy had issued a financial requirement of $100

Following completion of the system package program, a series of presentations were made to elements of AFSC headquarters, Air Force headquarters and the Department of Defense. To remain within the $115 million fiscal year 1963 ceiling, the Dyna-Soar office was forced to reduce the development test program, thereby decreasing the reliability of the glider system and limiting the scope of the flight test program. During one of the briefings to the Department of Defense, Dr. Brown recommended significant changes to the Dyna-Soar program. Additional funds would be allotted for further development testing, and most important, the Dyna-Soar glider was to fulfill multiorbit missions.[44]

On 14 May, the program office had completed a revision of its system package. The wind tunnel program was expanded. Glider and panel flutter tests were added. Work to increase the heat resistant ability of certain sections of the glider was contemplated. Refinement of the glider design and dynamic analysis of the air vehicle vibration were additional tasks. The program office further scheduled additional testing of the reaction control, the environmental control, and the guidance systems. A more comprehensive reliability program for the glider and the communication and tracking systems was to

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million for the construction of four vessels which would be employed in the Dyna-Soar program. The ASD commander emphasized that other space programs would eventually use these facilities, and, consequently, this cost should not be fully attributed to System 620A. 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 agreed that ship costs of $36 million and a total range requirement of $49 million were directly related to the Dyna-Soar program. Because of subsequent revisions to the program, range officials then submitted an increased estimate of $69 million for both the 10 October 1962 and the 11 January 1963 system package programs. The Dyna-Soar office did not concur with this figure, however, total range costs relating to System 620A were agreeably reduced to $48.888 million in May 1963.[43]

be inaugurated, and an analysis of a means to reduce the weight of the glider subsystems was to take place.

For the Dyna-Soar office, multiorbital missions were a logical and relatively inexpensive addition to the basic program and would probably be scheduled for the fifth or sixth ground-launch. Such a demonstration, in the opinion of the Dyna-Soar office, was a prerequisite to more extensive exploration of the military function in piloted, space flight. Multiorbital missions, however, necessitated modification of the guidance system, increased reliability of all subsystems, and the addition of a de-orbiting unit.

Previously, a single-orbit, Dyna-Soar mission did not require the employment of a de-orbiting system, largely because the flight profile was only an around-the-world, ballistic trajectory. The Dyna-Soar office considered two alternatives for equipping the glider with a de-orbiting ability. One possibility was to place a system in the transition section of the glider. Another approach, actually chosen, was 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 de-orbiting propulsion.

Along with these additions to the system package program, the Dyna-Soar office submitted a new funding schedule. The requirement was $152.6 million for fiscal year 1963, $145.2 million for 1964, $113.7 million for 1965, $78.3 million for 1966, and $17.7 million for 1967. This proposal would set the total cost for the Dyna-Soar program at $682.1 million.[45]

[redacted]

Before the Department of Defense acted on these revisions, the system office and Air Force headquarters had to determine a new designation for Dyna-Soar, more accurately reflecting the experimental nature of the program. In his February memorandum, Secretary of Defense McNamara directed Secretary Zuckert to replace the name "Dyna-Soar" with a numerical designation, such as the X-19. Mr. J. B. Trenholm, Jr., assistant director of the program office, requested his director for program control to derive a new nomenclature for Dyna-Soar. The assistant director added that the program office should offically request retention of "Dyna-Soar" as the popular name. Whatever the designation, Air Force headquarters required it by April.[46]

Following Air Force regulations, the director for program control reluctantly submitted ARDC form 81A, offering the designation, XJN-1 and, at the same time, requested use of "Dyna-Soar." Colonel Ferer at USAF headquarters did not concur with the XJN-1 label but offered instead XMS-1, designating experimental-manned-spacecraft. Other elements in Air Force headquarters and in the Department of Defense objected to both designations. Finally, on 19 June 1962, USAF headquarters derived and approved the designation, X-20.[47] On 26 June, a Department of Defense news release explained that this new designation described the experimental character of the program.[48] By the middle of July, Air Force headquarters allowed the word, "Dyna-Soar," to stand with X-20.[49]

On 13 July 1962, USAF headquarters informed the systems command that the Secretary of Defense conditionally approved the 14 May revision of the system package program. Instead of the requested $152.6 million

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for fiscal year 1963, Secretary McNamara authorized $135 million and insisted that future funding would not exceed this level. He further stipulated that Dyna-Soar schedules would have to be compatible with Titan IIIC milestones and that technical confidence and data acquisition in the X-20 program would have precedence over flight schedules. Air Force headquarters then directed the program office to make appropriate changes to the system package as soon as possible.[50]

In spite of the fact that the Dyna-Soar program had been redirected, funds and approval were still lacking for System 624A, Titan III. Since the X-20 was scheduled to ride the fourth development shot of Titan IIIC, flight dates for Dyna-Soar could not be set until the Titan schedule was determined. On 31 August 1962, the space division informed the X-20 office that calendar dates for booster launchings could not be furnished until funding had been released. This was expected by November, with program development beginning in December 1962. The first Titan IIIC launch would occur 29 months later, and the fourth shot (the first, Dyna-Soar, unmanned launch) would take place 36 months after program "go-ahead."[51]

Based on this Titan IIIC scheduling assumption, the X-20 system office completed, on 10 October, another system package program. Twenty air-drop tests were to be conducted from January through October 1965. Two unmanned, orbital launches were to occur in November 1965 and February 1966. The first of eight, piloted flights was to take place in May 1966, with a possible multiorbit launch occurring in November 1967.* The Dyna-Soar

*These X-20 schedules proved compatible with the Titan III schedules, for on 15 October 1962, Air Force headquarters issued System Program Directive 9. This authorized research and development of the space booster to begin on 1 December 1962 with a total of $745.5 million from fiscal year 1962 through 1966.

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office stipulated that $135 million would be required in fiscal year 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. The program would require $766.23 million for the development of the orbital X-20 vehicle.[52] Major General R. G. Ruegg, ASD commander, submitted this system package program to AFSC headquarters on 12 October 1962, however, it never received command endorsement.

While the X-20 office was concerned with Titan III schedules and approval of a new package program, AFSC headquarters directed a change in the organization of ASD which had possible significance for the Dyna-Soar program. On 28 September 1962, the systems command directed that the function of the ASD Field Test Office at Patrick Air Force Base, Florida, be transferred to the 6555th Aerospace Test Wing of the Ballistic Systems Division.[53]

Previously ARDC headquarters had established, on 4 August 1960, a general policy on test procedures which firmly placed control of system testing in the various project offices rather than the test centers.[54] With headquarters approval, the Dyna-Soar office appointed a test director for the entire Category II program and directed that the Air Force Flight Test Center provide a Deputy Director for Air-Launch and the WADD Field Test Office at Patrick Air Force Base, a Deputy Director for Ground-Launch.[55] The test centers, however, objected to giving the project offices full authority, largely because such a policy did not fully utilize their ability to conduct flight test programs. Consequently, on 31 January 1962, General

Schriever rescinded the August 1960 policy and directed that, while over-all authority still rested in the program offices, the centers and test wings would prepare and implement the test plans and appoint local test directors.[56] While the purpose of this new policy was to give the test centers more authority in the test program, 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.[57]

Throughout these changes in the Dyna-Soar test structure, the 6555th Aerospace Test Wing of the Ballistic Systems Division had authority only during the operation of the booster. With the transfer of the functions of the ASD field office to this test group, however, the aerospace wing became, in effect, the director of the orbital flight tests. This test group was responsible to the commander of BSD, who, in the instance of conflicting requirements of various assignments, would determine priorities for the operations of his test wing.[58]

In an effort to conserve program funds, the X-20 office formulated a flight test program, the "Westward-Ho" proposal, which would eliminate the necessity 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, and also a recovery center at Edwards Air Force Base. "Westward-Ho" simply proposed 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, who would be responsible in turn 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.[59]

The "Westward-Ho" logic of the X-20 office was not apparent to AFSC headquarters. On 19 December, the AFSC vice commander, Lieutenant General Estes, directed the establishment of a manned, space flight, review group, for the purpose of examining all aspects of the X-20 test program including the relationships of the various AFSC agencies. Brigadier General O. J. Glasser of the Electronic Systems Division was named chairman of this group, which was to be composed of representatives from AFSC headquarters, the aeronautical division, the space division, the missile test center and the missile development center.[60]

Colonel Moore noted that the Air Force Flight Test Center, the key agency in "Westward-Ho" had not been permitted representation at this review. Furthermore, he had offered to familiarize the committee with a presentation on the Dyna-Soar test requirement, but this proposal was rejected.[61] The significance of the coming review was not entirely clear to the X-20 program office.

General Glasser's committee formally convened on 3 and 23 January and 5 February 1963. While no decisions were made 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 was clear that "Westward-Ho" impinged on the interests of the Air Force Missile Development Center, the Space Systems Division, and the Air Force Missile Test Center. General Glasser, however, emphasized the central problem confronting the Dyna-Soar program: the open conflict between the Space Systems Division and the Aeronautical Systems Division for control of the only Air Force, manned, space program. The Organization and Management Panel offered some solutions to this problem. First, management of the program by AFSC headquarters would have to be altered. Like the Titan III program, the Dyna-Soar system should be placed under the guidance of the Deputy to the Commander for Manned Space Flight instead of the Deputy Chief of Staff for Systems. More important, the panel strongly recommended that the entire program be reassigned to the Space Systems Division. General Glasser did not favor such a radical solution but thought that a single AFSC division should be made the arbiter for both the Titan III and X-20 programs.[62]

While designating his deputy for manned space flight as a headquarters point of contact for the Dyna-Soar program, General Schriever, on 9 May 1963, altered the structure of the X-20 test force. He directed that the Space Systems Division would name the director for X-20 orbital flights, with the flight control center being located at the Satellite Test Center, Sunnyvale, California. The commander of AFSC did emphasize, however, that the Aeronautical Systems Division was responsible for the development of the X-20.[63] At the end of July, General Schriever also assigned responsibility for the air-launch program and pilot training to the space division.[64]

Although the Air Force had undertaken a manned, military, space study in 1961, the Department of Defense still had not determined a military, space mission for the Air Force. While the 1961 study had essentially compared the Dyna-Soar glider with a SAINT II lifting body, Secretary McNamara was also interested in the military potentialities of the two-man, Gemini capsule of NASA. In his 23 February 1962 memorandum, the Secretary of Defense expressed interest in participating in this program with the National Aeronautics and Space Administration for the purpose of demonstrating manned rendezvous.[65] On 18 and 19 January 1963, Secretary McNamara directed that a comparison study between the X-20 glider and the Gemini vehicle be made which would determine the more feasible approach to a military capability. He also asked for an evaluation of the Titan III and various alternative launch vehicles.[66]

A few days later, Gemini became even more significant to the Air Force, for the Department of Defense completed an agreement with the National Aeronautics and Space Administration, which permitted Air Force participation in the program. A planning board, chaired by the Assistant Secretary of the Air Force for Research and Development and the Associate Administrator of NASA, was to be established for the purpose of setting the requirements of the program. The agreement stipulated that the Department of Defense would not only participate in the program but would also financially assist in the attainment of Gemini objectives.[67]

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At the end of January, Major General O. J. Ritland, Deputy to the Commander for Manned Space Flight, emphasized to the commanders of ASD and SSD, that Secretary McNamara intended to focus on the X-20, Gemini and Titan III programs with the ultimate objective of developing a manned, military, space system. General Ritland warned that once a decision was made, it would be difficult for the Air Force to alter it. Consequently, command headquarters, the space division and the aeronautical division would have to prepare a comprehensive response to the secretary's request. General Ritland then gave the Space Systems Division the responsibility for providing statements of the Air Force, manned, space mission and for defining space system requirements, tests, and operations.[68]

By the end of February 1963, AFSC headquarters had compiled a position paper on the X-20 program. Six alternative programs were considered: maintain the present program, reorient to a lower budget through fiscal year 1964, accelerate the flight test program, reinstate a suborbital phase, expand the program further exploring technological and military objectives, and, finally, terminate the X-20 program. The conclusion of command headquarters was to continue the present X-20 and Titan III programs.[69]

Early in March, General LeMay offered his thoughts on the coming review by the Secretary of the Air Force. He firmly stated that continuation of Titan III was absolutely necessary and, most important, the current X-20 program should definitely proceed. The Air Force Chief of Staff emphasized that the Dyna-Soar vehicle would provide major extensions to areas of technology important to the development of future military systems and,

[redacted]

consequently, the Air Force should not consider termination of the X-20 program or delay of schedules for the approval of an alternative space program. General LeMay insisted that the purpose of Air Force participation in the Gemini program was limited to obtaining experience and information concerning manned space flight. The Chief of Staff underlined that the interest of the Air Force in the NASA program was strictly on the basis of an effort in addition to the Dyna-Soar program.[70]

After hearing presentations of the X-20, Gemini, and Titan III programs in the middle of March, Secretary McNamara reached several conclusions which seemed to reverse his previous position on the experimental nature of the Dyna-Soar program. He stated that the Air Force had been placing too much emphasis on controlled re-entry when it did not have any real objectives for orbital flight. Rather, the sequence should be the missions which could be performed in orbit, the methods to accomplish them, and only then the most feasible approach to re-entry. Dr. Brown, however, pointed out that the Air Force could not detail orbital missions unless it could perform controlled re-entry. Furthermore, the Director of Defense for Research and Engineering, stated that the widest lateral mobility, such as possessed by the X-20, during landing was necessary in performing military missions. Dr. McMillan surmised that Secretary McNamara did not favor immediate termination of the X-20 program.[71] Secretary McNamara did request, however, further comparison between Dyna-Soar and Gemini in the light of four military missions: satellite inspection, satellite defense, reconnaissance in space, and the orbiting of offensive weapon systems.[72]

On 10 May 1963, a committee composed of officials from the aeronautical and space divisions completed their response to Secretary McNamara's direction. The committee was aware that the Dyna-Soar glider had sufficient payload capacity for testing a large number of military components and that the X-20 demonstration of flexible re-entry would be an important result of the flight test program. Concerning Gemini, the committee also recognized that this program would enhance knowledge relating to maneuverability during orbit and consequently recommended the incorporation of a series of experiments leading to the testing of military subsystems. Further in the future, both vehicles could be adapted to serve as test craft for military subsystems; however, neither could, without modification, become a fully qualified weapon system for any of the missions specified by Secretary McNamara. With the employment of Titan III instead of Titan II and the incorporation of a mission module, this Gemini system could provide greater orbital maneuverability and payload capacity than the X-20. The Dyna-Soar vehicle, however, would provide greater flexibility during re-entry and, unlike Gemini, could return the military subsystems to Earth for examination and re-use.[73]

General Ritland forwarded this report to Air Force headquarters a few days later. The deputy for manned space flight recommended that the X-20 program be continued because of the contribution that a high lift-to-drag ratio re-entry vehicle 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 Space Center and seeing that military experiments were part of the program.[74]

While the Department of Defense had not made a final determination concerning the X-20 and Gemini, General Estes cautioned the Dyna-Soar office at the end of June that the Secretary of Defense was still studying the military potential of both approaches. The vice commander stated that the system office had to maintain a position which would permit continuation of the program, while at the same time restricting contractor actions to assure minimum liability in event of cancellation.[75]

While the X-20 and Gemini approaches to orbital flight were under examination, the Dyna-Soar office was also confronted with an adjustment to the program because of a pending budget reduction. In November 1962, it had been apparent that the Department of Defense was considering restriction of fiscal year 1963 and 1964 funds to $130 million and $125 million instead of the previously stipulated level of $135 million for both years.[76] Colonel Moore pointed out to AFSC headquarters that only through aggressive efforts would $135 million be sufficient for fiscal year 1963 and any proposed reduction would be based on a lack of understanding of the Dyna-Soar requirements. Furthermore, an increase in fiscal year 1964 funds was necessary, raising the figure to $147.652 million.[77] Later, the system office informed General LeMay that schedules could not be maintained if funding were reduced and that $135 million and $145 million would be required for fiscal years 1963 and 1964.[78]

During March 1963, the X-20 office prepared four funding alternatives, which General Estes submitted to Air Force headquarters at the end of the month. The most desirable approach was to maintain the program schedules as offered in the 10 October 1962 system package program by increasing the funding. The X-20 office estimated that $135 million was required for fiscal year 1963, $145 million for 1964, and $114 million for 1965, which gave a total program cost of $795 million. The second alternative was to authorize a ceiling of $792 million, with $135 million allotted for 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 1963, $135 million for 1964, and $130 million for 1965, with a program total of $807 million. 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 was to delay the entire program by six months, authorizing $130 million for 1963, $125 million for 1964, and $125 million for 1965. Under this alternative, the program would total $828 million.[79]

On 12 April 1963, Air Force headquarters accepted the third alternative. A funding level of $130 million was established for 1963 and the system office was directed to plan for $135 million in 1964. Headquarters stipulated that program schedules could not be delayed by more than two months and that a new system package program had to be submitted by 20 May.[80]

On 15 January 1963, the Dyna-Soar office had completed a tentative package program, which included the same funding and flight schedules as the 10 October 1962 proposal. The central difference was that the latter program incorporated the "Westward-Ho" proposal.[81] This system package program, however, was not submitted to AFSC headquarters for approval. In accordance with the 12 April 1963 instruction, the X-20 office completed another system package program on 6 May which was distributed to the various program participants for their comments. On 9 May, however, General Schriever assigned the orbital test responsibility to the Space Systems Division, and, consequently, AFSC headquarters again instructed the Dyna-Soar office to revise the X-20 system package program by 13 May.[82]

In the 13 May system package program, the X-20 office estimated that $130 million was required for fiscal year 1963, $135 million for 1964, $130 million for 1965, $110 million for 1966, and $73 million for 1967. The air-launch program was to extend 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 occurring in May 1967. The eighth and final piloted flight was to be conducted in November 1967.[83] Brigadier General D. M. Jones, acting commander of ASD, informed AFSC headquarters that there had been insufficient time to incorporate the details of the new test organization in the program package. Furthermore, a funding level of $130 million and $135 million for fiscal years 1963 and 1964 could delay Dyna-Soar flights by more than the two months anticipated in the 12 April direction of USAF headquarters.[84]

On 27 May, another system package program was completed. The same funding rates as the 13 May proposal were retained but the flight schedule was revised in order to conform with firm contractor estimates. The air-launch program was to extend from May 1965 through May 1966. The two unmanned launches were to take place in January and April 1966, and the first piloted launch was to occur 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 was to terminate in February 1968 with the eighth orbital launch.[85]

The Secretary of the Air Force gave his approval to this system package program on 8 June 1963; however, the Department of Defense did not accept the recommended funding. On 3 July, AFSC headquarters informed the Dyna-Soar office that attempts to secure additional funding had failed. The funding level for fiscal year 1964 was $125 million.[86] By September, it was clear to the Dyna-Soar office that the consequence of this reduced funding level would be to delay multiorbital flight from the seventh to the ninth ground-launch.[87]

While final approval by the Department of Defense of the Dyna-Soar system package program was still pending in the middle of 1963, the impact of the December 1961 redirection on the Dyna-Soar program was apparent. The first Dyna-Soar development plan of October 1957 had definite military objectives leading to the development of orbital reconnaissance and bombardment vehicles. In April 1959, Dr. York, then Director of Defense for Research and Engineering, altered these goals and placed major emphasis on the development of a suborbital research vehicle. In spite of intensive comparative studies with manned SAINT and Gemini vehicles, the central purpose, as established by Dr. York, had not changed. While the system program directive of December 1961 and Secretary McNamara's memorandum of February 1962 elevated Dyna-Soar to an orbital vehicle, the glider was officially described as an experimental system.

Conceivably the redirected program could appear as a reversal of the three-step approach which was aimed at the development of a suborbital system, an orbital glider with interim military ability, and an operational weapon system. Yet, under this old development plan, the real Dyna-Soar program had only consisted of a glider which would perform suborbital flight. Consequently, Department of Defense sanction of the new program marked an advancement over the three-step approach in that orbital and even multiorbital flights of the X-20 glider were now established objectives of Dyna-Soar.

CHAPTER IV

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GLOSSARY OF ABBREVIATIONS

Ac.	Aircraft
ACS	Assistant Chief of Staff
ADO	Advanced Development Objective
Adv.	Advanced
Aero.	Aeronautical
AF	Air Force
AFB	Air Force Base
AFFTC	Air Force Flight Test Center
AFLC	Air Force Logistics Command
AFMDC	Air Force Missile Development Center
AFMTC	Air Force Missile Test Center
AFPR	Air Force Plant Representative
AFSC	Air Force Systems Command
AMC	Air Materiel Command
Amend.	Amendment
ARDC	Air Research and Development Command
ARPA	Advanced Research Projects Agency
ART	Advanced Re-entry Technology
ASAF	Assistant Secretary of the Air Force
ASC	Aeronautical Systems Center
ASD	Aeronautical Systems Division
Asst.	Assistant
ATW	Aerospace Test Wing
Bd.	Board
BMD	Ballistic Missiles Division
Br.	Branch
Brig.	Brigadier
BSC	Ballistic Systems Center
BSD	Ballistic Systems Division
Capt.	Captain
Ch.	Chief
Chm.	Chairman
Cmdr.	Commander
Co.	Company
Col.	Colonel
CS	Chief of Staff
DCAS	Deputy Commander for Aerospace Systems
DCS	Deputy Chief of Staff
DD	Development Directive

DDR&E	Director of Defense for Research and Engineering
Def.	Defense
Dep.	Deputy
Det.	Detachment
Dev.	Development
Dir.	Director(ate)
Doc.	Document
DOD	Department of Defense
DSM	Directorate of Systems Management
DSMG	Designated Systems Management Group
Ec.	Executive
Engg.	Engineering
ESD	Electronic Systems Division
Fig.	Figure
Fld.	Field
Gen.	General
GOR	General Operational Requirement
HETS	Hyper-Environmental Test System
Hist.	Historical
Hqs.	Headquarters
Ident.	Identification
Intel.	Intelligence
Log.	Logistics
Lt.	Lieutenant
Ltr.	Letter
Maj.	Major
Mangt.	Management
Memo.	Memorandum
MMSCV	Manned, Military, Space, Capability Vehicle
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration

N.D.	No Date
No.	Number
Ofc.	Office
Ops.	Operations
P., pp.	Page, Pages
Pres.	President
Presn.	Presentation
Proc.	Procurement
Prod.	Production
Proj.	Project
Propul.	Propulsion
R&D	Research and Development
Recon.	Reconnaissance
Res.	Research
Rev.	Review
Rpt.	Report
SAB	Scientific Advisory Board
SAF	Secretary of the Air Force
SAFUS	Under Secretary of the Air Force
SDR	System Development Requirement
Secy.	Secretary
SPD	System Program Directive
Spec.	Special
SPO	System Program Office
SSD	Space Systems Division
SSD	System Study Directive
Subj.	Subject
Sys.	System(s)
Tech.	Technology
TWX	Teletypewriter Exchange Message
U.S.	United States
USAF	United States Air Force
VCS	Vice Chief of Staff
Vol.	Volume
VTOL	Vertical-Takeoff-and-Landing

WADC	Wright Air Development Center
WADD	Wright Air Development Division
WAR	Weekly Activity Report
Weap.	Weapon
WSPO	Weapon System Project Office

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