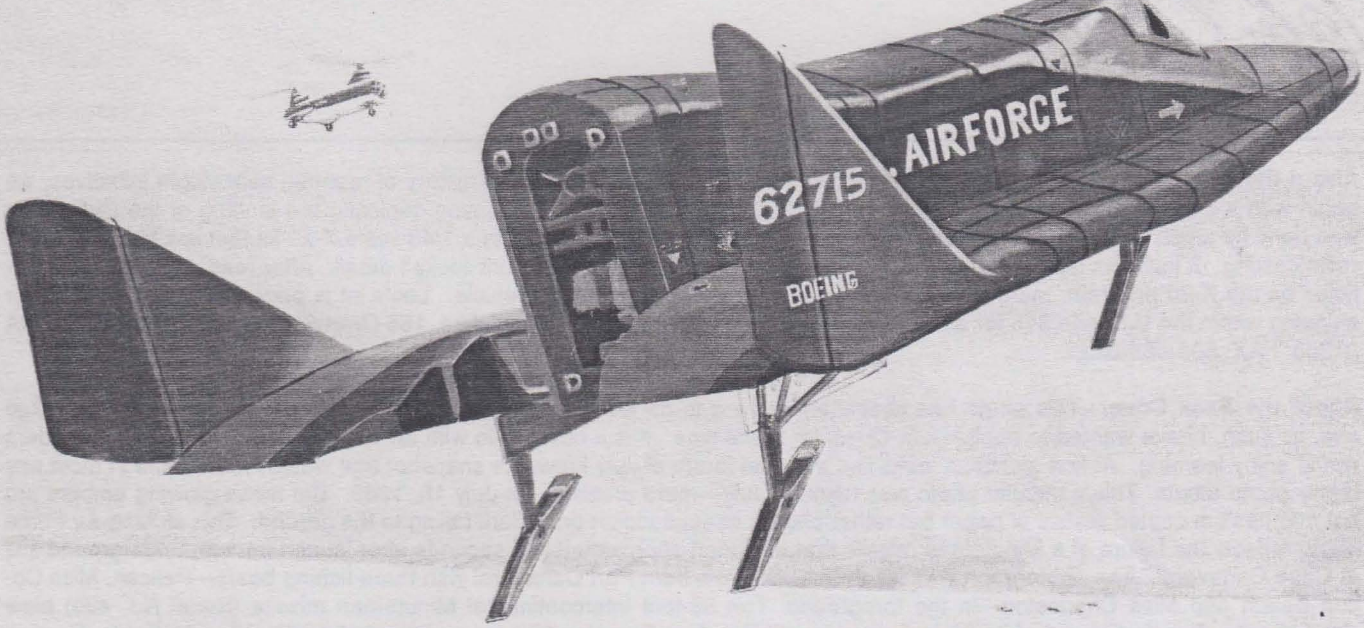
# Quest™

## The History of Spaceflight Magazine

**Vol. 3 No. 4 Winter 1994** **$5.95**



# CAPCOM

Welcome to the last issue of 1994. *Quest* is now approaching its fourth year of publication and continues to provide its readers with the only regular source of detailed articles and information on the history of our planet's space endeavours. With the new year, our faithful readers will continue to see improvements made in each and every issue, first and foremost being that of getting each quarterly issue out earlier. Our new year resolution for 1995 is to make a major effort at getting issues out in a more consistent fashion. It does take time to assemble each issue which I liken to a fine piece of art and I believe that when readers finally do get their issues, they are not dissapointed in its content. I hope that each issue is worth the wait, for good writing takes time and we strive to give each of our subscribers only the best.

Speaking of the best, I would like to alert readers to our two feature pieces in this issue. The first is actually comprised of many articles, all of which focus on the Dyna-Soar program. This issue begins a long awaited and previously promised series which will attempt to explore the history of military manned spaceflight initiatives. Part I will take readers to the edge of space with the Dyna-Soar Program. Continuing with the Spring 1995 issue, we will explore the Manned Orbiting Laboratory (MOL). From there we will then cover the proposed military Gemini missions ("Gemini B" ) which includes an assortment of fascinating variations on the familiar two-manned U.S. spacecraft. The other feature article in this issue focuses on the greatest disaster to yet fall on this globe's efforts to explore the heavens. Known as the Nedelin Disaster, guest writer Asif Siddiqi gives readers a haunting account of a previously "hidden" incident in the former Soviet Union. This article is the definitive story of what actually happened over thirty years ago that cost over 150 lives and attributed to the delay in launching the first man in space.

Finally, in previous editorials I stated that we were working on a full-color poster-size version of our popular "Rockets of the World" envelopes. This was due, in part, to a large number of readers that received one of our special envelopes imprinted with over 130 rockets from around the world. Many wrote in asking if a poster version of this envelope was available. After much tedious effort, Peter Alway has updated his meticulous drawings and added many new launch vehicles to create a stellar 22" x 34" full-color poster featuring 155 rockets from around the world—all in 1/300 scale. Rockets from over a dozen countries are represented in this beautiful color poster which depicts the entire history of rocketry. For complete ordering details, plus information on a special bonus offer, see our full-page ad on page 59 of this issue!

Glen E. Swanson
Glen E. Swanson
Editor/Publisher, CSPACE PRESS

**About the Front Cover:** To launch the first installment of our new series on the history of manned spaceflight initiatives, we begin with a critical examination of the Dyna-Soar X-20 program. The cover painting depicting the landing of the Dyna-Soar was done by artist Tony Weddel for Lou Maglio of Collect-Aire Models. Lou offers a 1/48 scale X-20 kit that is a highly detailed resin casting. It includes fully recessed panel lines, numerous metal parts and full cockpit detail. After reading this issue of articles on the X-20 program, many may want to build an actual model of the vehicle. Lou's kit is priced at $99.95 plus $5 for shipping within the U.S. and $15 for all others via air. Send your order to: Collect-Aire, 166 Granville Lane, North Andover, MA 01845: FAX: 508-685-0220.

**About the Back Cover:** This photo has absolutely nothing to do with any articles in this issue but it is among my favorites and, as such, I have wanted to publish it in *Quest* for some time. It is a cool photo with an interesting story that I think readers would enjoy learning. At first glance, it looks like a typical fourth of July fireworks snapshot that would find a home in most any family photo album. This particular photo was taken in July—more precisely on July 16, 1963. But those glowing embers are not magnesium coated pieces of paper but rather chunks of solid rocket propellant falling to the ground. This striking Air Force photo reflects the failure of a Minuteman missile that exploded approximately 5 seconds after launch from an underground silo at Cape Canaveral. The photograph was taken by Dick Crow from Port Canaveral with three fishing boats—Pelican, Miss Cocoa Beach and Miss Charleston—in the foreground. The 58-foot intercontinental Minuteman missile (Serial No. 430) blew apart shortly after darting out of its 85-foot deep launching pit at Complex 32B for an intended 4,000-mile test flight. Flaming fragments showered a wide area the night of July 16, 1963 and started several small brush fires. The Air Force reported that there were no injuries or damage to facilities. The brilliant fireworks display awoke many Space Coast residents, some were lucky enough to witness the event which officials estimated cost taxpayers approximately $2 million (in 1963 dollars!). This particular Minuteman missile was an advanced Wing 2 model, a type which the Defense Department declared operational earlier that same month. The Wing 2 was designed for greater range, payload and accuracy than the Wing 1. For those interested in the details of this photo, the picture is actually a double exposure. The first shot was taken of the harbor at F8 with an electronic flash and the second "streak" picture was taken on launch at F16 with the shutter wide open. The photographer used super high pan film in his Speed Graphic. Photo No. 1410 Courtesy USAF 45th Space Wing. This photo and a brief article about the event were originally published on the front page of the July 17, 1963 issue of *The Cocoa Tribune*.

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# CONTENTS

## FEATURES



## DEPARTMENTS




QUEST MAGAZINE
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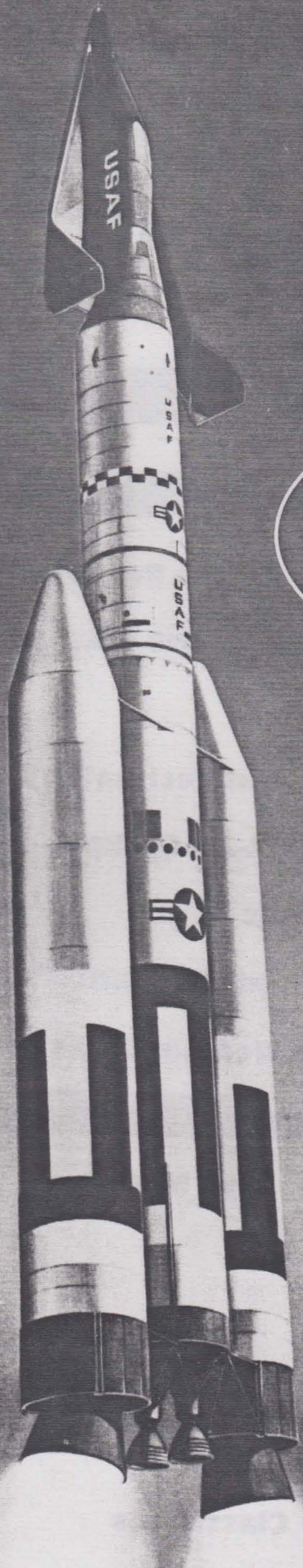
CSPACE PRESS

# THE DYNA-SOAR PROGRAM




History of Manned Military Space Initiatives Part I

# WHY THE AIR FORCE PROPOSED THE DYNA-SOAR X-20 PROGRAM

by Roy F. Houchin II

In the final months of World War II, Henry H. "Hap" Arnold, the Commanding General of the Army Air Force (AAF), wondered how the high quality of scientific thought the Army Air Force benefited from during the war could be sustained in peacetime. Many of the brightest minds in industry and academia made invaluable contributions to American air power by increasing the speed, range, payload, and accuracy of strategic bombing, and multiplying the destructiveness of armament. While their discoveries transformed the nature of aerial warfare by advancing the existing technologies of propulsion, materials, fuels, radar, and explosives, the preeminent state of German technology illustrated the inherent need for America to continue with its air power research in peacetime to avoid technological catastrophe in any future war. Besides creating the Deputy Chief of Staff, Research and Development (R&D) position within his Air Staff organization, headed by Major General Curtis E. LeMay, General Arnold initiated two research projects: a non-profit research and development corporation (RAND) to study the subject of intercontinental warfare and the Scientific Advisory Board (SAB) to search the world for the most advanced aeronautical ideas generated by wartime research and determine the potential of those ideas for future applications.[1] As a result of a September 1945 luncheon agreement, they created the RAND corporation, composed of civilian scientists and engineers and tasked to investigate the role of airpower in intercontinental warfare.[2] As General Arnold's scientific advisor and chairman of the AAF's Scientific Advisory Board (SAB), Dr. Theodore von Karman and his team of scientists completed a thirteen-volume work entitled *Toward New Horizons* on 15 December 1945.[3] Von Karman linked the latest scientific developments to a forecast of future efforts for the Army Air Force to maintain technological superiority and advised General Arnold to pursue scientific enquiries and establish a separate AAF agency dedicated to aeronautical research. General Arnold took both of Dr. von Karman's suggestions, creating the USAF SAB in 1947 and the Air Research and Development Command (ARDC) in 1950. As Air Force leaders considered the long-range advice of the SAB and the studies of RAND, they began investigating the possibilities within the ARDC of integrating the new technology within Air Force doctrine. In the mid-1950s Air Force leaders embraced the promise of ballistic missile technology and began to consider the manned boost-glide technology leading to their proposal for a small space shuttle, the Dyna-Soar, X-20, program.

*Opposite Page: Artist rendering of the final Dyna-Soar X-20 atop the booster that would carry it into space—the Titan IIIC. Drawing Courtesy Roy Houchin via Al Misenko and the History Office/Aeronautical Systems Division, Wright-Patterson AFB, Dayton, OH.*

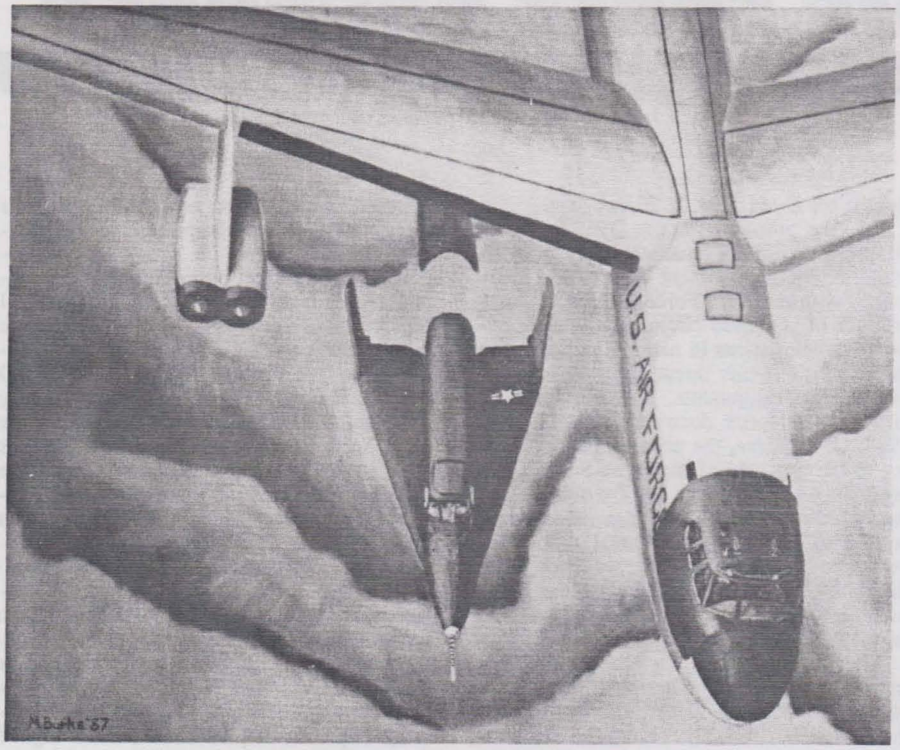
Yet, the proposal for the Dyna-Soar, X-20, program did not emanate solely from an evolutionary development of scientific institutions within the Air Force. Indeed, it was a product of a closed-circle relationship between developments in national policies, the nature of the enemy threat, the state of technological developments, and the dicta of previous air force doctrine from 1945 to 1957. Of all these, the primary factors leading to the proposal of the Dyna-Soar, X-20, program on 10 October 1957 would be the Air Force's proclivity for a manned strategic bomber to fulfill the fundamental mission inherent to achieving its independence from the Army in 1947—strategic nuclear bombardment—and the inclusion of ballistic missile technology into its doctrine in 1955.

After World War II, the Truman administration struggled to determine a national strategy to wage an ideological war against the Soviet Union.[4] The communist subversion of Poland and other East European states, disputes over the administration of Germany, apparent Soviet unwillingness to demobilize its military, Soviet supported destabilization of Greece and Turkey, communist incursions in democratic Czechoslovakia, the Berlin Blockade, and the failure to stop the proliferation of nuclear weapons through cooperative actions within the United Nations combined with American reactions to these events to create a "Cold War" environment between the United States and the Soviet Union. Subsequently, the AAF pushed its infant R&D programs, believing air power promised the only true deterrent to Soviet expansion.[5] In turn, the AAF and the aviation industries depended on one another economically and technologically; indeed, the security of the nation might hinge on the ability of American aviation corporations to expand their production rapidly and perform the R&D required to ensure America maintained the highest state of technology and deterrence.[6] Anticipating reductions in federal contracts with the aviation industry as America adjusted to a peacetime economy and recognizing the importance of R&D in preventing the United States from having to wage future wars, industrialist Donald Douglas, Chairman of the Douglas Aircraft Corporation, and General Arnold committed the aviation industry and the AAF to a long range study of future warfare.

In the spring of 1946, interservice rivalry flared as the Navy sought partners for its Earth Satellite Vehicle Program, the Army continued with its V-2 activities, and the administration mocked the importance of intercontinental ballistic missiles (ICBMs) and satellites. Amid the turbulence, the AAF requested a RAND report on the military prospects and value of an earth satellite.[7] RAND's report, released on 2 May 1946, suggested satellites would undoubtedly prove to be of great military value; they could become an invulnerable observation "aircraft" and function as a communications relay station. Equally important, a U.S. satellite would have a major politico-psychological effect by inflaming the imagination of mankind, producing international repercussions comparable to the atomic bomb.[8] Such a vehicle would cost $150 million, take five years to build, and weigh 500 pounds. Some AAF leaders saw the military potential of satellites and argued against the other services for the inclusion of satellites as a strategic aviation payload aboard the MX 774 HIROC ICBM. However, Dr. Vannevar Bush, Chairman of the Joint Research and Development Board for the armed services (and responsible for clarifying the jurisdiction of each service's roles and missions in future warfare) believed the technological problems of weight and kill radius inherent with existing atomic bombs and the development of a booster to carry them, or satellites, made ICBMs technologically impractical. In addition, Bush argued for the economic savings of manned bombers, suggesting the expense of a ballistic missile weapon system would economically exhaust the United States before a similar Soviet program would exhaust its funds.[9]

Deputy Chief of Staff for AAF R&D, Major General LeMay, echoed Dr. Bush's sentiments. Major General LeMay felt ICBMs might be more efficient in the future and could replace manned bombers, but, in the near term, manned bombers and their ancillary equipment would be able to counter the Soviet threat. Indeed, even when ICBMs became efficient, military flexibility would demand the existence of manned vehicles to deliver atomic weapons to locations inaccessible to ICBMs, or to conduct secondary operations against remaining targets following an initial ICBM attack, or to conduct attacks against targets of opportunity not selected for ICBMs. In essence, while the complexity of future warfare would dictate the need for several weapon systems to meet the requirements of enemy threats in modern warfare, manned bombers would continue to be the primary delivery platform for atomic weapons in the near-term.[10]

On 26 July 1947, Congress passed the National Defense Act, creating a layer of centralized civilian control over the competing services, separating the Air Force from the Army, and creating the National Military Establishment R&D Board, with Dr. Bush as its chairman, to coordinate the service's R&D programs.[11] As Congress centralized military operations and recognized the Air Force's unique role of strategic nuclear bombardment as the foundation for granting it independence from the Army, post war inflation strapped the R&D efforts of programs designed to fight potential Cold War threats. Dr. Bush, in response to reductions in the previous fiscal year's (FY) budgets by Bureau of Budget director James E. Webb, and anticipating continued reductions for the current FY, contemplated limiting the entire



*Artist rendering showing a Dyna-Soar being air-dropped from a B-52. Original oil painting by artist Mike Burke.*

Department of Defense (DOD) budget, beginning in FY 1949, to an arbitrary ceiling of $500 million a year.[12] As a result, while the Soviets fashioned an intense ICBM program (and investigated the potential for an intercontinental manned hypersonic boost-glider to carry an atomic bomb), the United States did not move forward with its ICBM programs because of the administration's desire for fiscal restraint, its perception of Soviet technological capabilities, and its desire, with Air Force concurrence, to restrict Cold War military developments to selected areas other than ballistic missiles.[13]

While the nation searched for a coherent nuclear strategy to cope with the Soviets in a period of fiscal restraint, George Kennan's "The Source's of Soviet Conduct" appeared in Foreign Affairs, focusing American perceptions of the Soviet threat and defining American reaction as "containment."[14] When the president's air warfare commission, the Finletter Commission, delivered its recommendations in a report entitled "Survival in the Air" on New Year's Day 1948, the importance of nuclear deterrence through a strong air force became apparent, as did the costs of a national strategy.[15] Simultaneously, Air Force planners signed a policy statement advocating their responsibility for strategic missiles and satellites.[16] At a meeting in Key West, Florida on 21 April 1948, the Joint Chiefs of Staff (JCS) delegated responsibility for strategic air warfare to the Air Force.[17] The JCS responded with a new war plan in May, calling for an offensive stance in Europe, a defensive stance in Asia, and a powerful air offensive to exploit the destructive and psychological power of atomic weapons.[18] By June, the Navy, no longer believing it could attain an ICBM role, transferred its satellite funds to more pressing programs, terminating the Earth Satellite Vehicle Project. The Navy's bid for a joint satellite program, and joint funding, failed as the National Military Establishment R&D Board decided, while feasible, no military or scientific utility, commensurate with the required expenditures, existed for a satellite.[19] As the prospects for a satellite, or ICBM, program vanished and a national strategy of containment, enforced through a strong manned bomber force capable of delivering the nation's atomic deterrent, developed, Air Force planners began to realize they must demonstrate a military mission for satellites, or any new weapon system, before they could be justified in terms of the national economy or military doctrine.

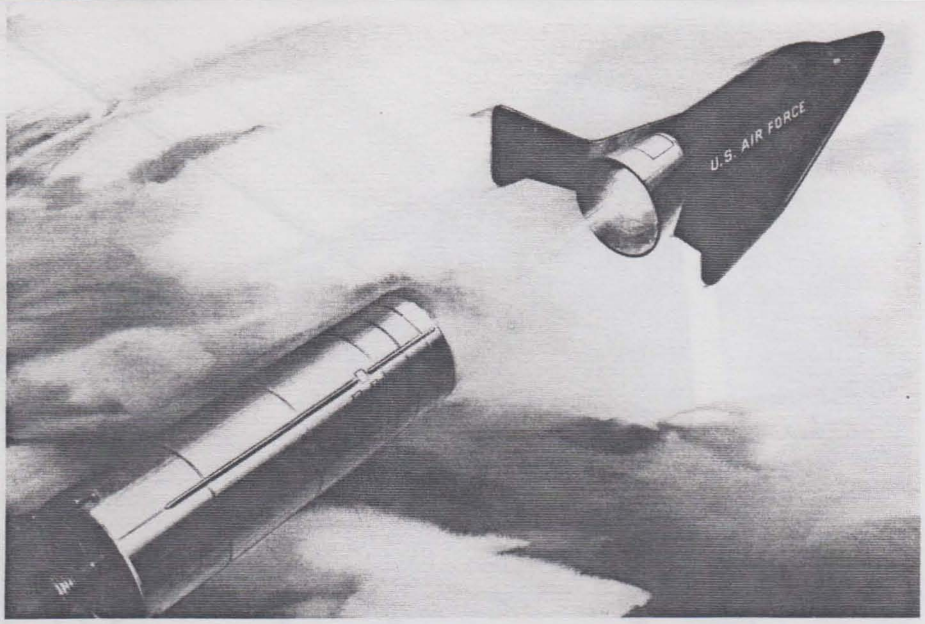
Concurrent with the Air Force's Key West doctrinal developments, the SAB gained increased credibility with Air Force leaders when it became organizationally attached to the Air Force Chief of Staff with Major General Lawrence C. Craige as its military director and Dr. von Karman as the senior civilian scientist on 15 April 1948. The new SAB would follow the original research guidelines established by Major General LeMay and Dr. von Karman in January 1946. It would meet as a body semi-annually to give the Air Staff Director of Research and Development suggestions on future air power trends and long range possibilities.[20] By November 1948, the SAB would complete a report on organizational reform and a scientific forecast to prepare the Air Force to meet future Soviet weapon systems.

In addition to the doctrinal and scientific considerations of 1948, economic constraints and the Air Force's institutional inclination for manned bombers prevented research into the technological solutions for an ICBM or reconnaissance satellite. Yet, while most Air Force planners concurred with Major General LeMay's opinions regarding the primacy of manned bombers, some Air Force planners agreed with the reforms proposed by Major General Craige, believing technological progress in atomic bombs would eventually reduce the weapon's size, increase its yield, and decrease its cost (and the cost of the boosters). This minority of Air Force planners prepared for a future role in astronautics to ensure promulgation of an Air Force policy on satellites and an increased share of DOD missile appropriations.[21] As a result, they assigned RAND the task of continuing its studies of the potential military utility of reconnaissance satellites and the politico-psychological advantages of a satellite system designed for communications.[22]

When the Soviet Union exploded its atomic bomb on 3 Sept 1949, the news shocked administration officials and the JCS; both believed the Soviets incapable of atomic tests before 1952. Despite French reports in 1947 and 1948, as well as a 1948 statement by Soviet deputy foreign minister Andrei Veshinsky regarding the lack of an American monopoly on atomic weapons, administration officials failed to consider the rapid advance of Soviet atomic technology in their assessments for military R&D funding. Why plan for a Soviet threat in 1949 when it would not exist until 1952?![23] Also in September 1949, the SAB's Ridenour Report, named for University of Illinois Dean Louis N. Ridenour, chairman of the SAB working group, advocated sweeping reforms within the Air Force's scientific organization. It proposed a separate command for R&D (ARDC), a Deputy Chief of Staff for Development on the Air Staff, and unitary budgeting for USAF outlays. While many of the fiscal policy suggestions of the report were not popular among top Air Force leaders, Vice Chief of Staff Muir S. Fairchild announced implementation of the Ridenour reforms on 2 January 1950.[24]

Soviet possession of an atomic bomb forced a reassessment of American strategy and, after lengthy debates over military and moral issues, led to the administration's decision on 31 January 1950 to develop the hydrogen bomb—a technological breakthrough capable of restoring the types of ICBM and satellite development outlined in Towards New Horizons and the 1946 RAND report on the potential of earth orbiting satellites.[25] In addition, innovations in missile technology would provide the possibility for all military services to employ weapons (intermediate range ballistic missiles—IRBMs—or ICBMs) directly against the Soviet Union, jeopardizing the Air Force's strategic bombing mission. With its primary mission threatened, the independence of the Air Force would be challenged as well.

In March 1950, a State Department committee report recommended a rapid and sustained buildup of political, economic, and military strength in the free world to counter similar Soviet capabilities. Estimating America's lead in atomic weapons would disappear by 1954, the committee believed Americans should realize budgetary restraints were secondary to America's need to counter the Soviet threat.[26] On 2 June 1950, the Communist North Koreans tested the




*A late 1950s conceptual drawing showing the X-20 separatng from the Titan I second stage. The remaining transition section would stay with the glider before beginning the re-entry phase of flight at which point it too, would be jettisoned. Drawing Courtesy Roy Houchin and Don Pealer and USAF.*

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

During the next month, RAND researchers reported satellites, though not weapons, would serve a primary role in maintaining national security through strategic and meteorological reconnaissance. By gathering intelligence information of high military value, unavailable from alternative sources, they would provide a novel and unconventional element of reconnaissance while they provided an international politico-psychological factor in favor of the United States. Because of the political implications, what Americans said about satellites would be as important as what they did not say about satellites. Since they could not be kept secret, they must, politically, be handled judiciously. Soviet reaction would be unpredictable; Soviet propaganda made it advisable for the United States to dampen the military potential of satellites and stress the peaceful nature of this technological advance. The legality of space based reconnaissance hinged on international acceptance of the peaceful right of innocent passage—a concept never adhered to by the Soviets. Indeed, they might construe overflights as an act of aggression.[27] To secure these objectives, suggested the RAND report, the United States should launch an experimental satellite on an equatorial orbit (to prevent an overflight of the Soviet Union) to test the issue of freedom of space. While the possibility of the Soviet's developing reconnaissance satellites existed, America's open society would seem to preempt their development.[28]

Still, as the history of military aviation illustrated, should the Soviets develop reconnaissance satellites, the nature of reconnaissance activities would dictate the need for defensive systems to protect satellite resources. Thus, the United States or the Soviet Union would eventually obtain antisatellite (ASAT) capabilities. Should such a capability be required in the future, Air Force leaders like Major General LeMay believed a manned weapon system would offer the best solution and allow the greatest flexibility for alternate missions. In turn, it would ease the growing concerns of many officers within the Air Force by sustaining a manned strategic role within its doctrine while embracing ballistic missile technology and ensuring the Air Force remained the dominant missile service. Air Force leaders understood these issues and realized budgetary constraints on ICBMs and satellites would ease if the feasibility of space-based photography could be proven. In turn, Soviet military reactions to counter American satellites would justify new R&D on defensive weapon systems for protection. For these Air Force aspirations to reach fruition, the existing administration would have to promote and secure international acceptance for reconnaissance satellites and it must be equally willing to promote and secure international acceptance of manned military operations.[29]

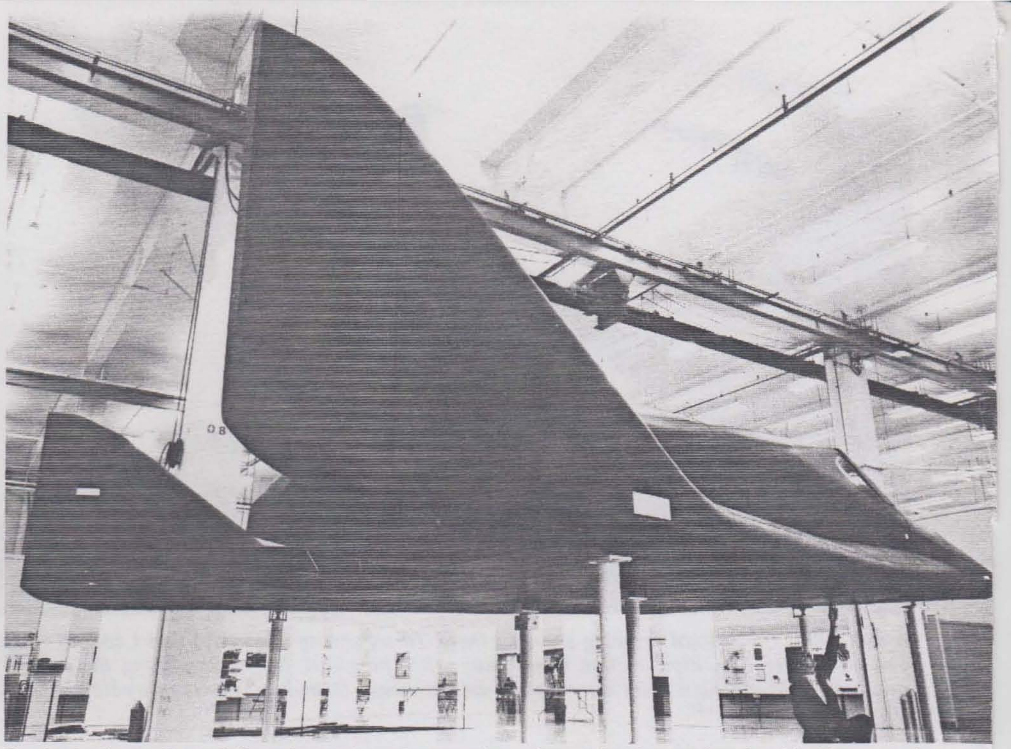
The Korean War added substance to the specter of Communist aggression and fostered necessity for American vigilance and nuclear supremacy. As fiscal constraints lifted, political, and military supporters rallied to develop an ICBM and its nuclear payload. In the Spring of 1951, Air Force leaders offered K.T. Keller, the administration's special advisor on missiles, a descendant of the unsuccessful MX-774 HIROC program, the Atlas ICBM Program—Weapon System 107A, for development.[30] Although the Atlas program's financial problems seemed solved with its acceptance for development, the technical requirements associated with a fission bomb (rather than a fusion—hydrogen—bomb), such as rigorous specifications for accuracy and distance (0.01 degree over 5,000 miles with a 10,000 pound payload), remained; indeed, they would not be resolved until proof of a compact and more powerful hydrogen bomb emerged.[31] By April 1951, a technical study for Project Feedback, a military reconnaissance satellite program, defined the hardware specifications required for an American reconnaissance satellite. Yet, Air Force reconnaissance satellite technology continued in the shadow of the service's Atlas ICBM development. Without a nuclear payload for the Atlas booster, it would not be developed. Hopefully, by the time the Atlas reached maturity as an ICBM, it could also serve as a booster for reconnaissance satellites.[32]

Having examined the feasibility of manned military space operations since World War II, Dr. Walter R. Dornberger, a research employee of the Bell Aircraft Company and ex-Major General in the German army who headed Germany's military rocket development program, approached Air Force leaders in April 1952 with a proposal for a manned boost-glide bomber, called "BOMI."[33] BOMI offered the Air Force an opportunity to combine ballistic missile technology with a manned bomber role. Additionally, Dr. Dornberger believed other roles, such as various types of reconnaissance, might be suitable for boost-glide technology.

On 25 August 1952, Aristid V. Grosse, a Temple University physicist and Manhattan Project veteran, completed a report of the "satellite problem" for President Truman. Like the RAND study, Grosse's report stressed the importance of reconnaissance satellites for their scientific, military, and psychological value; in addition, he suggested that because of the enormous global potential for influencing the minds of citizens in every nation during the Cold War, the Soviet Union might like to take the lead in the development and launching of a satellite. Should the Soviets accomplish this, the politico-psychological blow to America's international prestige would be tremendous.[34] By the end of 1952, the National Academy of Science (NAS) appointed a National Committee for the 1954 International Geophysical Year (IGY) to lobby the White House for a civilian satellite program to study the earth from space. If the American committee could persuade the international Special Committee for the International Geophysical Year (SCIGY) to promote worldwide launchings of earth satellites for global science, then the prerequisites for international acceptance of reconnaissance satellites requested in the RAND and Grosse reports would be a *fait accompli*.[35]

By December of 1952, as the nation prepared to inaugurate a new president, the Air Force's SAB felt the detonation of a hydrogen bomb in November, the accuracy and distance guidelines initially required for ICBM development could be relaxed to reflect new thermonuclear warhead technology.[36] The technological limitations cited by Dr. Bush and Major General LeMay as factors for encouraging the continuation of manned bombers would soon be gone.

While Eisenhower was intent on ending the Korean War, slashing a growing defense budget, and curbing inflation, he also wanted to consummate a "cooler" Cold War through nuclear arms control agreements with the Soviets. To accomplish his goals, Eisenhower would place increased reliance on nuclear strength, arms control initiatives, and a lower defense budget; yet, he would not risk falling behind the Soviet Union in nuclear arms. To properly balance nuclear and conventional defense spending, domes-



*Boeing's Dyna-Soar full-scale engineering mockup shown for inspection by Air Force and NASA officials from September 11-22, 1961 in Seattle. Photo Courtesy Roy Houchin via Al Misenko and the History Office/Aeronautical Systems Division, Wright-Patterson AFB, Dayton, Ohio.*

tic inflation, and ensure verifiable arms control treaties, Eisenhower needed accurate, reliable, and timely intelligence about Soviet ICBM developments.[37] From these objectives grew two themes in missile and space policy during the Eisenhower administration: eliminating the gap between American and Soviet missile development through continuous and timely surveillance of the Soviet Union and easing the nation into the space age with a civilian space program.

In August 1953, the Soviet Union detonated its first hydrogen bomb, demonstrating, once again, the United States did not hold a monopoly on atomic technology. Subsequently, during the following month, Eisenhower approved NSC-162/2, a strategic national security report later referred to as his "New Look" policy.[38] Rather than wage a conventional war against a communist offense anywhere and at anytime, America was to maintain unmistakable strategic nuclear superiority, and assure the Soviets, through the proper diplomatic rhetoric, of its willingness to use it. The United States would first rely on indigenous forces to combat communism, supported with tactical air and sea power, to include nuclear weapons if needed. Ultimately, the United States would deter aggression through massive retaliatory power. The Air Force, the only service spared from the proposed 30 percent drop in spending and one quarter cut in personnel, would carry the responsibility for delivering the nuclear weapons and attacking the places of the administration's choosing.

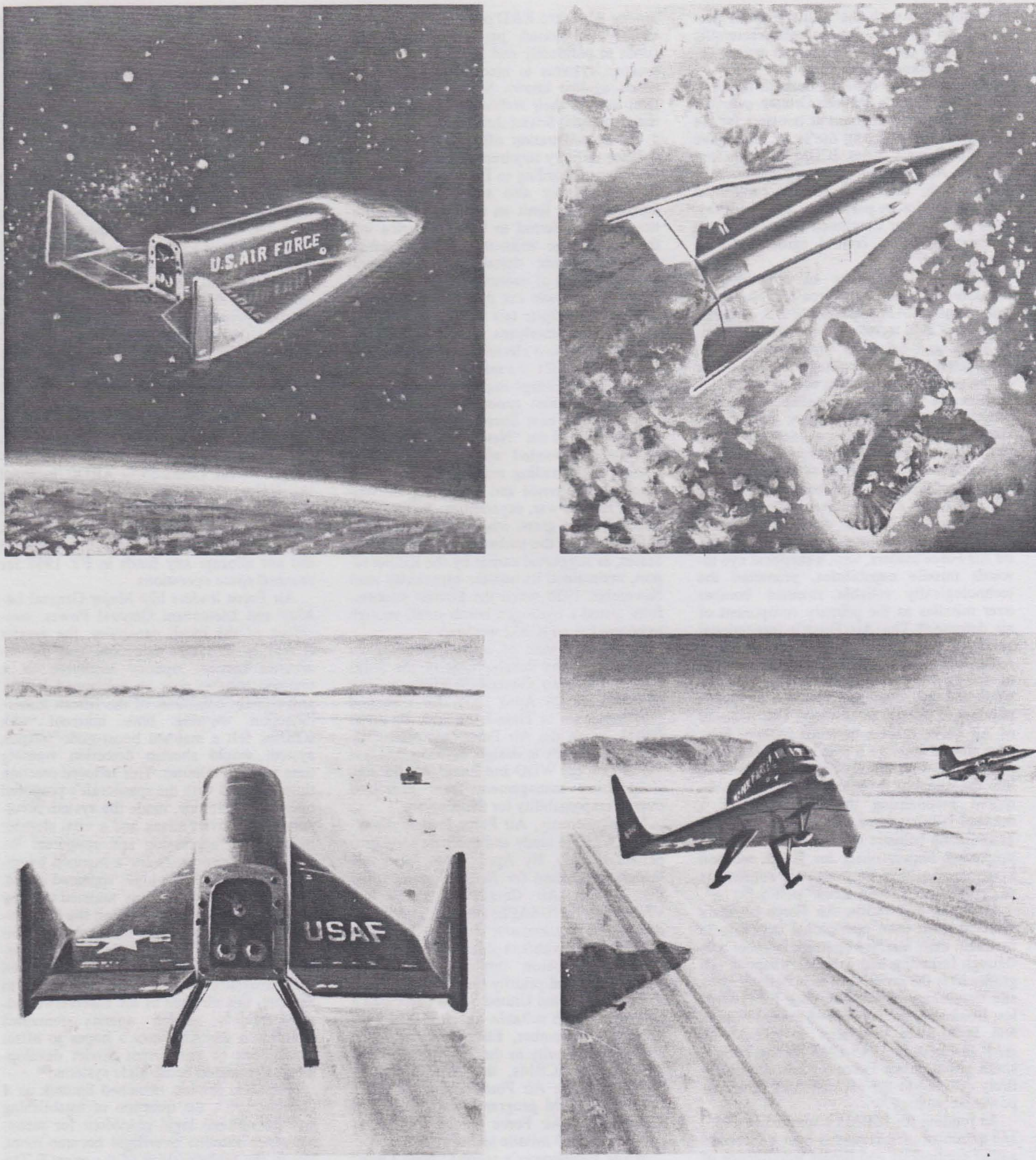
The Air Force Strategic Missiles Evaluation Committee established at the request of Trevor Gardner, Special Assistant for R&D to Secretary of the Air Force, Harold E. Talbott, began the first of its three meetings to determine the nature of hydrogen bomb technology and Soviet ICBM capabilities in November 1953. The committee believed, based on reports from German scientists leaving the Soviet Union, that the Soviets began their ICBM development as early as 1946. Thus, the growth of Soviet ICBM development, combined with its demonstrated thermonuclear capability, potentially placed them significantly ahead of America's sporadic ICBM development.[39] From 23 March through 15 August 1954, Air Force leaders acted on the Committee's recommendations, creating a Western Development Division of the Air Research Development Command (WDD/ARDC), under the command of Brigadier General Bernard A. Schriever, to manage all phases of development and operational requirements for Project Atlas. Additionally, the Air Material Command (AMC), responsible for Air Force procurement and contracting, created the Special Aircraft Project Office (later known as the Ballistic Missile Office—BMO) to handle the AMC responsibilities for Project Atlas and co-located it with the WDD. By September, Brigadier General Schriever contracted with the Ramo-Wooldridge Corporation, a pioneering civilian management team of former Hughes Aircraft Company employees, to augment Air Force teams with their scientific and technical expertise; together they formed a new development and management team, rounding out the committee's suggestions for America's response to the growing Soviet threat.[40] Additionally, after considerable debate, Air Force leaders contracted with Bell for a study of an advanced boost-glide bomber-reconnaissance system on 1 April 1954 to investigate the advantages of space-based manned reconnaissance. Against this backdrop of worried perceptions, on 4 October 1954, the SCIGY recommended all world governments to attempt to launch an earth satellite in the interest of global science.[41] While the international question of satellite overflight would be answered through the SCIGY launches, they would also give the Soviets a cover for their ICBM developments since the Soviets could say their ICBM was the booster for their IGY satellite.

Coinciding with the findings of Air Force Strategic Missiles Evaluation Committee, the administration's Technological Capabilities Panel brought the best minds in the nation together to prevent another technological Pearl Harbor like the Soviet hydrogen bomb.[42] The "Killian Report," unofficially named for its chairman, MIT president James R. Killian, detailed the panel's findings to the NSC on 14 February 1955; while a variety of options existed, based on timetables for American and Soviet capabilities, all depended on the early achievement of ICBMs by one opponent or the other. Thus, the panel recommended the highest priority for Air Force ICBM development, an IRBM suitable for land or shipboard launch, rapid construction of a distant early warning line in the Arctic, a strong and balanced research program to determine the feasibility of ICBM interception and destruction, a greater application of science and technology to fighting limited wars and, finally, an increase in intelligence gathering capabilities.

On 16 March 1955, Air Force leaders secretly circulated a proposal for America's first space program through General Operations Requirement 90. The requirement described a strategic reconnaissance satellite, Weapon System 117L. They envisioned a large sophisticated spacecraft, integrating the latest technology from dozens of American industries.[43] Although they believed in a working relationship between the first generation ICBMs and the development of space-based military technology (for a variety of defensive and reconnaissance roles), the DOD and the Eisenhower administration did not fully agree. Indeed, as the Killian report recommended top priority for ICBMs and IRBMs, DOD and administration officials believed no satellite would be employed as an offensive atomic weapon system.[44]

Based on the favorable results of the initial 1952 Bell study (BOMI), the Air Force issued a General Operational Requirement for a hypersonic strategic bombardment system on 12 May 1955.[45] Still, Air Force planners questioned investing scarce R&D funds into high risk manned space operations when unmanned satellite reconnaissance systems merited short-term priority.

Considering the high altitude U-2 spy-plane a stop gap and risky measure, the Eisenhower administration realized, to assure continuous surveillance of Soviet installations and exact targeting of Soviet bases, it must secure international acceptance of reconnaissance satellites. The Eisenhower administration's position on satellite programs became formalized in NSC-5520 on 20 May 1955.[46] Once again underlining the prestige and psychological benefits for the first nation to launch a satellite, the report asked for a small scientific satellite program to be launched in 1958 under the international auspices of the IGY to demonstrate peaceful purposes and test the principle of "Freedom of Space." Concurrently, the IGY program should not jeopardize any other satellite programs. Thus, the NSC-5520 also gave unquestionable primacy to the protection of the Air Force's WS117L reconnaissance program as it gave approval of an IGY satellite, provided the administration stressed the IGY satellite's peaceful nature and did not allow




*Dyna-Soar X-20 Post Mission Scenario is depicted in this series of artist renderings. After beginning the re-entry phase of flight, the X-20's pilot would jettison the transition section. Because the cockpit glazing (windows) would have been the largest carried on a manned spacecraft up to that time and with temperatures expected to exceed that of the melting point of the glass in the cockpit area, a special heat resistant shield would have been carried over the forward three windows. The single side windows would have remained uncovered during on-orbit flight and re-entry as they would not have been subjected to these high heating rates. After the high heat phase of re-entry had passed, the heat shield covering the front windows would have been jettisoned to allow the pilot good forward vision for landing. Dyna-Soar's landing gear would have been a three-point skid arrangement since conventional rubber tires on aluminum or steel rims could not be considered because of the high re-entry heat in the landing bays. The design of the main skis provided a high degree of friction allowing short skid distances which eliminated the need for brakes. Photos Courtesy Roy Houchin via Al Misenko and the History Office/Aeronautical Systems Division, Wright-Patterson AFB, Dayton, Ohio.*

it to interfere with the military space program. On 28 July, the peaceful, scientific character of the administration's policy became public knowledge.

As Eisenhower officials debated the merits of the Army's Project Orbiter over the Navy's Project Vanguard as boosters for the IGY satellite, selecting the latter, they gave the Air Force's Atlas ICBM program top priority. As a weapon system of definite military worth, the DOD readily committed R&D funds for its perfection; in turn, President Eisenhower continued to press for an international arms control agreement with the Soviets.[47]

Following ten years of technological breakthroughs, the Air Force's 1955 doctrinal manual, *Air Force Manual 1-2*, integrated Atlas ICBM technology into the traditional roles and missions of air power, but considered a manned strategic bomber force as the primary component to implement Eisenhower's "New Look" policy of massive retaliation. Air Force leaders like Major General LeMay adopted a cautious approach to the "push button war," favoring ICBMs as a complement rather than as a replacement to manned strategic bombers.[48] Until 1955, the Air Force stutter-stepped economically and doctrinally in its attempts to bring ICBMs into development. Through this period Air Force leaders, with a skeptical eye towards missile capabilities, promoted the technologically reliable manned bomber over missiles as the primary component of air defense.[49] The Air Force's institutional penchant for equating the necessity for a manned bomber to fulfil its primary mission of strategic bombardment, and ensure its continued independence, hindered the incorporation of missile technology. The majority of Air Force leaders believed ballistic missiles should undergo a step by step development, followed by operational integration into the weapons inventory. This process required maintaining the deterrence of a manned bomber force while simultaneously assimilating ballistic missile technology and projecting requirements for future weapon systems, all within the budgetary constraints of Eisenhower's "New Look" policy.[50]

Until the mid-1950s, Air Force planners selected short-term operational concerns to maintain their manned strategic bomber role through refueling and external weapons upgrades over the promise of new ballistic missile technology outlined in their R&D studies. Ironically, the concept of guided missile and boost-glide programs envisioned by AAF planners in 1945-1946 sprang from a small group of Air Force leaders almost entirely devoted to the expansion of future air power technology.[51]

As funding for ICBMs improved in 1955, and administration concerns over a means to gather continuous and timely intelligence of the Soviet Union's nuclear capability also increased, Air Force leaders favorably considered ICBMs as a supplemental weapon system, or as a replacement, for some manned bomber units. At the same time, ICBMs offered Air Force leaders an opportunity to extend operations into space through satellite reconnaissance and boost-glide technology.[52] However, the technological, economic, and political uncertainty of manned space operations forced caution among Air Force R&D planners who, as previously mentioned, parcelled their scarce funds to politically and technologically safe weapon systems to meet current operation needs against known Soviet threats rather than expand their technological horizons to meet potential Soviet threats.

As administration officials attempted to balance military requirements with domestic initiatives according to Eisenhower's "Great Equation," they also sought international agreements to limit an arms race. In addition, they preferred to bring America into the missile age without panic and, subsequently, without destabilizing the president's concept of economic balance. In FY 1955, Eisenhower cut defense spending by 20 percent, despite talk of rolling back Soviet power. Americans concurred with his fiscal policies and elected the president for a second term. Still, the services chaffed under the funding ceilings imposed by DOD and the administration under the "Great Equation."[53] When new Soviet strategic capabilities threatened the "New Look" policy, Eisenhower responded with a second "New Look," downgrading massive retaliation in favor of deterrence and upgrading conventional, limited war, capabilities. As the Atlas ICBM budget grew, other ballistic missiles suffered under the cutbacks; yet, the United States, as suggested earlier by the Killian report, maintained its nuclear superiority until November 1955 when the Soviets successfully tested a hydrogen bomb small enough to be used as an ICBM warhead.

In fact, because of initial technological successes in the development of the Atlas ICBM, Brigadier General Schriever gained approval, on 28 April 1955, for a second ICBM, known as Titan I. As with the Atlas ICBM, when the Air Force authorized the Martin Company to design, develop, and test the Titan I, the WDD and Ramo-Wooldridge Corporation management team exercised overall responsibility for the program.

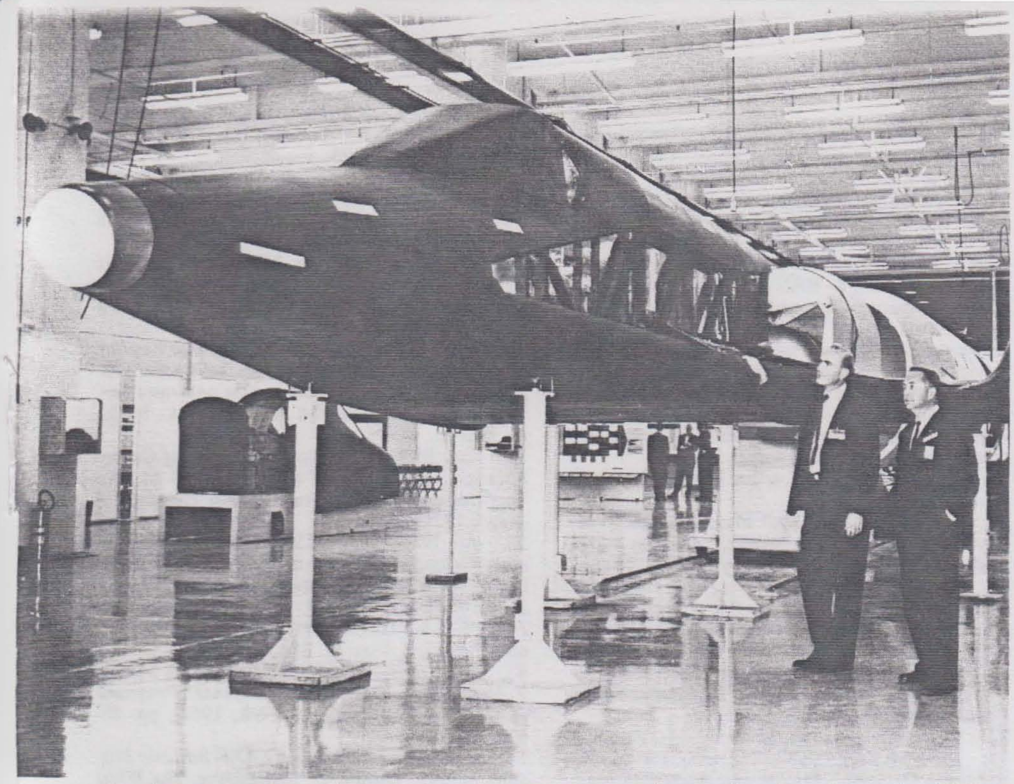
Simultaneously, Air Force leaders directed the WDD to study and evaluate solid propellant IRBMs. By April 1956, Air Force leaders contracted for IRBM studies while the Tactical Air Command (TAC) and USAF Europe (USAFE) issued a qualitative operational requirement; but Air Force leaders could not validate their operational requirement because limited R&D funds placed the fiscal priority on ICBM development. In May, the United States detonated a hydrogen bomb suitable for an ICBM warhead. By December, Eisenhower assigned the highest priority to the Air Force's Atlas and Titan I ICBMs, the Army's Jupiter IRBM, and the Air Force's Thor IRBM.[54] With two ICBM programs and one IRBM program, the Air Force gained the largest portion of DOD missile appropriations.

While Eisenhower's second "New Look" policy evolved, the other services attempted to share the mission of strategic warfare by developing their own IRBM missiles to counter the Air Force's IRBMs intensified interservice rivalry.[55] The resulting competition between the three services for IRBM development opened old concerns over who would receive what roles and missions and how much funding would be involved. Secretary of Defense Charles C. Wilson felt, once the missiles proved their feasibility, the final decision of roles and missions would be resolved. On 26 November 1956 the time arrived; Secretary Wilson assigned a 200 mile range IRBM for Army missiles, the remainder of land based ICBMS/IRBMs (and, once again, the largest amount of funding) would be the Air Force's responsibility and the Navy would be responsible for sea based IRBMs.[56]

Concurrent with the services competition for IRBMs throughout 1956, Air Force leaders, in March, concluded another contract with the Bell Aircraft Company for a research study of a manned boost-glide reconnaissance system known as "Brass Bell."[57] This study did not duplicate Bell's initial study of BOMI; indeed, the BOMI concept showed promise and evolved into a rocket bomber (ROBO) feasibility study. By November 1956, as Secretary Wilson made his ICBM/IRBM declarations, the ARDC issued a system requirement for a hypersonic R&D platform, known as "Hywards," to serve as a test craft for the development of subsystems to be employed in future boost-glide systems.[58] Although Lieutenant General Herbert B. Power, Commander ARDC, believed the United States should stop considering new and novel projects, such as the boost-gliders, and start developing them to offset Soviet technological progress, the Air Force did not allocate any funds in FY 1957 for manned space operations.

Air Force leaders like Major General LeMay and Lieutenant General Power, conscious of the recall capability, the greater flexibility in target selection, and the increased tactical options available to a manned bomber over an unmanned ICBM, and equally conscious of the fifteen minute detection warning time inherent with ICBMs, felt a manned boost-glide weapon system would shorten detection warning time to three minutes. This reduced reaction time, coupled with the spacecraft's proposed operational altitude, made the system invulnerable to Soviet attack and a vital element in deterring aggression and supported the Air Force's proclivity for a manned bomber.[59] While Air Force logic appeared sound, the ultimate success of any manned military space system would depend on the administration's perception of its utility and compatibility to the administration's vitally important, and soon to be operational, unmanned reconnaissance satellites. Months prior to Sputnik, this element of the Eisenhower administration's hidden agenda remained clouded in the Air Force's hopes to offset perceptions of concurrent Soviet developments in manned boost-glide systems.[60]

When the Soviets launched Sputnik on 4 October 1957, the question of establishing an international legal precedent for reconnaissance satellite overflight became moot, lost in the repercussions of the event.[61] The orbiting of Sputnik shocked, then galvanized, the American people and Congress into committing vast resources to the nation's missile and space programs. Even though concerns for American prestige and security from Soviet space threats called for military countermeasures on the order of Dyna-Soar, the administration still advocated and directed a peaceful response to the Soviet incursion into space.[62] In placating the proponents of space weapons systems,



*Another view of Boeing's Dyna-Soar full-scale engineering mockup from Sepetmber 1961 at the factory in Seattle. Note the full-scale model of a modified Titan II booster, one of several launch vehicles considered for use in the program. Photo by Roy Houchin via Al Misenko and the History Office/Aeronautical Systems Division, Wright-Patterson AFB, Dayton, Ohio.*

and in providing some insurance, the Advanced Research Project Agency (ARPA) and all three services pursued research on a variety of space weapons; but funding restrictions permitted only feasibility studies into space countermeasures.[63]

Prior to the exigency of formulating a response to Sputnik, Air Force leaders envisioned the three aforementioned boost-glide roles as plausible ways to incorporate the reconnaissance capabilities of satellites, the strategic bombing role intrinsic to the Air Force's independence, and the latest developments in ballistic missile technology into Air Force doctrine, but the cost of three parallel programs to realize those goals could not be justified within Eisenhower's budgetary constraints. Therefore, Air Force leaders consolidated the three feasibility studies, Hywards, Brass Bell, and Rocket Bomber (ROBO), into a single program—Dyna-Soar on 10 October 1957.[64] The first development phase (Step I) of Dyna-Soar from the Hywards program, would be a manned research vehicle to obtain aerodynamic, structural, and human factor data at speeds and altitudes significantly beyond the reach of the X-15. Dyna-Soar would operate in a flight regime of 10,800 mph and 350,000 feet altitude compared to the X-15's 4,000 mph and 250,000 feet. In addition, Step I would provide a means to evaluate military subsystems. In establishing test criteria for Dyna-Soar, Air Force leaders made a clear distinction between experimenting with a research prototype and a conceptual test vehicle. Unlike the X-15, designed to provide information for general application, Dyna-Soar was designed to provide information for the development of a weapon system.[65] The second phase of Dyna-Soar (Step II) would have produced a vehicle like the one outlined in the Brass Bell study, a manned reconnaissance spacecraft capable of obtaining an altitude of 170,00 feet over a distance of 5,000-10,000 nautical miles at a maximum velocity of 13,200 mph.[66] The final phase of Dyna-Soar's development (Step III) incorporated the ROBO design specifications by using a more sophisticated vehicle able to obtain an orbital altitude of 300,000 feet at 15,000 mph. During this phase Dyna-Soar would become an operational weapon system capable of orbital nuclear bombardment, improved reconnaissance capabilities and, eventually, satellite inspection (identification and neutralization). With Dyna-Soar, the Air Force sustained the strategic bombing mission inherent to its institutional independence while incorporating satellite reconnaissance and ballistic missile technology.[67]

From the initial forecasts in Dr. von Karman's multivolume work, *Toward New Horizons*, through the Air Force's incorporation of ballistic missile technology in *AFM 1-2* to the consolidation of the Air Force's three hypersonic studies into one development plan, Air Force leaders believed advances in aerospace technology would ensure the Air Force's independence from the other services while providing the best possible means for national defense. Initially, ballistic missile technology seemed promising. Yet, when the technological solutions to reduce the size of the atomic bomb did not appear to be within reach and the problems related to maintaining a high degree of accuracy could not be quickly resolved, ballistic missile technology emerged as an economic and institutional burden, lagging behind the technological capabilities and institutional stability of manned bombers. With the development of the hydrogen bomb, the problems of size and the inherent need for accuracy seemed solved. The increasing threat of Soviet ICBM capabilities highlighted the need for, and America's inability to obtain, timely and accurate reconnaissance information. While satellite reconnaissance would yield the necessary information, it also needed ballistic missile technology to achieve its mission. Ultimately, Air Force leaders embraced ballistic missile technology, as did the other services in their quests to gain a larger share of decreasing defense appropriations. After gaining the opportunity to develop the Atlas and Titan I ICBMs, the Thor IRBM, and a satellite reconnaissance system—Weapon System 117L, Air Force leaders appeared the victors. Yet, the institutional question of ballistic missile technology replacing all manned bombers remained. The Dyna-Soar, X-20, program, a product of a closed-circle relationship between the developments in national policies, the nature of the enemy threat, the state of technological developments, and the dicta of previous air power doctrine, became a solution. With Dyna-Soar, the Air Force maintained its institution affinity for a manned strategic bombardment role, inherent to its independence, incorporated ballistic missile and satellite technology into a manned weapon system, and propelled its ideology into the realms of space. ●

## Endnotes

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# THE DYNA-SOAR X-20: A HISTORICAL OVERVIEW

by Terry Smith

The surrender of Nazi Germany in May, 1945, brought to the United States a large number of scientific and technical documents, one of which would lead directly to the development of the Space Shuttle system of today.

The work of Dr. Eugene Sanger and Irene Bredt on their concept of an "antipodal bomber" that would have spanned intercontinental distances to drop bombs on U.S. targets was of great interest to the military planners of the postwar U.S. His "Silver Bird," as Dr. Sanger referred to his creation, would have reached speeds close to Mach 1.5 traveling along a two mile long horizontal track before firing its own rocket motors and climbing to the edge of space at 14,000 miles per hour. Its target was New York City, and after dropping its bomb load, would have "skipped" in the atmosphere in a series of bounces to a point halfway around the world where the crew would have ditched in the ocean and been picked up by submarine to be returned to Germany. There were also plans to extend their skipping points to reach around the world and return to the launch site, a feature that would be a major selling point for the Space Shuttle thirty years later.

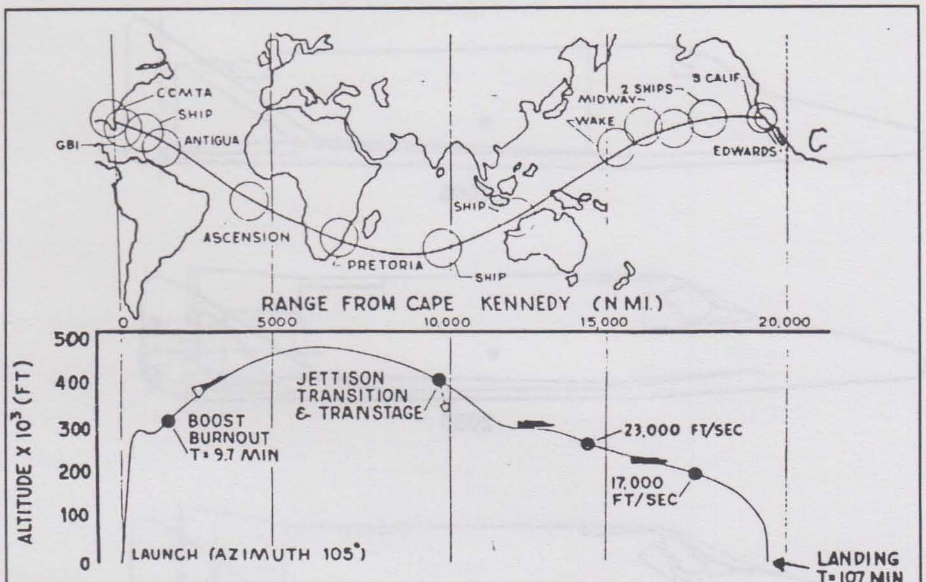
The new U.S. Air Force, in its studies of the Antipodal Bomber thought, that if this concept could be made to work in connection with the new Atom Bomb, it would be a potent weapon system. The design of several postwar weapon systems based on the Sanger–Bredt concept would eventually evolve into what would be called the X-20 Dyna–Soar.

In 1951, the Bell Aircraft Company proposed a boost–glide vehicle called "BOMI" (bomber missile) to the Air Force. The BOMI study, also known as the Dornberger Project named after its director, Dr. Walter Dornberger, combined the elements of a missile (vertical launch) with those of an aircraft (pilot control–runway landing).

After reviewing the Bell proposal for over a year, the Air Force rejected the plan as they felt BOMI duplicated work already in progress on the Atlas ICBM program and the Feedback Reconnaissance Satellite Studies.

Bell again submitted BOMI to the Air Force in 1953 with more favorable results. On April 1, 1954, the Air Force granted Bell a one year contract to perform a design study of an "advanced bomber–reconnaissance weapon system."

After two years of study and $420,000 in funds, the range had become "global," but questions about the vehicle's cooling system, stability, and control lead to the concept fading away. However, the idea of a boost–glide vehicle was still very much alive. Bell Aircraft continued to be involved in several Air Force military space systems' studies including System 118P, a reconnaissance air spacecraft that was very similar to BOMI. The company also worked on a piloted, high–altitude reconnaissance system known as Brass Bell.



*X-20 One-Orbit Mission. Graphic Courtesy Terry Smith.*

An additional study called for by the Air Force in 1955 was for a boost–glide vehicle that would be "a manned, hypersonic, rocket–powered, bombardment, and reconnaissance weapon system." In December of 1956, three companies were awarded contracts: Convair, Douglas and North American. Bell and the Martin Company would later join the other three companies in what would become ROBO, a ROcket BOmber.

The Air Force asked for a research vehicle to provide information on aerodynamics, structure, and human factors to be used to develop future hypersonic systems. The program, known as Hywards (Hypersonic Weapons Research and Development Supporting System) was studied as System 455L in 1956.

In 1957, the Air Force had decided on a three–phase development program that brought the separate studies together into a global bomber. The ROBO concept was what the Air Force thought should be the end result of a six to eight year research and flight test effort. With this three–phase effort, the Air Force would be flying a hypersonic research vehicle by 1965, a Brass Bell type boost–glide spacecraft by 1968, and the full weapons system by 1974 (ROBO).

This new three-phase development program was what the Air Force was looking for, and in 1957, it was given the name "Dyna–Soar," a contraction of the terms "Dynamic Ascent" and "Soaring flight."

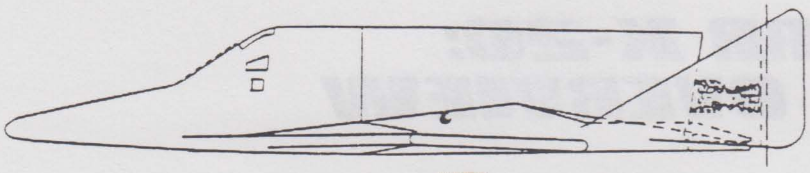
At this time the NACA, soon to be the government agency NASA, became interested in the Dyna–Soar plans of the Air Force. NASA was looking at the program because it would be a way to obtain aerodynamic data far and above the X–15's top speed, then thought to reach Mach 6. The agency would only play a small role in the program, providing technical advice and assistance. On November 15, Air Force management approved the restructured program with an allocation of $3 million in 1958.

January 1 brought requests for proposals to thirteen aerospace contractors for the Dyna–Soar Project. By March, nine contractors had responded to the call with several unique designs. All of the concepts were different in design and booster choice, but all had one common element (except for the modified North American X–15), this being the use of the "delta–wing."

The two concepts which gained the most attention were from the Martin Bell and Boeing teams. Martin Bell felt that an active cooling system would be needed while Boeing went with a system that would use special metals to radiate the heat away.

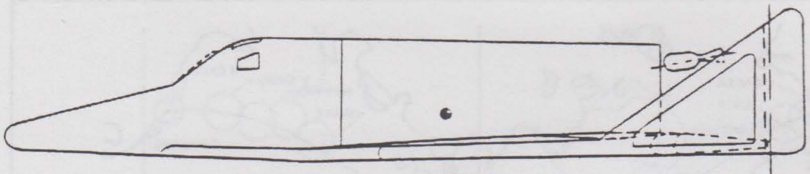
After a complete evaluation of all the proposals, the Air Force announced on June 16, 1958, that Martin Bell and Boeing were finalists in the Dyna–Soar program. Each company was awarded $9 million for additional studies and development work on their respective designs.

The first of many reviews of the program concerning the usefulness of the project led to a redirection that reduced it to a two–phase program with phase one being a manned prototype glider with a first orbital flight in 1963. While these flight tests were



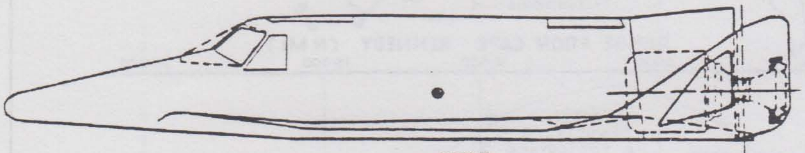
1050

Fin Sweep: 59.5°
Fin Area (With Rudder): 32 sq. ft.
Rudder Area: 9.7 sq. ft.
Wing L.E. Diameters: 2", 4"
Nose Diameter: 6"



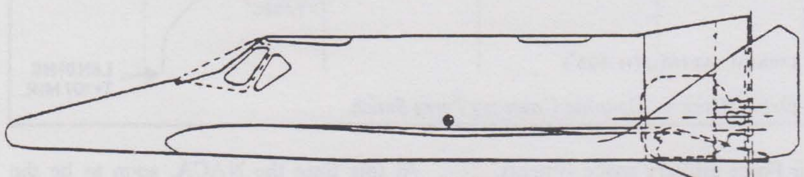
2005

Fin Sweep: 55.5°
Fin Area (With Rudder): 31 sq. ft.
Rudder Area: 9.35 sq. ft.
Wing L.E. Diameters: 2", 4"
Nose Diameter: 7.5"



2035

Fin Sweep: 55°
Fin Area (With Rudder): 31 sq. ft.
Rudder Area: 10.6 sq. ft.
Wing L.E. Diameters: 2", 4"
Nose Diameter: 7.5"



2050

Fin Sweep: 55°
Fin Area (With Rudder): 31 sq. ft.
Rudder Area: 13.3 sq. ft.
Wing L.E. Diameters: 6", 4"
Nose Diameter: 7.5"

**NOTE:** The letter A, F and M denote position of Maximum wing thickness; Aft, forward and middle

# Evolution of a Dyna-Soar

The following three pages reveal the major changes in the Dyna-Soar configuration and the corresponding aerodynamic characteristics of these configurations.

**Model 814-1050** came out in March 1959 and was the final version of the 814 series.

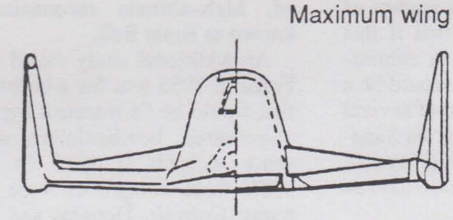
**Model 844-2005** was proposed in July 1959 and was the glider used in the Phase Alpha Study. The wing thickness was reduced to eliminate pitching moment problems.

**Model 844-2035** configuration came out in November 1960 and had larger elevon control surfaces for more effective hypersonic control.

**Model 844-2050** configuration dated August 1961. The slope of the windshield was decreased to eliminate a hot spot.

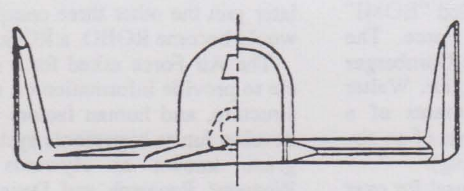
**Model 844-2050-E** came out in December 1961 and was the final configuration. A ramp was added to the top of the aft section of the fuselage for stability reasons.

The data and drawings were provided by Roy Houchin via Ronald W. DuVal and Lee Saegesser, NASA History Office, Washington, D.C.



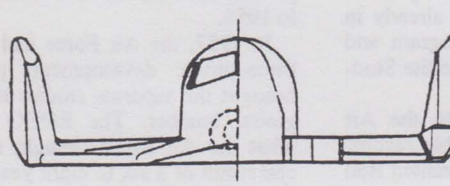
1050

Fin Thickness: 6"
Maximum Wing Thickness: M 25"
Mean Wing Thickness: 11.64"



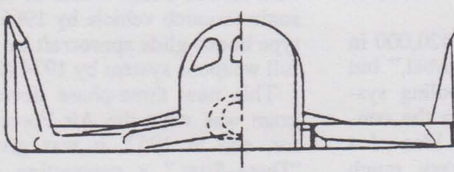
2005

Fin Thickness: 6"
Maximum Wing Thickness: A 12"
Mean Wing Thickness: 9.51"



2035

Fin Thickness: 8"
Maximum Wing Thickness: A 13"
Mean Wing Thickness: 9.28"

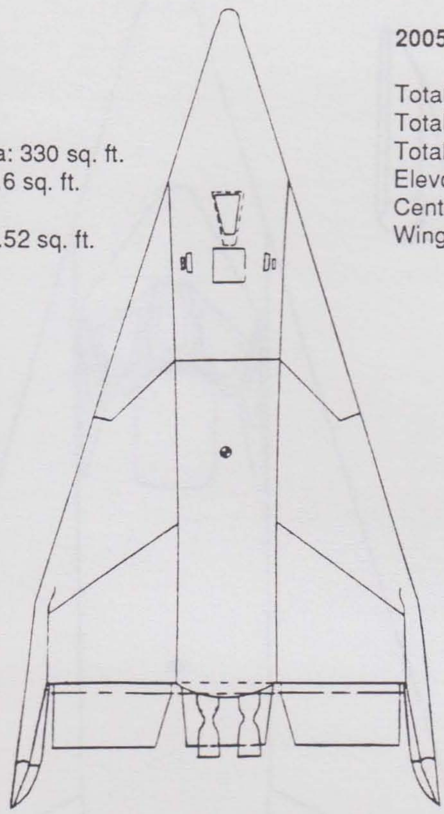


2050

Fin Thickness: 6"
Maximum Wing Thickness: F 20"
Mean Wing Thickness: 13.56"

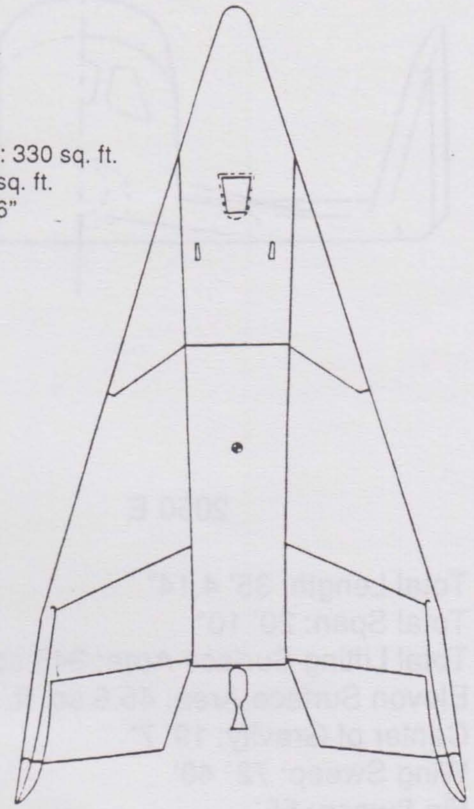
### 1050

Total Length: 34' 7.5"
Total Span: 18' 7.2"
Total Lifting Surface Area: 330 sq. ft.
Elevon Surface Area: 22.6 sq. ft.
Center of Gravity: 19' 3"
Elevator Surface Area: 8.52 sq. ft.
Wing Sweep: 73˚



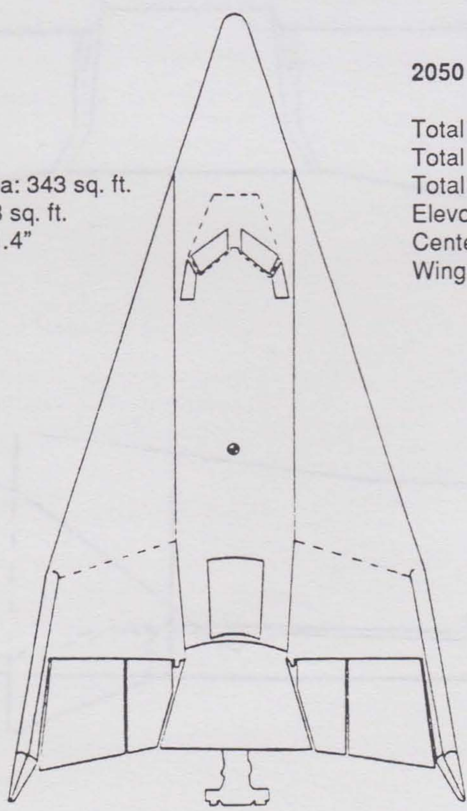
### 2005

Total Length: 35' 3.8"
Total Span: 19' 8"
Total Lifting Surface Area: 330 sq. ft.
Elevon Surface Area: 34 sq. ft.
Center of Gravity: 17' 11.6"
Wing Sweep: 73˚



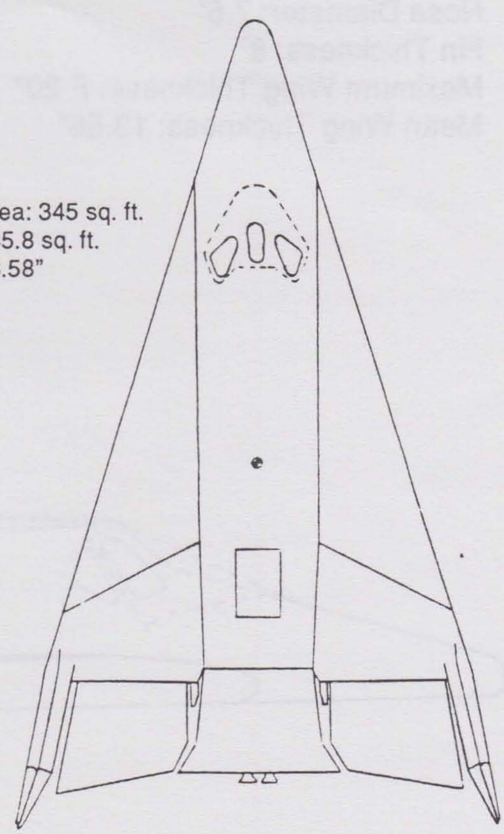
### 2035

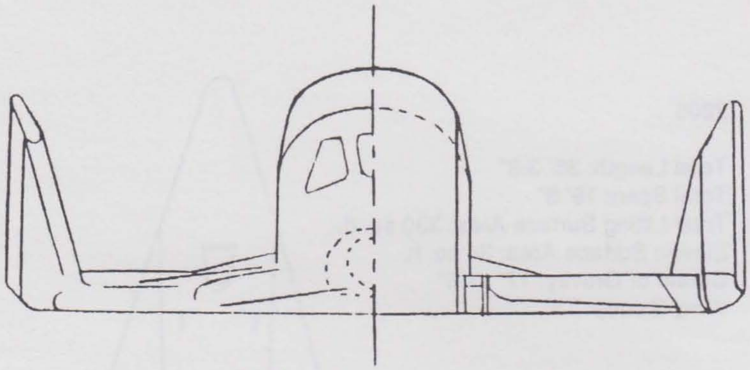
Total Length: 35' 4.2"
Total Span: 20' 1.7"
Total Lifting Surface Area: 343 sq. ft.
Elevon Surface Area: 48 sq. ft.
Center of Gravity: 17' 11.4"
Wing Sweep: 72˚ 45'

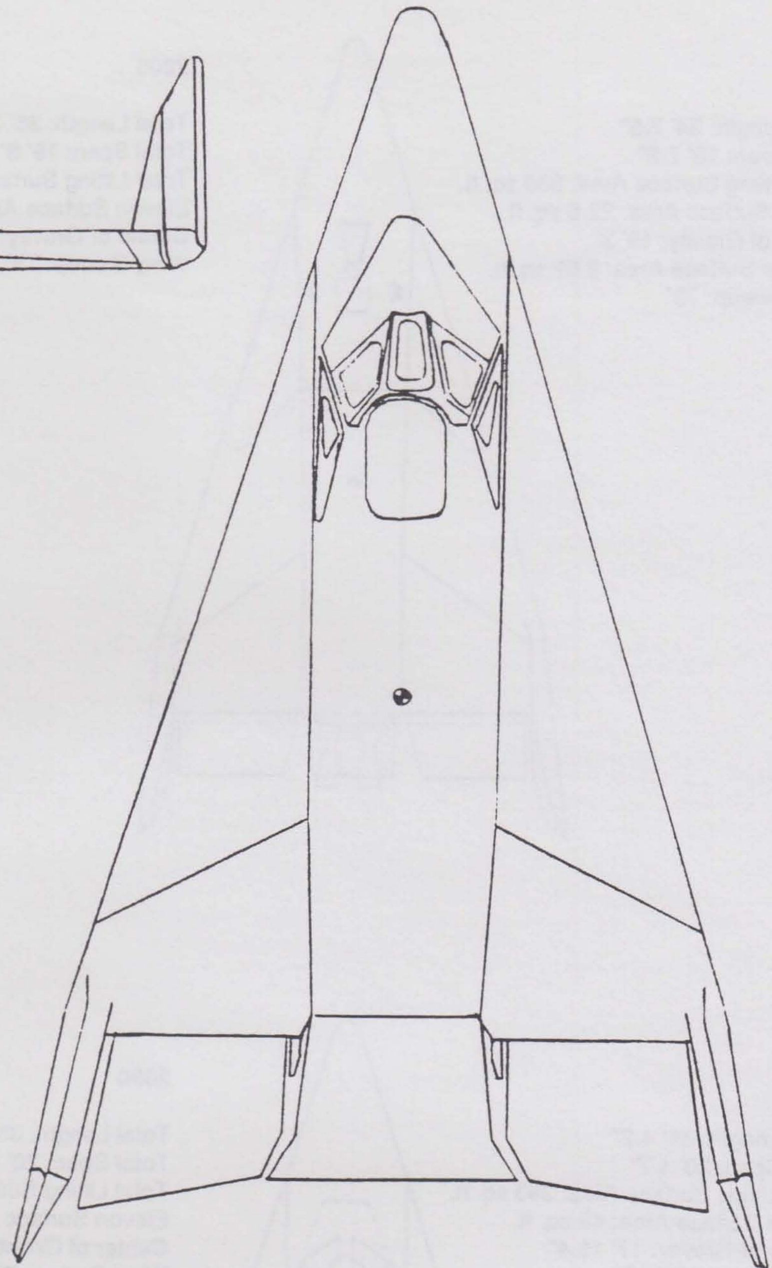


### 2050

Total Length: 35' 4.14"
Total Span: 20' 10"
Total Lifting Surface Area: 345 sq. ft.
Elevon Surface Area: 45.8 sq. ft.
Center of Gravity: 18' 3.58"
Wing Sweep: 72˚ 48'

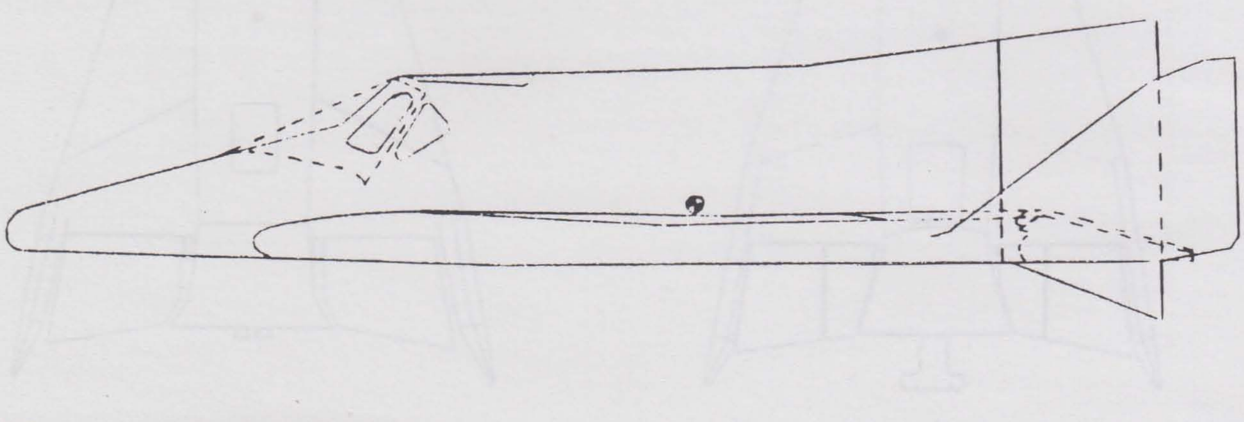






## 2050 E

Total Length: 35' 4.14"
Total Span: 20' 10"
Total Lifting Surface Area: 345 sq. ft.
Elevon Surface Area: 45.8 sq. ft.
Center of Gravity: 19' 7"
Wing Sweep: 72˚ 48'
Fin Sweep: 55˚
Fin Area (With Rudder): 31.4 sq. ft.
Rudder Area: 10.67 sq. ft.
Wing L.E. Diameters: 6",4"
Nose Diameter: 7.5"
Fin Thickness: 8"
Maximum Wing Thickness: F 20"
Mean Wing Thickness: 13.56"



being carried out, studies would continue on phase II so that an operational weapon system could be put into service by 1967.

Was Dyna–Soar a weapon system or a research vehicle? This question hung over the project into early 1959 as forces within the Pentagon fought for funding. The Deputy Secretary of Defense authorized $10 million for the studies while stating that the money was for research and development and not for a weapons system.

It was up to Dr. Herbert F. York, Director of Defense for Research and Engineering, to lay out the goal of Dyna–Soar. He stated that the program was for research into non–orbital exploration of hypersonic flight. It would be manned, maneuverable, and capable of pilot–controlled landings.

The S.P.O. (System Project Office), on the other hand, stated that Dyna–Soar would be used to "determine the military potential of a boost–glide weapon system and provide research data on flight characteristics up to and including global flight."

With an authorized expenditure of $64.5 million for 1959 and 1960, the Air Force was told by DoD to follow the objectives put forth by Dr. York. Despite efforts to revive the military mission of Dyna–Soar, this redirection shifted emphasis of the project to that of research and development.

With the Air Force accepting Dr. York's outline of the program for the time being, attention now focused on the question of which booster to use. Boeing's concept called for the use of the planned Atlas–Centaur, but this vehicle could only provide suborbital speeds for the expected 8,000 to 10,000 pound glider. Martin Bell had specified the use of Martin's modified Titan ICBM. This launch vehicle could boost the Martin Bell design to orbital speed. There were other designs for boosters that received attention including a purpose–built Dyna–Soar booster. This was known as Titan C with plans to use it as an upper–stage to the soon to be built Saturn I.

The Ballistic Missile Division had decided by August, 1959, that the Titan C should be the booster for Dyna–Soar after studying all of the competing designs. This decision was not accepted, and the question of a booster for Dyna–Soar would be decided later.

With the new decade approaching, the Dyna–Soar program was again re–examined and a new three step program was put forward. Step I would use a manned glider weighing under 10,000 pounds and be launched by a modified Titan I to suborbital speed. Step II would use the basic spaceplane launched to orbital speeds and involve testing of military applications. Step III would be the full–up weapons system using experience gained from the previous test flights.

The Air Force Weapons Board approved the revised Dyna–Soar plan on November 2, 1959, outlining a series of tests that included nineteen airdrops, eight unmanned suborbital flights, and eight piloted suborbital flights to occur by May, 1964. A manned orbital launch would be made under the Step II plan by August, 1965.

The Air Force announced on November 9, 1959, that the Boeing Aircraft Company had the contract to develop Dyna–Soar, with the Martin Company to be responsible for booster development. On November 17, Dyna–Soar was designated System 620 A.

With the program finally moving closer to hardware definition, high officials in the Eisenhower administration began to question the completion of the project. To answer these and other detractors, the Air Force formed a group to review the design put forth by Boeing and to also look at booster selection and flight test objectives.

This review came to be known as Phase Alpha and was basically a complete look at all of the work done by all contractors in the original competition. Conducted over the span of the first few months of 1960, the Phase Alpha studied different re–entry vehicle options including high and low lift vehicles, delta–wing platforms, folding wings, and swing wings. The final result of this extended effort being a confirmation that the Boeing design was the best configuration.

April 1, 1960, saw the Dyna–Soar project office announce a new test schedule that now included a series of twenty air drops with the spaceplane being carried aloft to 45,000 feet by a modified B–52 bomber and dropped to test low speed handling and landing characteristics. Later airdrops would include powered flights up to Mach 2. Five unmanned suborbital flights would begin in November, 1963, to be followed by eleven piloted suborbital tests with launch taking place at Cape Canaveral and landing at four down–range sites including the Bahamas and Fortaleza, Brazil.

Boeing signed a contract with the Air Force on April 27 to build the Dyna–Soar with the Martin Company receiving its contract for modified Titan 1 airframes on June 8. The Aerojet General Corporation was contracted to supply the Titan first and second stage motors with Minneapolis–Honeywell signed to develop the guidance subsystem and RCA to provide communication and data down–link hardware.

After reviewing the changes needed to make the Titan I a suitable booster for Dyna–Soar, it was becoming clear that the payload capability was close to the limit. After the weight of the manned–rated subsystems, the large guidance fins, and the growing weight of the Dyna–Soar itself was added up, the move to the more powerful Titan II booster was proposed in November, 1960.

Martin had begun development of the Titan II as a replacement for the Titan I in 1959 incorporating a more powerful first stage and a redesigned and enlarged second stage. After a two month study, the Titan II replaced Titan I as the Dyna–Soar booster.

The one orbit flight of Yuri Gagarin in April, 1961, caused some changes in the schedule of Dyna–Soar, with Boeing offering a plan called Project Streamline which outlined the dropping of the suborbital flights, using off the shelf subsystems and integrating the spaceplane with NASA's Saturn I boosters to provide orbital flights by April, 1963. This schedule would beat the present launch date of August, 1964, by almost sixteen months.

After looking at Boeing's Project Streamline, the Special Projects Offices offered an alternative plan which keyed on three boosters to launch the Dyna–Soar during Phase I. As in Project Streamline, a modified Saturn I was considered, along with the Titan II with a Centaur second stage and the Titan II with solid rocket boosters as the first stage. The Titan II with solid rockets was called SOLTAN (Solid Titan) but this designation would later change to the now more familiar Titan III.

As originally designed, the Titan III would have used a strengthened Titan II as the core with two three–segment 100 inch diameter solid rockets. These would have been referred to as stage 0. With continued design work, the SRB's would grow to five segments and 120 inches in diameter. Although other boosters were still considered, they would continue to lose favor as Titan III would meet several mission requirements, in addition to that of Dyna–Soar, which the Air Force would need in the coming decade. It also passed the most important test, that being the test of multiple roles which the new Secretary of Defense felt new defense systems should fulfill. By the end of October, 1961, the Department of Defense had decided that Titan III would be the military space launcher for the foreseeable future.

With the booster issue definitely settled this time, attention turned back to the Dyna–Soar with a mockup inspection at the Boeing plant in September, 1961. No major changes were noted, and Boeing would now gear up for production of the ten airframes ordered. These ten production Dyna–Soars were assigned the Air Force serial numbers: 61–2374 through 61–2383.

In December, 1961, a revised Dyna-Soar schedule was approved that dropped suborbital flights completely and directed program officials to work toward orbital flight with the Titan III. The B–52 airdrop tests would begin in April, 1964, with the first unmanned Titan III Dyna–Soar launched in February, 1965. All flights would now end at Edwards Air Force Base after a single orbit. The first manned flight was expected in August, 1965.

The new Secretary of Defense, Robert S. McNamara, after reviewing the redirected program, wrote a memo to the Secretary of the Air Force stating that he felt the name of the program should be changed to better reflect the experimental nature of the program. After months of research, the Air Force finally settled on X–20 as the new program name. This would link it in the public's mind to the already famous line of research aircraft flown in the last fifteen years. Air Force headquarters were quick to approve the X–20 designation, but also retained the Dyna–Soar name to be used in conjunction with X–20 in all information releases.

By the summer of 1962, with plans moving into the production stage, the Dyna–Soar office released a new schedule that included up to twenty air-drops, the first of these beginning in September, 1964, and the last coming in August, 1965. While the airdrop programs were carried out, two unmanned orbital flights would be launched to verify the Titan III C–Dyna–Soar integration, and to provide data that would back up wind tunnel tests. With these tests complete, the program would continue with a series of manned flights beginning in November, 1965, with completion after eight missions in the summer of 1967. Plans were also being put forth that would extend some later X–20 flights to multiple orbit missions.

As Dyna–Soar had been designed from the start as a single orbit vehicle, the change to multiple orbit missions would prove to be more difficult than first thought. Some changes that had to be made would involve the accuracy of the guidance system and on orbit systems' reliability. The amount of system consumables would also have to be increased to cover the longer period, up to 72 hours, that Dyna–Soar would fly in orbit. The major problem would be the need for some sort of de–orbit system.

The Dyna–Soar office studied several different proposals which included mounting the de–orbit retro–rockets in the tail of the spaceplane or using the new Transtage with its new restartable rocket motors. The choice of the Transtage offered several advantages over a simple retrorocket installation. Transtage would not only allow de–orbit capability, but could also be used for on–orbit maneuvers and orbit changes. These attributes sold the Air Force on the Transtage and it became the system chosen.

The Transtage would be the upper stage of Titan III and be used to inject the X–20 into an accurate orbit. On later missions, the on–orbit capabilities of Transtage could be used for satellite inspection and high altitude intercept missions. With Transtage now part of the Titan III booster system, plans were made that would place the first unmanned Dyna–Soar flight on the fourth test flight of the Titan III C development schedule.

At the 1962 meeting of the Air Force Association at Las Vegas, Nevada, a full-size engineering mockup of Dyna–Soar was shown to the public for the first time. Many were impressed with its highly swept twenty-foot delta wingspan and thirty–five foot length. Compared to the Mercury Spacecraft then flying, the Dyna–Soar was a vision of the future and made the Mercury program look like the wrong choice had been made in picking blunt body re–entry over lifting re–entry.

Also announced were the names of six pilots who were to fly the X–20 Dyna–Soar into orbit. Five were Air Force officers who had been involved in the program for some time. They were Captain Albert H. Crews, Jr., Major Henry C. Gordon, Captain William J. "Pete" Knight, Major Russell Rogers, and Major James W. Wood. Milton C. Thompson, a civilian working for NASA was the sixth member of this X–20 astronaut's class.

The beginning of 1963 again saw the Dyna–Soar program under attack within the DoD and the Air Force trying to keep the program alive. The DoD felt there should be a justifiable military mission and to redirect the program to this end or to cancel it. During this time an internal battle between the Space Systems Division and the Aeronautical Systems Division began again, and while these two groups fought among themselves, they prevented the Air Force from presenting a united front to the opponents of the X–20 program.

In late January, 1963, Secretary McNamara ordered reviews of X–20, Gemini, and the Titan III with the hope that an answer could be found to the question of which vehicle offered the best approach to a manned military space system. While its supporters argued among themselves, this review process started the ball rolling toward cancellation of Dyna–Soar.

In response to Secretary McNamara's questions, the Air Force prepared several options, some of which included maintaining the current program, accelerating the flight test program, expanding the program's military objectives, or finally canceling the entire program.

The Air Force also commented on the so–called "Blue Gemini" program saying that although the Air Force would participate in NASA's Gemini program, and were, in fact, already designing experiments to fly on some missions, this participation would be in addition to the Dyna–Soar program and not as a replacement.

March, 1963, found Secretary McNamara at the Boeing Missiles Systems Plant attending a briefing on the status of X–20 and the Titan III C programs. Again questions were raised about the usefulness of the program and its relationship to future military space programs.

With the threat of program cancellation beginning to become stronger, the Air Force still awarded Boeing a contract that covered airdrop tests and one mid–1965 unmanned flight test. The vehicle to be used in the airdrop program was being built at the time and was expected to be ready by the summer of 1964.

The Dyna–Soar office began looking into other missions that the X–20 could perform. One of these suggested an X–20 B that could be used for satellite inspection or destruction if the need should arise. Another example was the X–20 X which would have been a two–man X–20 with a fourteen day on–orbit stay time that, with use of the Transtage, would have been able to orbit as high as 1,000 miles.

The use of Dyna–Soar as a "Space Shuttle" vehicle to service a military space station was also brought forward as proof that the X–20 would be useful to the military.

The idea that Dyna–Soar could be used as a supply vehicle to some future space station, military or otherwise, was also on the mind of Vice President Lyndon Johnson in a meeting with Secretary McNamara on July 22. Johnson wanted to know the importance of space stations in regard to National Security. McNamara replied that a military role was needed in space, and he should have space station plans outlined by early 1964.

In early September, the Dyna–Soar office released a revised flight program that again delayed the program. Airdrops would begin in May, 1965, with the first manned orbital flight in July, 1966. The first multi–orbit mission would come in late 1967. Total program costs were now projected to approach one billion dollars.

A meeting was called by Secretary McNamara to again discuss the X–20, Titan III C program. Dr. Harold Brown, the Secretary of Defense for Research and Engineering, and Brockway McMillian, Under Secretary of the Air Force, were also in attendance. McNamara wanted the Air Force to tell him what it planned to do with the X–20 after the program had demonstrated lifting re–entry and pilot controlled landing. He also asked Under Secretary McMillian about the X–20 in connection with a space station program. McNamara left the meeting convinced that the X–20 Dyna–Soar was a dead-end program. The prospect of cancellation now seemed certain.

On December 4, the Air Force circulated a memo that outlined three proposals for an X–20/space station. All three designs used a pressurized space in the Transtage and use of the pressurized equipment compartment to carry up to four passengers. The memo also suggested, in what must have been a case of sour grapes, that the Gemini program be canceled.

The Space Station plans received little attention from Secretary McNamara, and on December 10, 1963, he announced that the X–20 program would be canceled. It would be up to unmanned programs to prove out the concepts of Dyna–Soar. The Assent program, using what looked like small scale Dyna–Soars would carry on research in lifting re–entry and high temperature metals.

Dyna–Soar suffered from a series of upheavals, redirections, and lack of vision by those persons responsible for its eventual demise. Seven years later, the Air Force, in concert with NASA, would again begin to look to lifting re–entry as a means of returning to earth.

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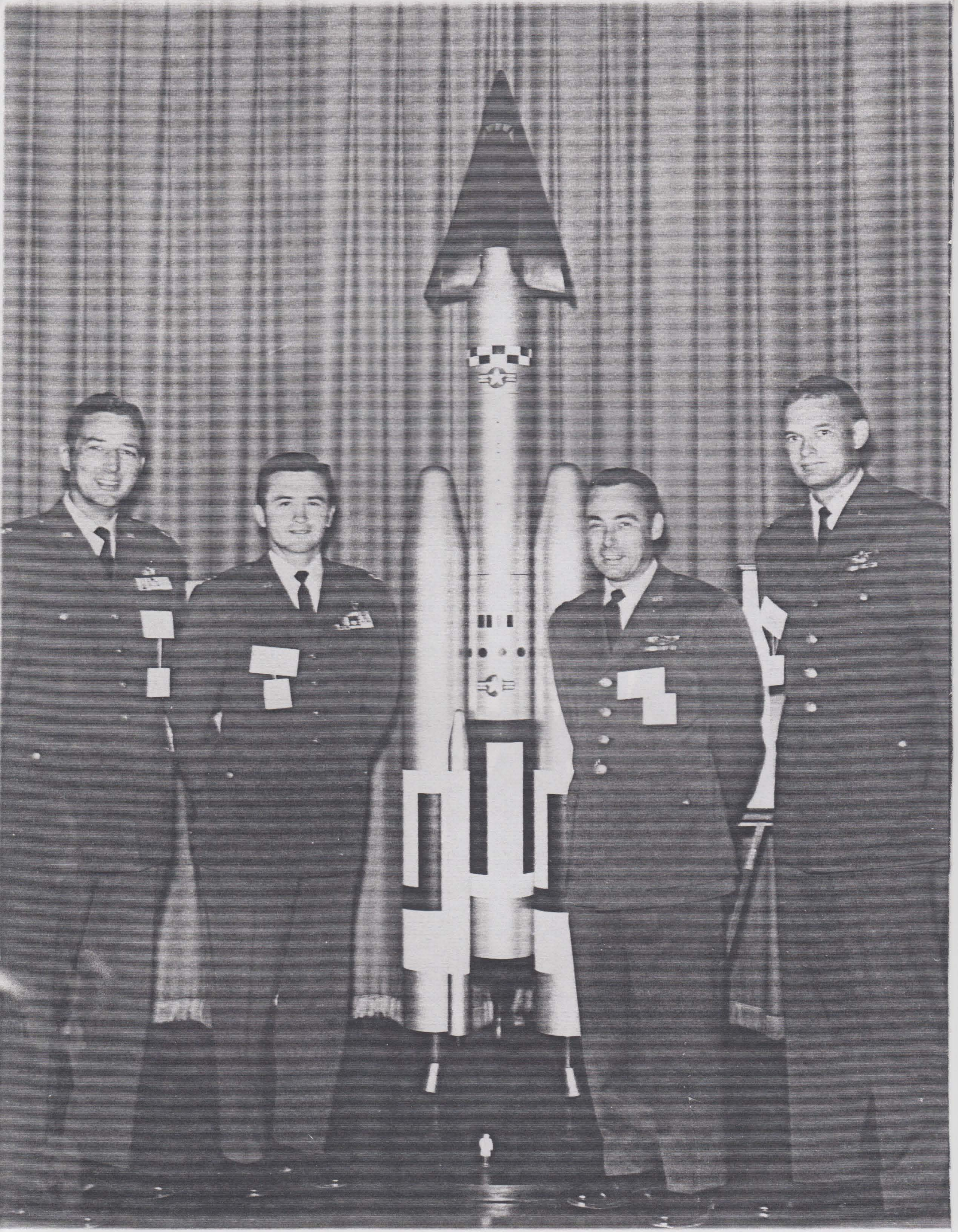
THE X-20
PILOTS



Five out of six pilots selected to fly the Dyna-Soar X-20 were Air Force officers with extensive experience in supersonic aircraft and experimental flight test techniques. All were graduates of the Air Force's Experimental Test Pilot School, or Aerospace Research Pilot School at Edwards Air Force Base in California.

The Five Air Force X-20 Pilots were:

Captain Albert H. Crews, 33, an experimental test pilot at the Air Force Flight Test Center. One of eight test pilots that attended the Aerospace Research Pilot course at Edwards AFB.

Major Henry C. Gordon, 36, also an experimental test pilot at the Air Force Flight Test Center and an air combat veteran of Korea.

Captain William J. Knight, 32, another member of the test pilot team at Edwards AFB.

Major Russel L. Rogers, 34, flew 142 mission during the Korean conflict.

Major James W. Wood, 38, a test pilot at Edwards AFB since 1957. Until his selection as one of the Dyna-Soar pilots, he was assistant chief of fighter operations in the Air Force Flight Test Center's Directorate of Flight Test.

The sixth member of the Dyna-Soar team was Milton O. Thomas, a test pilot with NASA.

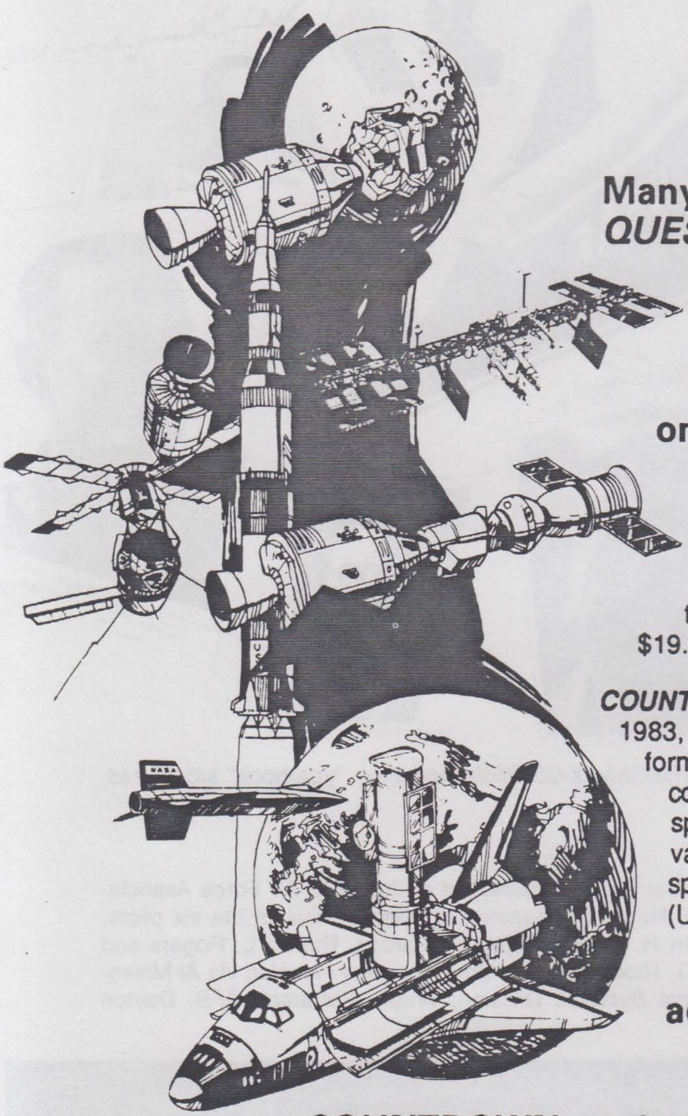
Prime training facilities for the X-20 program were at Edwards AFB.

**Photo Two Pages Back:**
They almost flew a Dyna-Soar—the X-20 pilots. Front to back: William J. Knight, Russell L. Rogers, Milton O. Thomas, James W. Wood, Henry C. Gordon and Albert H. Crews. Photo Courtesy Don Pealer.

**Photo Opposite Page:**
A model of the final Dyna-Soar X-20 configuration complete with Titan IIIC booster serves as a suitable backdrop for four of the project's pilots. Standing left to right are Henry C. Gordon, Russell L. Rogers, William J. Knight and Albert H. Crews. Photo Courtesy Roy Houchin via Al Misenko at the History Office/ Aeronautical Systems Division, Wright Patterson AFB, Dayton Ohio.


**Above:** Class portrait of all six Dyna-Soar X-20 Pilots and their "yearbook" signatures. Photo Courtesy USAF.

**Below:** Final version of the Dyna-Soar X-20 as displayed at the 1962 Air Force Association Convention held in Las Vegas, Nevada. Standing in front are five of the six pilots. Left to right William J. Knight, Albert H. Crews, Henry C. Gordon, Russel L. Rogers and James W. Wood. Abeset is Milton O. Thomas. Photo Courtesy Roy Houchin via Al Misenko at the History Office/Aeronautical Systems Division, Wright Patterson AFB, Dayton Ohio.



# DYNA-SOAR X-20: A LOOK AT HARDWARE AND TECHNOLOGY

**by Terry Smith**

The cancellation of the X–20 Dyna–Soar project did not close out all work on X–20 related research. Several different components and design features were tested well into the mid–1960s. Continued research into refractive metals and high speed lifting re–entry was carried out in ground test facilities and with the use of small scale research vehicles such as ASSET and the Start Programs including Prime.

This article will attempt to show some of the more important aspects which led to research for the X–20 program. These ranged in 1963, from advanced concepts to the actual building of hardware.

The one Dyna–Soar objective that did not change throughout the constant redirection and bureaucratic mishandling of the program was this: to demonstrate a piloted vehicle capable of controlled lifting maneuverable re–entry. Some secondary objectives were to test the vehicle in hypersonic flight for extended periods and for pinpoint landings at predesignated locations.

Mission plans being developed at the time of cancellation describe an early test flight consisting of one orbit around the earth. Launch would take place from Cape Canaveral on a Titan III C boosting the X–20 to a velocity of 24,470 feet per second and an altitude of 320,000 feet at the end of a short burn of the Transtage. The X–20 vehicle with Transition and Transtage still attached would coast to a maximum altitude of 480,000 feet before beginning re–entry over the western Pacific. The Transtage and Transition sections would be jettisoned at the beginning of entry interface. Landing would occur at Edwards Air Force Base at a mission elapsed time of 107 minutes. The highest heat levels were expected to occur at speeds between 17,000 and 24,000 feet per second. In order to withstand these high levels of heat and structural loads, the internal and external structure of the X–20 would be constructed of exotic metals consisting of Rene'41 steel, molybdenum, and columbium.

During the early competition for the Dyna–Soar contract, two different design philosophies were put forward to handle the problem of re–entry heating. The "Bell Aircraft" design for the Dyna–Soar used a system of active cooling. This would use a network of tubes filled with a circulating liquid that were located in the leading edges and nose sections to cool the re–entry heat. The Boeing designed Dyna–Soar, on the other hand, would use a system of passive radiation cooled thermal protection. The Air Force, in picking Boeing's approach, caused major advances to be made in the development of new metals, ceramics, and high temperature insulations. New methods of manufacturing and testing would have to be invented to reach a level where success would be assured for the program.

The environment the Dyna–Soar was expected to operate in exceeded all levels of aerodynamic knowledge and capability of available flight vehicle materials technology in 1958.

The final design of Dyna–Soar was the result of over 14,000 hours of wind tunnel tests, which included 1,800 hours of subsonic, 2,700 hours of supersonic, and 8,500 hours hypersonic. This research used at one time or another all of the available wind tunnel and shock tunnels in the U.S. The wing platform ended up as a pure delta with a sweep of 70 degrees. This gave a L/D ratio of 1.5 and a hypersonic lift coefficient of 0.6 with an expected 1,500 nautical mile cross range ability. The radiation cooled structure was designed to last through four flights and to carry a payload of 1,000 pounds contained in a payload compartment of 75 cubic feet.

The X–20 was designed to be a statically stable glider in the normal range of re–entry and subsonic glide conditions. In achieving this goal the design of the flight control system would be simplified. The design of the basic wing section on the 1960 S–20 configuration would use a double wedge upper surface and flat under surface. This would have provided good hypersonic flight characteristics and an ease of manufacture. This design would have required the addition of flip out fins for low speed flight, so the upper surface of the wing was modified to result in continued excellent hypersonic characteristics and improved low speed handling. This modification, however, resulted in problems at transonic speeds and increase in elevon hinge movement at low supersonic speeds. Wind tunnel studies showed that the addition of an aft body ramp would correct these problems. This would give the X–20 its distinctive hump back. The above description is just one example of the many design challenges that the designers of Dyna–Soar overcame.

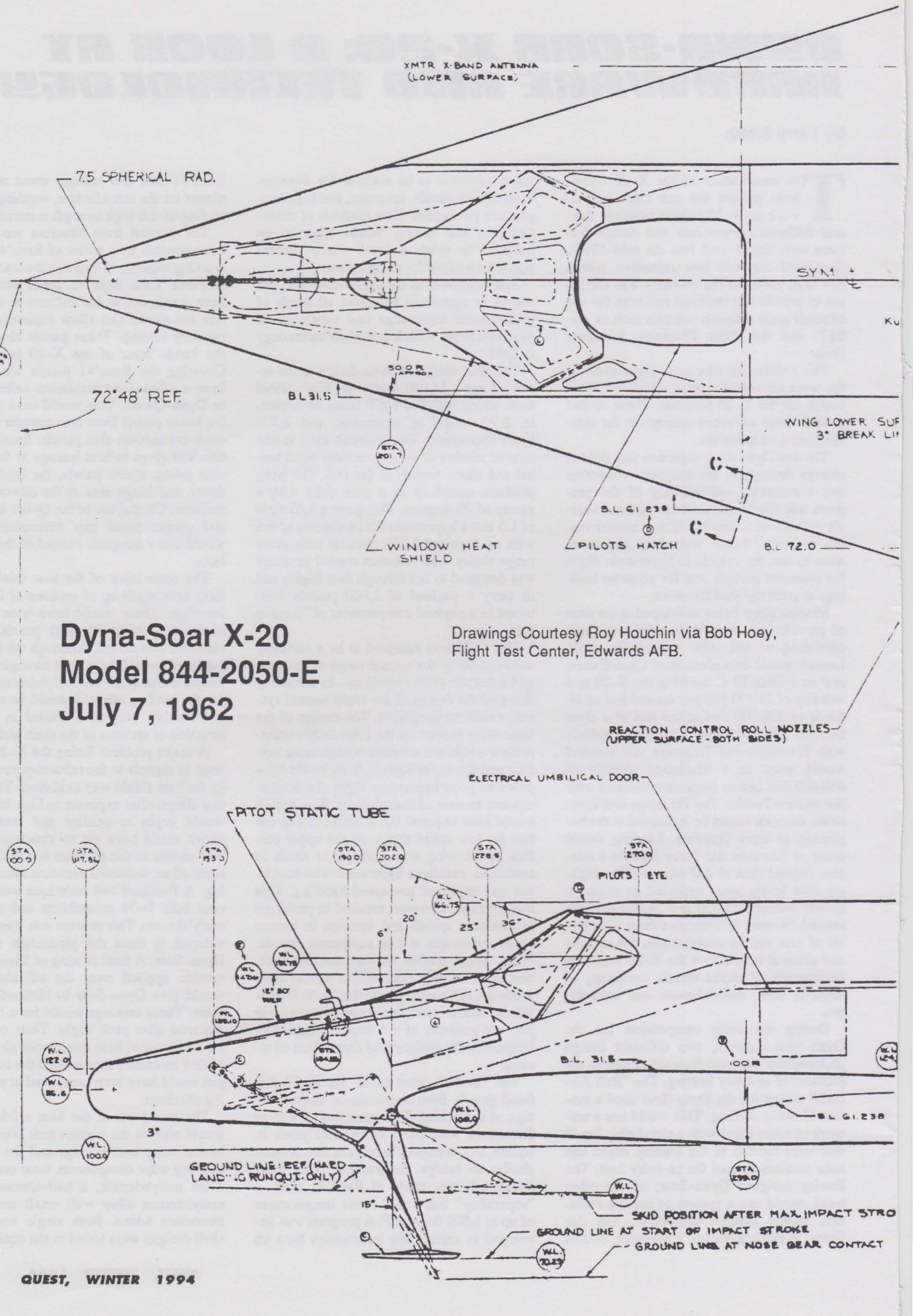
The internal structure of the X–20 differed greatly from conventional aircraft design of the period. This consisted of a truss framework with fixed and pinned joints in square and triangular elements that looked similar to bridge construction. This truss framework was made of Rene'41 steel, a "superalloy" that could resist temperatures of up to 1,800 degrees F. A program was developed to expand the information base on Rene'41 steel that brought about new techniques on the manufacture, welding and extruding of this high strength material.

The internal truss structure would have been covered by a series of Rene'41 panels working together to become the load bearing airframe. Each Rene'41 panel would have been corrugated to add stiffness to the structure but would also allow expansion during re–entry heating. These panels also formed the inside layer of the X–20 heat shield. Covering the Rene'41 panels would have been a silica–fiber insulation called Q–felt or Dyna–Quartz. This would have protected the lower panels from heat transfer from the outer columbium skin panels. Special attention was given to heat leakage at the expansion joints, access panels, the landing gear doors, and hinge area at the elevon control surfaces. Careful use of the Q–felt insulation and proper panel gap dimension control would allow adequate control of these problems.

The outer layer of the heat shield would have been made up of sections of D–36 columbium. These would have been attached to the underlying Rene–41 panels using a stand-off clip design. Although the D–36 columbium would have less strength at high temperatures than the molybdenum chosen for the leading edges, it could be machined and welded, properties needed in the construction of sections of the main airframe.

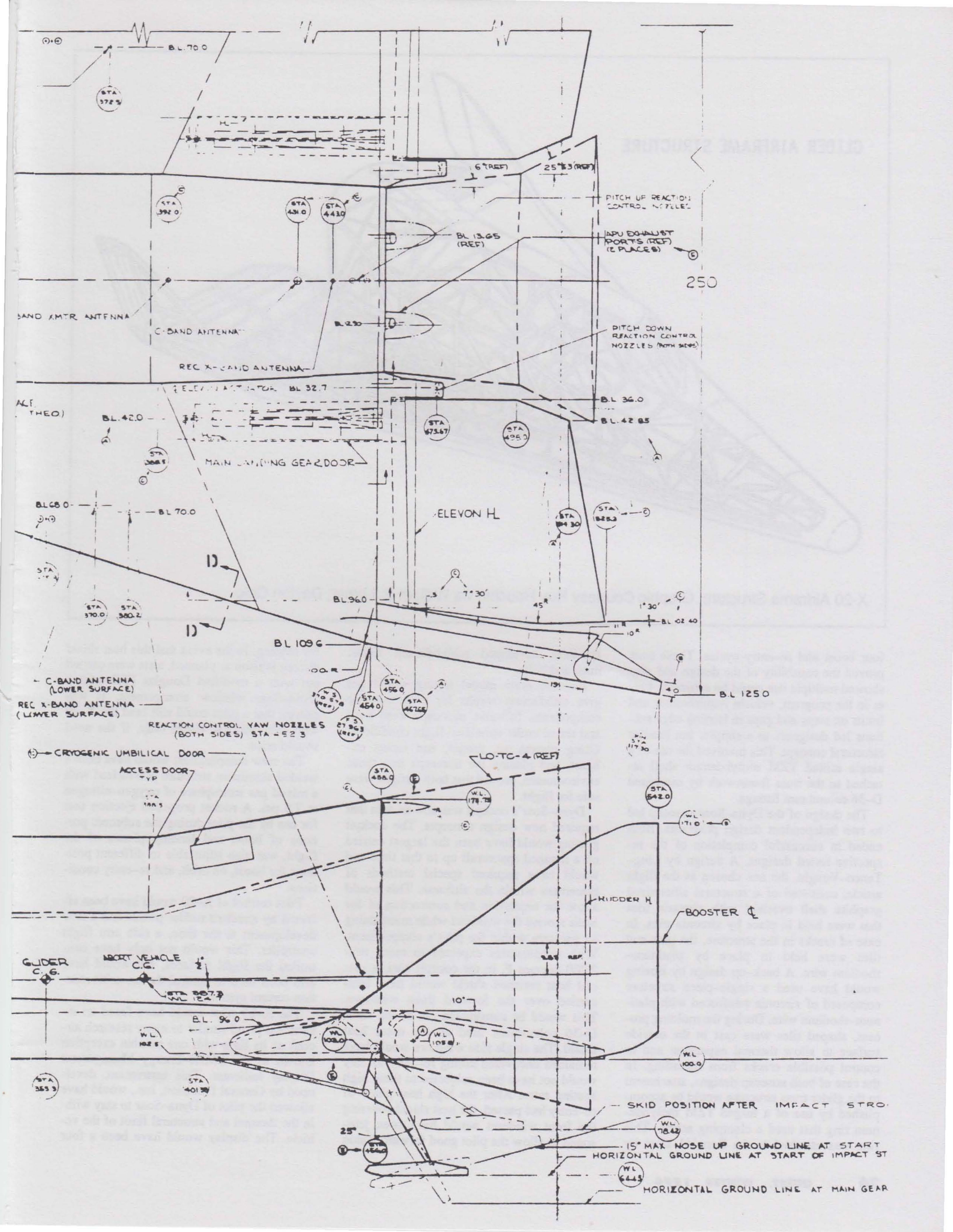
A major problem facing the X–20 project team in regards to the refractory metals used in the heat shield was oxidation. These special alloys, after exposure to high heat loads, would begin to oxidize and break down which could have led to structural failure. The answer to this problem was the development of an oxidation resistant silicide coating. A fluidized bed technique was used to coat both D–36 columbium and the TZM molybdenum. This process was specially developed to meet the production needs of Dyna–Soar. A final coating of Synar–silicon carbide applied over the silicide coating would give Dyna–Soar its distinctive black color. These coatings would have had to be replaced after each flight. Tests conducted on a four panel heat shield with simulations of five re–entries showed that the coating repair could have been completed at post landing checkout.

The two parts of the heat shielding that would receive the highest heat levels would be the wing leading edge and the nosecap. Leading edge components were made up of TZM molybdenum, a half–titanium, half–molybdenum alloy with small amounts of zirconium added. Both single and double shell designs were tested to the equivalent of

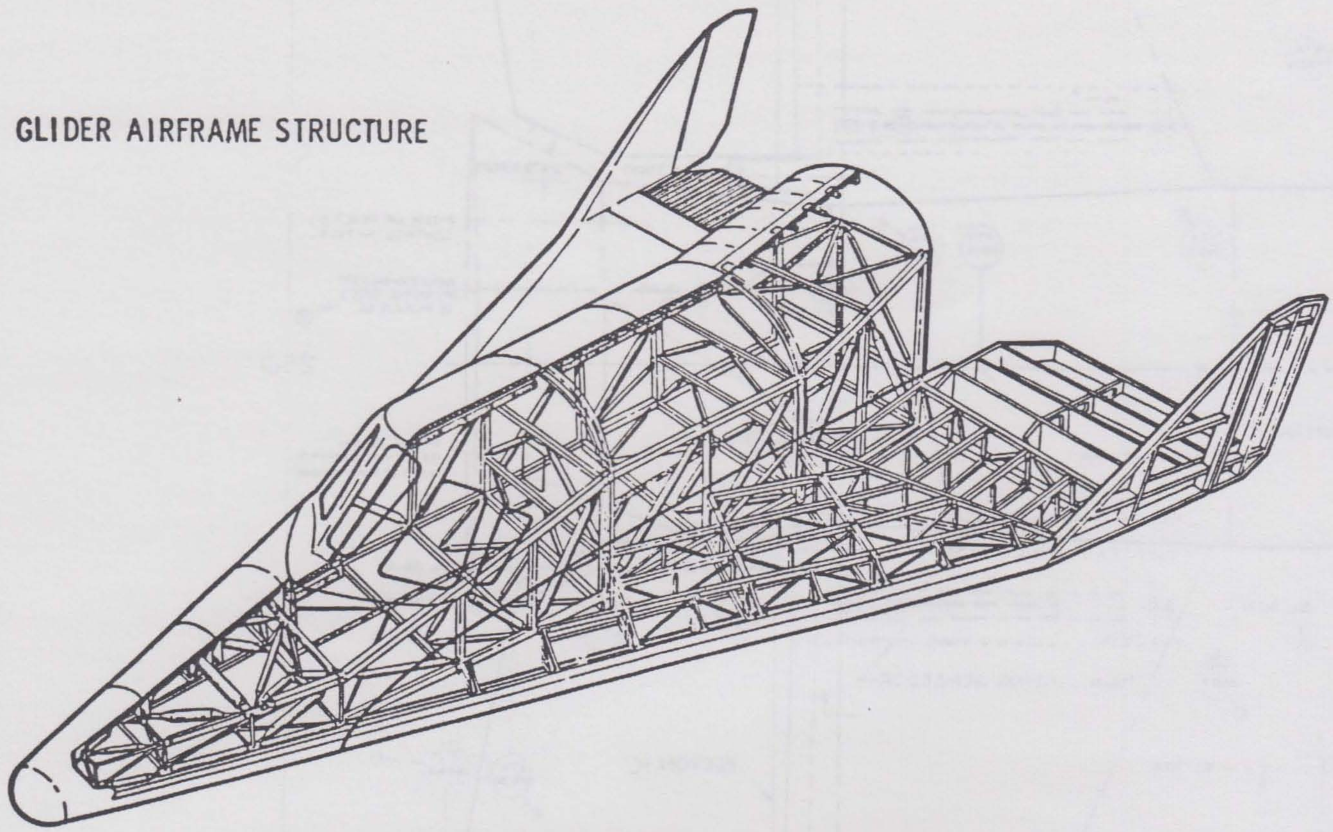



**Dyna-Soar X-20**
**Model 844-2050-E**
**July 7, 1962**

Drawings Courtesy Roy Houchin via Bob Hoey, Flight Test Center, Edwards AFB.



BL 70.0
STA 372.5
STA 392.0
STA 431.0
STA 443.0
6°(REF)
25°53'(REF)
PITCH UP REACTION CONTROL NOZZLES
BL 13.65 (REF)
APU EXHAUST PORTS (REF) (2 PLACES)
250
BAND XMTR ANTENNA
C-BAND ANTENNA
BL 23.0
PITCH DOWN REACTION CONTROL NOZZLES (BOTH SIDES)
REC X-BAND ANTENNA
BL 32.7
BL 36.0
BL 42.85
BL 42.0
STA 473.67
STA 495.0
MAIN LANDING GEAR DOOR
BL 68.0
BL 70.0
ELEVON
STA 528.3
D
STA 370.0
STA 380.2
BL 96.0
17°30'
45°
1°30'
BL 102.40
BL 109.6
STA 456.0
STA 454.0
BL 125.0
C-BAND ANTENNA (LOWER SURFACE)
REC X-BAND ANTENNA (LOWER SURFACE)
REACTION CONTROL YAW NOZZLES (BOTH SIDES) STA 452.3
CRYOGENIC UMBILICAL DOOR
ACCESS DOOR TYP
LO-TC-4 (REF)
STA 488.0
W.L. 178.78
STA 542.0
W.L. 171.0
RUDDER
BOOSTER ℄
GLIDER C.G.
ABORT VEHICLE C.G.
10°
BL 96.0
W.L. 102.0
W.L. 105.6
W.L. 100.0
STA 353.3
STA 401.38
SKID POSITION AFTER IMPACT STRO
W.L. 78.42
25°
15° MAX NOSE UP GROUND LINE AT START
HORIZONTAL GROUND LINE AT START OF IMPACT ST
W.L. 64.43
HORIZONTAL GROUND LINE AT MAIN GEAR




X-20 Airframe Structure. Graphic Courtesy Roy Houchin via William E. Lamar, Dayton Ohio.

four boost and re–entry cycles. These tests proved the capability of the design and also showed multiple use could be achieved. Later in the program, vehicle requirements and limits on steps and gaps in leading edge sections led designers to a simpler but heavier structural concept. This involved the use of a single milled TZM molybdenum shell attached to the truss framework by machined D–36 columbium fittings.

The design of the Dyna–Soar nosecap led to two independent design programs. Both ended in successful completion of the respective tested designs. A design by Ling–Tenco–Vought, the one chosen as the flight article, consisted of a structural siliconized graphite shell overlaid with zirconia tiles that were held in place by zirconia pins. In case of cracks in the structure, the pins and tiles were held in place by platinum–rhodium wire. A back–up design by Boeing would have used a single–piece structure composed of zirconia reinforced with platinum–rhodium wire. During the molding process, shaped tiles were cast in the outside surface to allow thermal expansion and to control possible cracks from spreading. In the case of both nosecap designs, attachment to the glider truss structure would be accomplished by use of a forged TZM molybdenum ring that used a clamping action. This ring was attached to the Rene'41 truss by specially developed molybdenum rivets, nuts, and bolts.

Because scale model testing would not give satisfactory results for these ceramic components, full–size nosecaps were built and tested under simulated flight conditions. Using plasma jet, ramjet, and rocket exhaust, and placing the nosecaps into those environments, proved that both designs were safe for flight.

Dyna–Soar's cockpit was also an area that required new design concepts. The cockpit glazing would have been the largest carried on a manned spacecraft up to that time and would have required special methods of placement within the airframe. This would allow for expansion and contraction of the areas around the windows while maintaining air pressure within the pilot's compartment. With temperatures expected to reach near 2,000 degrees F. in the cockpit area, a special heat resistant shield would have been carried over the forward three windows. This would be constructed out of the same D–36 columbium used as the outer heat shield. The single side windows would have remained uncovered during re–entry as they would not have been subjected to these high heating rates. After the high heat phase of re–entry had passed, the heat shield covering the front windows would have been jettisoned to allow the pilot good forward vision for landing. In the event that this heat shield did not jettison as planned, tests were carried out with a modified Douglas F5D with a Dyna–Soar window arrangement. It was proven that a pilot could still land the X–20 with side window vision only, if the need should arise.

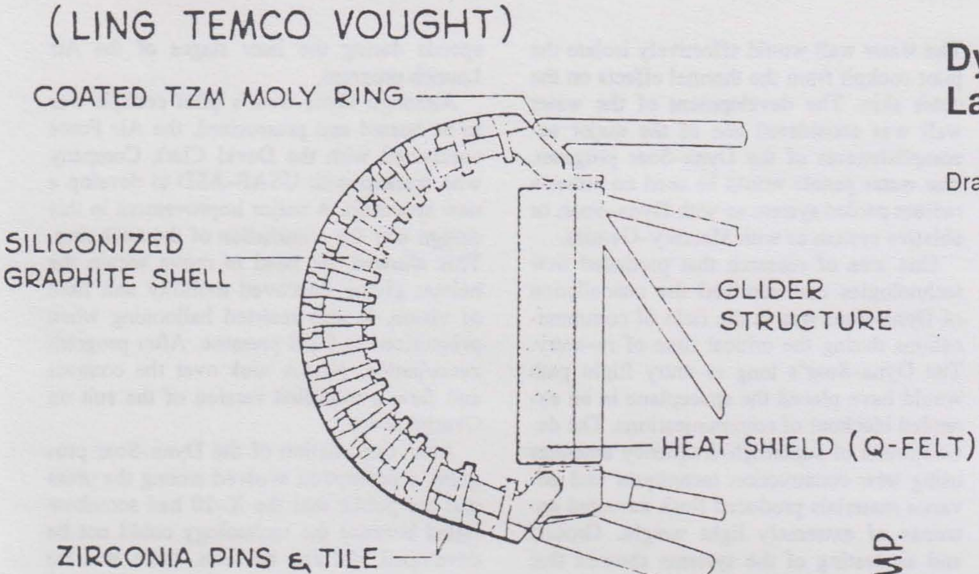
The crew compartment would have been a welded aluminum structure pressurized with a mixed gas atmosphere of oxygen–nitrogen at 7.5 psi. A rocket propelled ejection seat for use by the pilot during the subsonic portions of boost and landing phases of the flight, was also adjustable to different positions for boost, on orbit, and re–entry conditions.

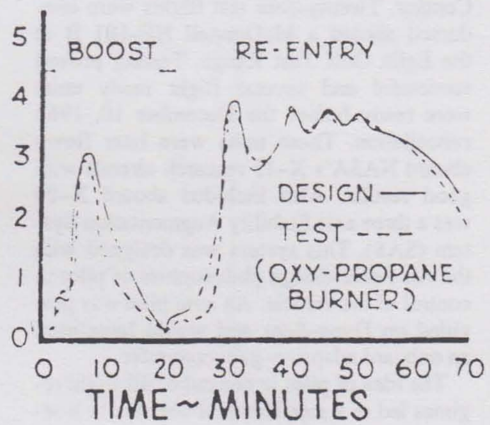
Pilot control of X–20 would have been effected by standard rudder pedals and a new development at the time, a side arm flight controller. This would not only have controlled the flight surfaces, but would have also been used to control the on–orbit reaction control system.

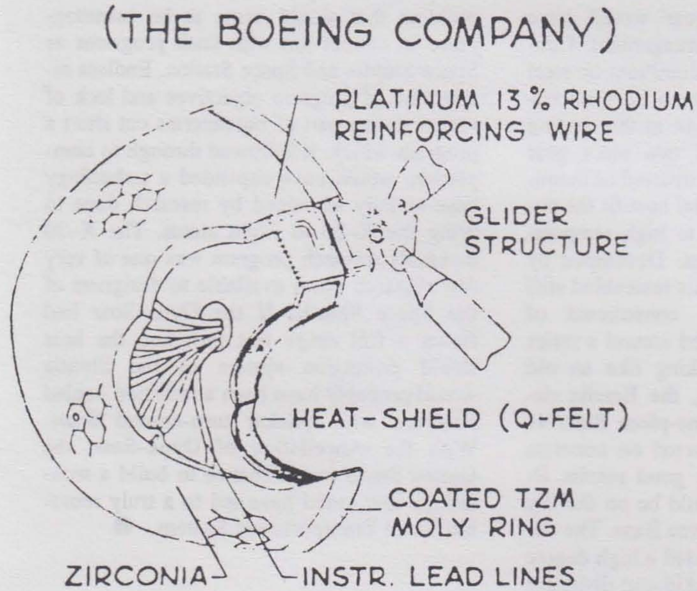
The X–20 pilot would have faced an instrument panel similar to many research aircraft of its time with one notable exception known as the EMDI–Energy Management Display Indicator. This instrument, developed by General Precision, Inc., would have allowed the pilot of Dyna–Soar to stay within the thermal and structural limit of the vehicle. The display would have been a four

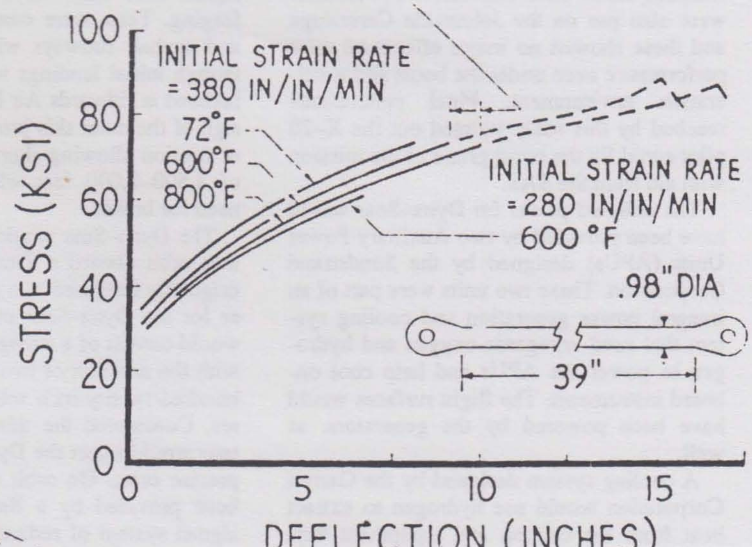
## Dyna-Soar Nose Cone and Landing Gear Details

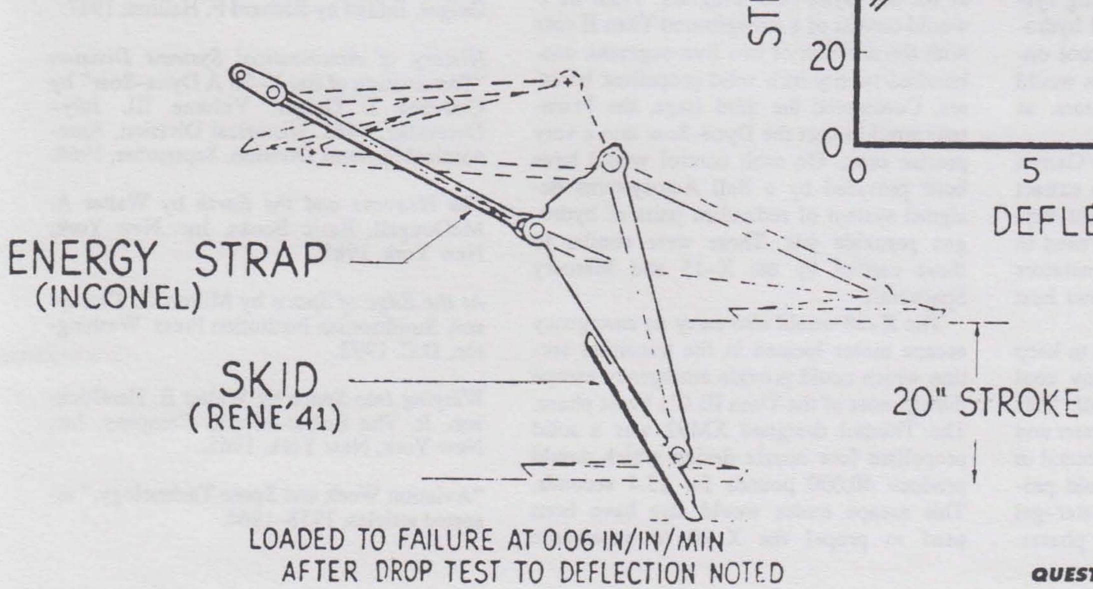
Drawings Courtesy Terry Smith and USAF




LOADED TO FAILURE AT 0.06 IN/IN/MIN AFTER DROP TEST TO DEFLECTION NOTED inch cathode ray tube with transparent overlays that moved along with the forward flight of the X–20.

The EMDI would also have displayed information that would have allowed the X–20 pilot to pick from different landing sites along the precomputed footprint transparencies. Use of this instrument display avoided the requirement that the X–20 carry a large onboard computer. The X–20 consultant pilot group "flew" the EMDI in the flight simulator and reported favorable results.

Dyna–Soar would have used an inertial guidance unit provided by Minneapolis–Honeywell. This unit was an adapted version of the system used for the Atlas–Centaur. Twenty–four test flights were conducted aboard a McDonnell NF–101 B at the Eglin Gulf Test Range. Testing proved successful and several flight ready units were ready before the December 10, 1963 cancellation. These units were later flown aboard NASA's X–15 research aircraft with good results. Also included aboard X–20 was a three axis Stability Augmentation System (SAS). This system was designed with the Air Force design philosophies of pilot in control of the vehicle. An auto pilot was provided on Dyna–Soar and would have used an onboard adaptive–gain computer.

The idea of pilot in control of all flight regimes led to a supplemental contract to Boeing for the study of Dyna–Soar pilots' ability to control the Titan booster during the boost phase. Called Pilot in the Booster Loop (PIBOL), this study encompassed nearly 100 flights made in a six degree–of–freedom fixed base simulator. Simulations were also run on the Johnsville Centrifuge and these showed no major effects on pilot performance even under the boost and acceleration environment. Final conclusions reached by this study pointed out the X–20 pilot could fly the boost phase of the mission with aid from the SAS.

The onboard power for Dyna–Soar would have been provided by two Auxiliary Power Units (APUs) designed by the Sundstrand Corporation. These two units were part of an integral power generation and cooling system that used cryogenic oxygen and hydrogen to power the APUs and help cool onboard instruments. The flight surfaces would have been powered by the generators, as well.

A cooling system designed by the Garrett Corporation would use hydrogen to extract heat from the cockpit and equipment bay. Redundant cooling loops would be used to transfer heat from the electrical generators and APUs to a hydrogen glycol–water heat exchanger.

Another development in the effort to keep the pilot cockpit and equipment bay cool was the invention of the water–wall. This heatsink was a gel mixture of 95% water and 5% cyanogum 41 jelling agent distributed in a series of wicks. These wicks would provide proper distribution of the water–gel during boost, on orbit, and re–entry phases. The water wall would effectively isolate the pilot cockpit from the thermal effects on the outer skin. The development of the water wall was considered one of the major accomplishments of the Dyna–Soar program. The water panels would be used on either a radiant cooled system as with Dyna–Soar, or ablative system as with Mercury–Gemini.

One area of research that produced new technologies that survived the cancellation of Dyna–Soar was in the field of communications during the critical time of re–entry. The Dyna–Soar's long re–entry flight path would have placed the spaceplane in an extended blackout of communications. The development of superhigh–frequency antennas using new construction techniques and advance materials produced flush mounted antennas of extremely light weight. Ground and air testing of the systems showed that they could have been brought to flight ready status.

Dyna–Soar's landing gear would have been a three point skid arrangement. Conventional rubber tires on aluminum or steel rims could not be considered because reentry heat would be too high in the landing gear bays. The nose and two main gear struts would have been constructed of Inconel, as it was felt this material best fit the design criteria of resistance to high temperature and strength properties. Developed by Goodyear, the main gear skis resembled stiff wire brushes and were constructed of Rene'41 wire bristles wound around a series of longitudinal rods. Looking like an old fashioned kitchen dishpan, the Bendix designed nose skid was a one-piece Rene'41 forging. Tests were conducted on concrete and asphalt runways with good results although initial landings would be on the dry lakebed at Edwards Air Force Base. The design of the main skis provided a high degree of friction allowing short skid–out distances of 4,500–8,000 feet which eliminated the need for brakes.

The Dyna–Soar would have been boosted into orbit aboard a Titan III C which was originally designed as a purpose built booster for the Dyna–Soar program. Titan III C would consist of a strengthened Titan II core with the addition of two five–segment, one-hundred-twenty-inch solid propellant boosters. Considered the third stage, the Transtage would inject the Dyna–Soar into a very precise orbit. On orbit control would have been provided by a Bell Aerosystems designed system of redundant pairs of hydrogen peroxide jets. These were similar to those carried by the X–15 and Mercury Spacecraft.

The X–20 would also carry an emergency escape motor located in the transition section which could provide emergency escape during most of the Titan III C's boost phase. The Thiohol designed XM92 was a solid propellant four nozzle design which would produce 40,000 pounds for 13.4 seconds. This escape motor would also have been used to propel the X–20 to supersonic speeds during the later stages of the Air Launch program.

Although Dyna–Soar's pilot cockpit was to be heated and pressurized, the Air Force contracted with the David Clark Company who worked with USAF–ASD to develop a new spacesuit. A major improvement in this design was the elimination of the neck ring. This allowed the head to move within the helmet giving improved mobility and field of vision. It also resisted ballooning when pressurized to 5 psi pressure. After program cancellation, NASA took over the contract and flew a modified version of the suit on Gemini seven.

After cancellation of the Dyna–Soar program, a perception evolved among the press and the public that the X–20 had somehow failed because the technology could not be developed. As can be seen, there was no lack of technical base for the stated aims of the program. Dyna–Soar suffered from a problem that would come to be commonplace in connection with such programs as Space Shuttle and Space Station. Endless redirection of program objectives and lack of vision on the part of bureaucrats cut short a program which, if followed through to completion, would have expanded a technology base already advanced by research done to bring the X–20 to flight status. The X–20 materials research program was one of very few research bases available to designers of the Space Shuttle. If the Dyna–Soar had flown a full range test program, the heat shield protection system of the Shuttle would probably have been a radiation cooled structure with quicker turn-around times. With the cancellation of Dyna–Soar, the United States lost a chance to build a technology that could have led to a truly reusable Space Transportation System. ●

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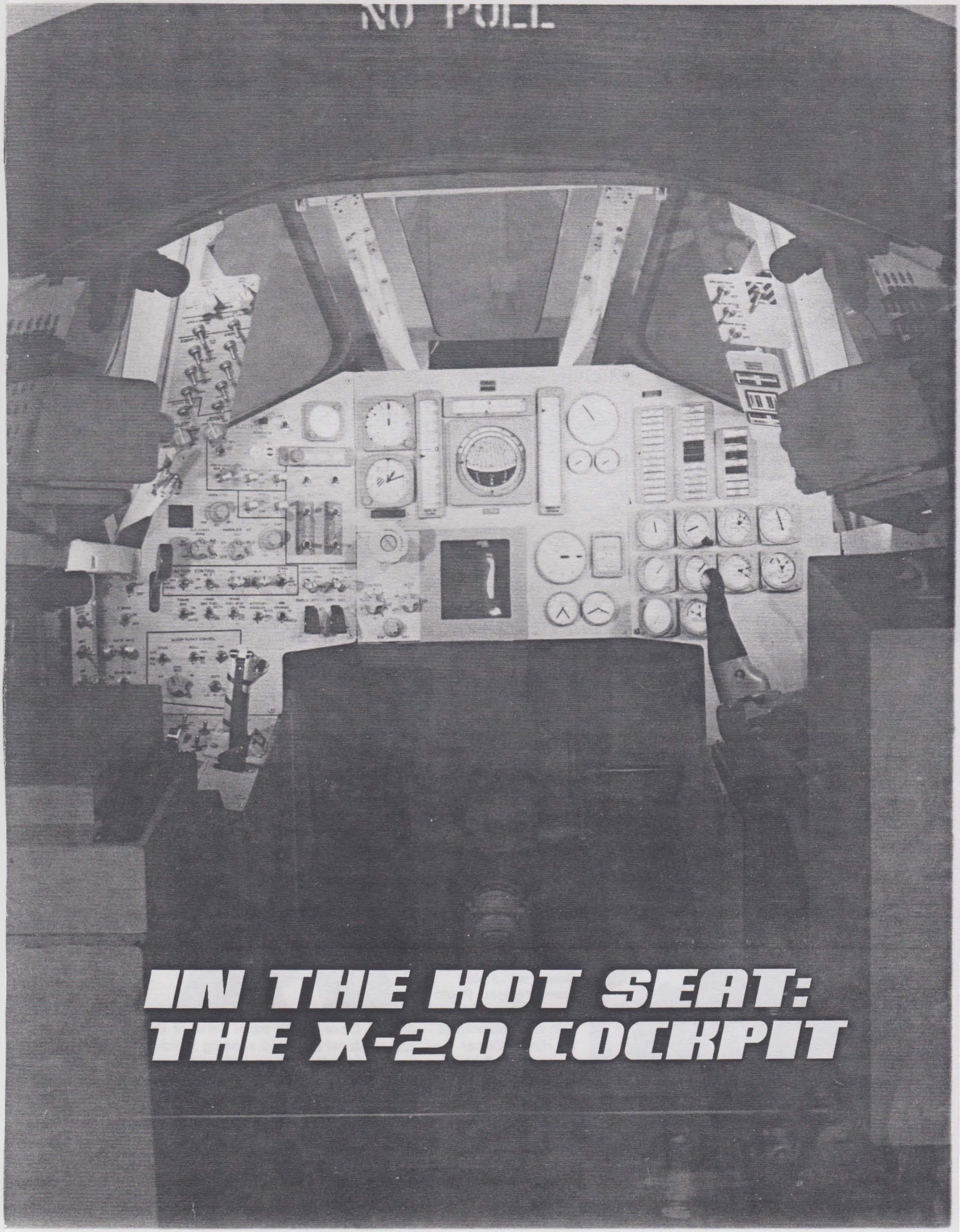
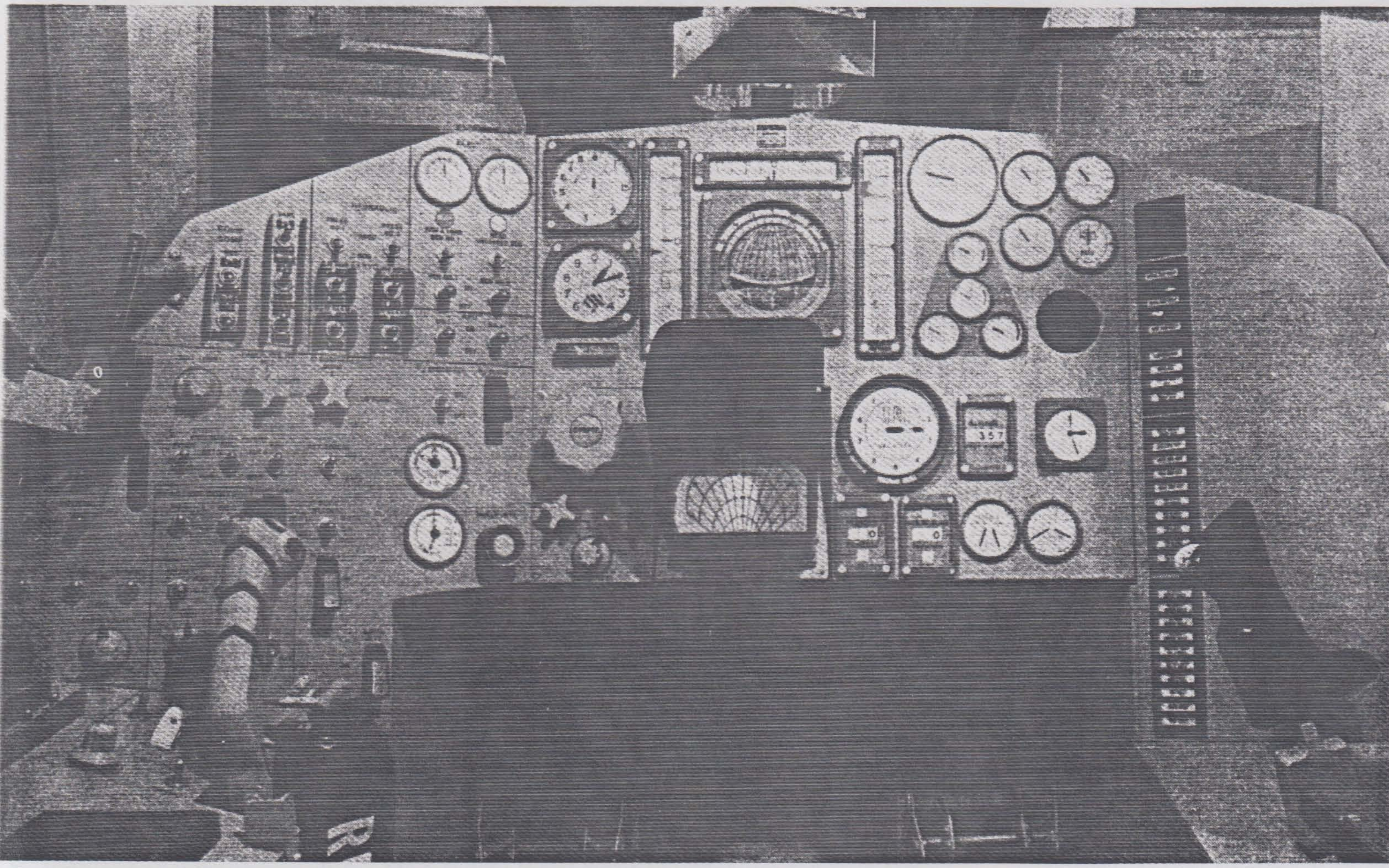


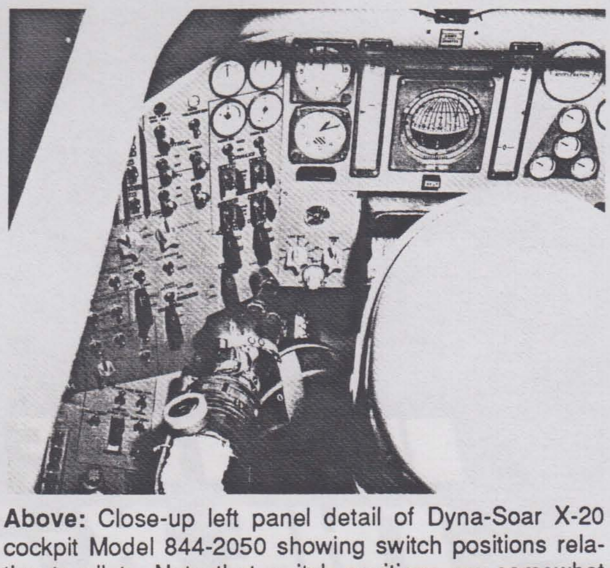

# IN THE HOT SEAT: THE X-20 COCKPIT



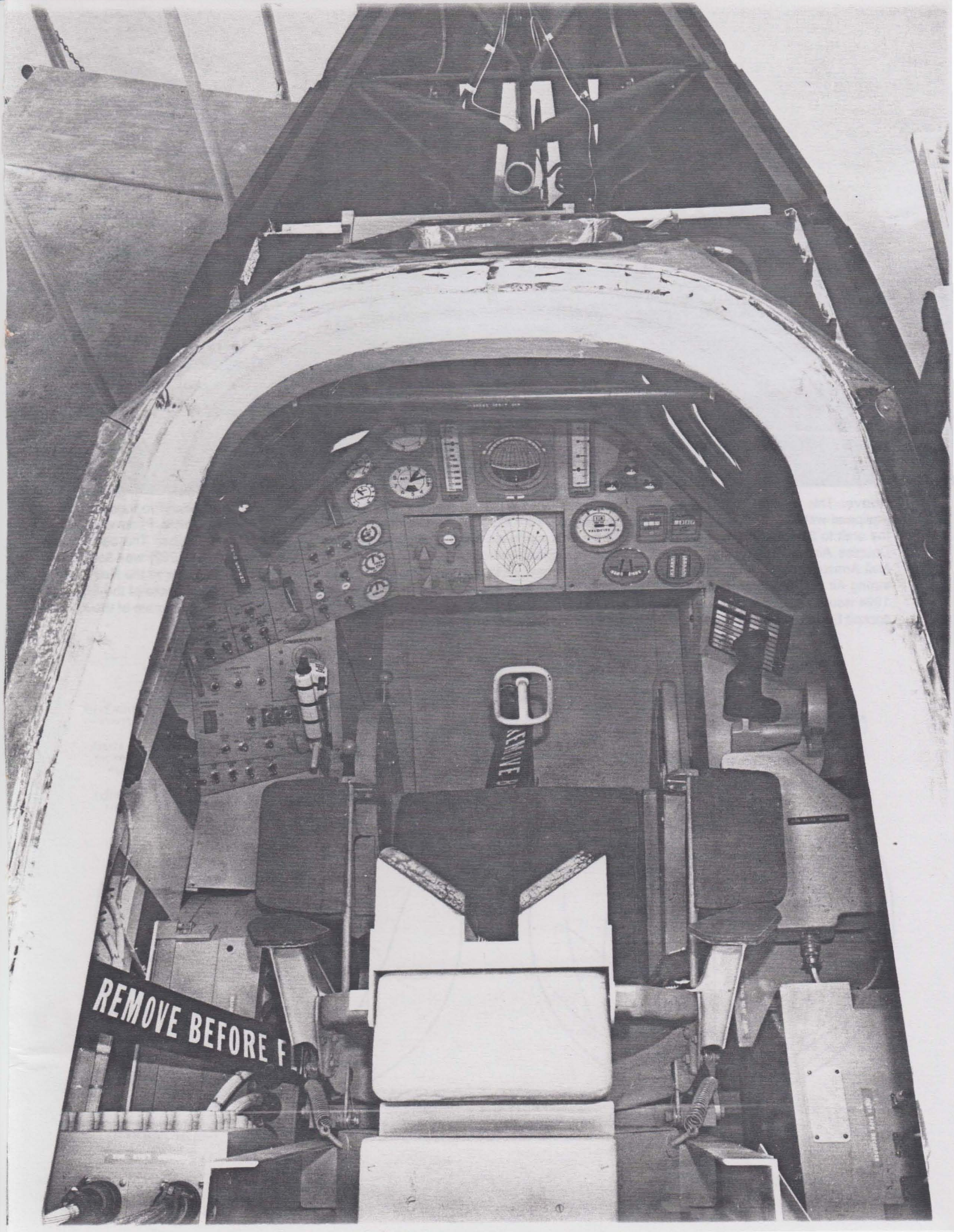
**Above:** Another version of the Dyna-Soar X-20 cockpit. This particular version is believed to be that of Model 844-2050 circa September, 1961 as displayed at Boeing in Seattle, Washington. Note the two main features, the Energy Management Display Indicator (center) and the innovative side-stick controller (visible on right) which survived the many cockpit modifications. Photo Courtesy USAF Museum Archives. This photo also appeared on p. 230 of the July 22, 1963 issue of *Aviation Week & Space Technology*.

**Previous Page:** Final version of the X-20 cockpit as displayed at the 1962 Air Force Association Convention held in Las Vegas, Nevada. This full-size engineering mockup depicts the cockpit of Model 844-2050-E which was expected to be the final configuration. Photo Courtesy Roy Houchin via Roger McCormick and the Air Force Space Museum, Cape Canaveral Florida.

**Left:** X-20 pilot Major James W. Wood checks out one of the Dyna-Soar interior cockpit mockups at Boeing with a program engineer. Photo Courtesy Roy Houchin via Al Misenko at the History Office/ Aeronautical Systems Division, Wright Patterson AFB, Dayton Ohio.



**Above:** Close-up left panel detail of Dyna-Soar X-20 cockpit Model 844-2050 showing switch positions relative to pilot. Note that switch positions are somewhat different than above photo. Photo Courtesy USAF Museum Archives. **Facing Page:** Another variation of cockpit Model 844-2050. Photo Courtesy Roy Houchin via Al Misenko at the History Office/Aeronautical Systems Division, Wright Patterson AFB, Dayton Ohio.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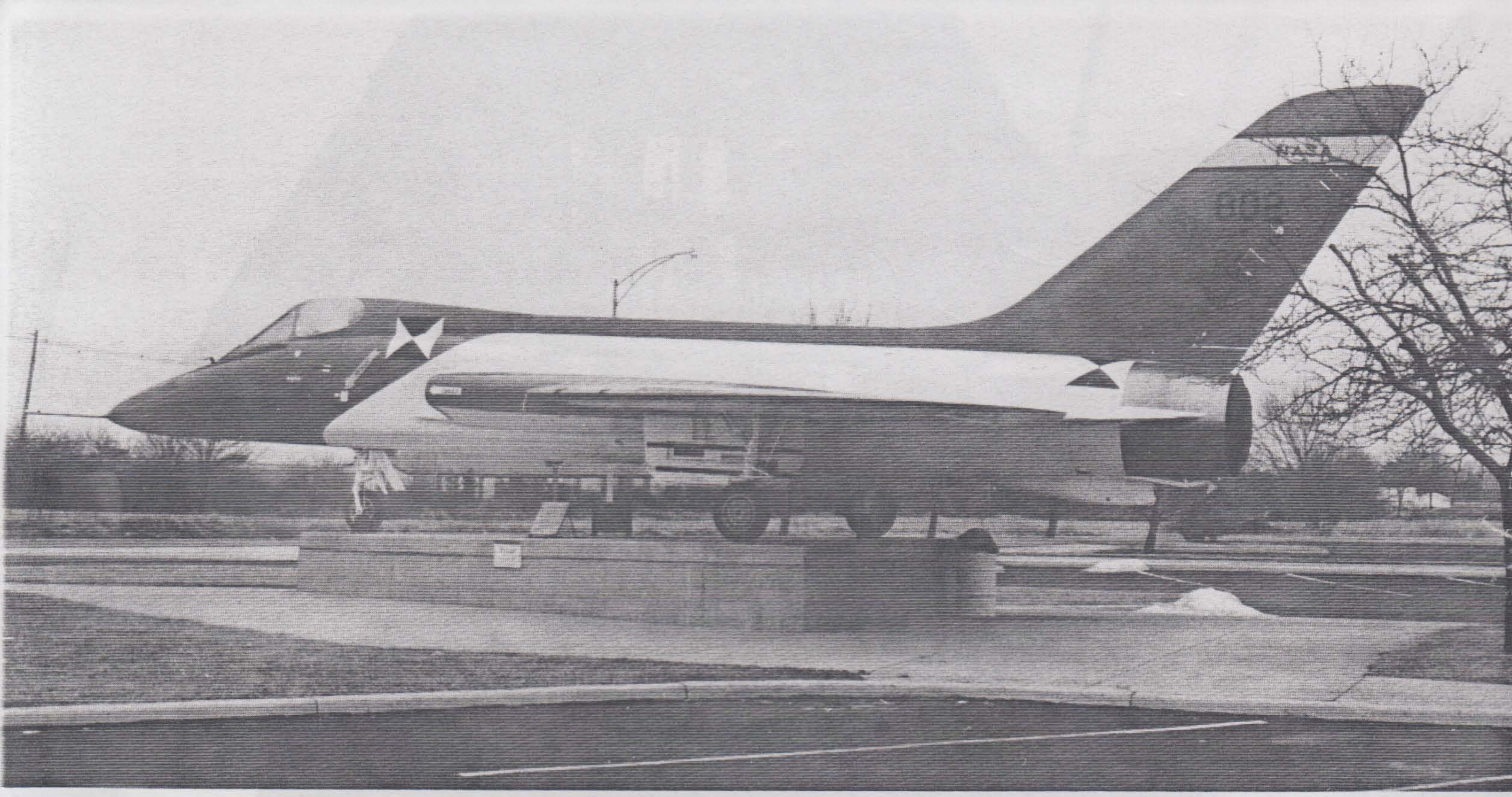
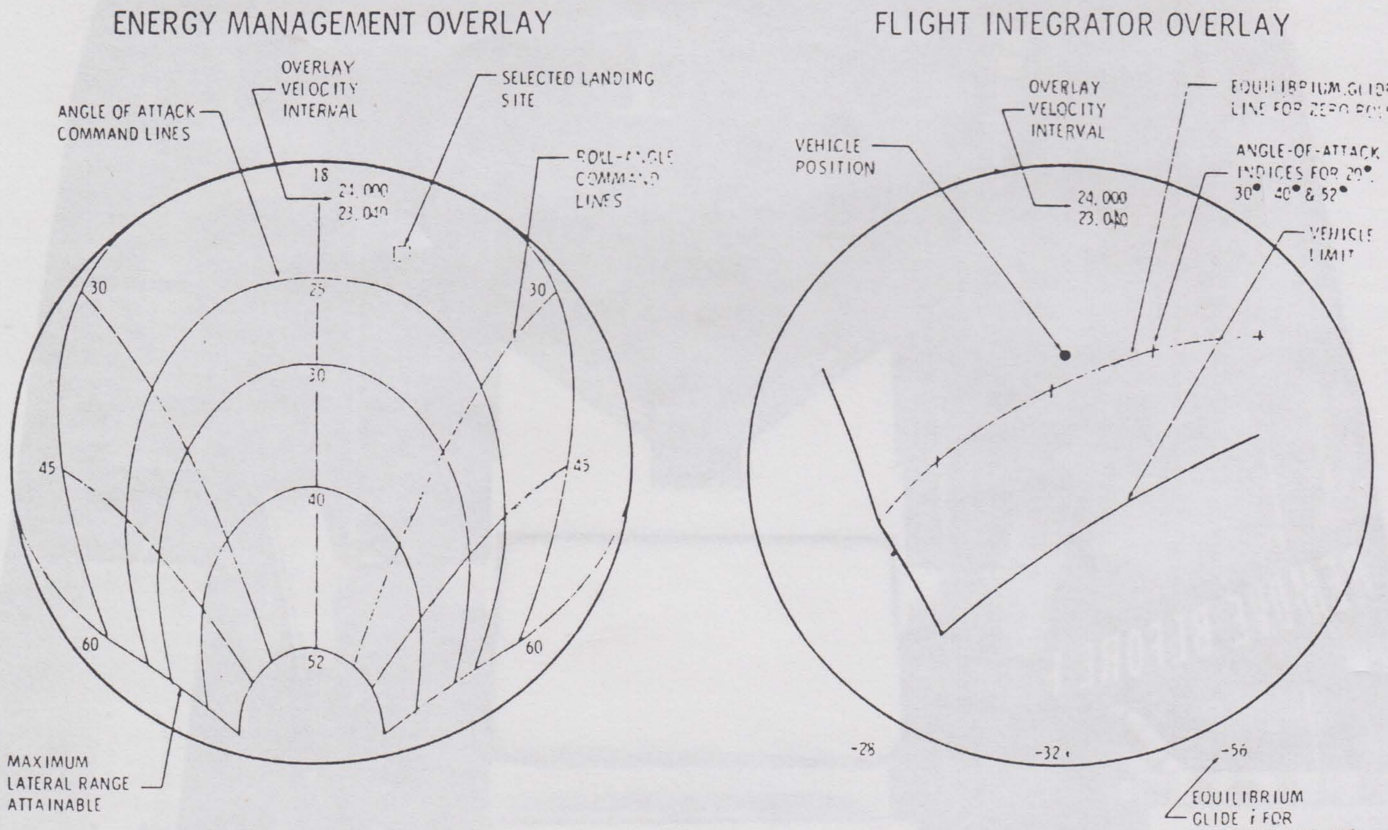


**Above:** This XF-5D Skylancer was modified for use by the Air Force Pilots training for the X-20 Dyna-Soar Program. It was equipped with similar instrumentation and was modified for flight and glide characteristics of the never-built vehicle. Pilots would fly the craft to 30,000-40,000 feet altitude, cut the power and glide back to try and simulate the X-20's flight dynamics. This particular Douglas Aircraft (NASA 802; Registration/Military Serial Number Bul39208; Constructors/Manufacturers No. 11282) was flown by Neil Armstrong and has recently been repainted to show its experimental colors. It can be seen at the entrance to the Neil Armstrong Air and Space Museum in Wapakoneta, Ohio. By the way, this is the same vehicle shown on the cover photo of the Spring 1994 issue of *Quest* which featured articles on the X-15 program. Photo Courtesy Glen E. Swanson. **Below:** A diagram of the X-20 cockpit Energy Management Display Indicator. Drawing Courtesy Terry Smith/USAF.



# THE X-20 PRESSURE SUIT

by Gary L. Harris

When the X-20 program began, pressure suit technology was very primitive. All X-20 suits were little more than modified high altitude, David Clark Company military aviation pressure garments that were fabricated into a sitting position. The A/P 22-S used an inner pressure bladder sealed by means of a pressure tight zipper. Anthropomorphic shape (man like) was maintained by means of a link net bladder retention layer. The entire assembly was protected by an aluminized flash coverall.

The nylon link net was a David Clark Company patent which closely resembled nylon flash netting. Ostensibly, link net was to impart some mobility into the suit arms and elbows by maintaining functional constant volume (hence constant pressure). Whatever the case, the suit had very little mobility when pressurized and would have been flown unpressurized except in an emergency. This suit was essentially the same as the X-15 rig with a series of modified glasfiber helmets.


**Photos:**

**Opposite Page:**

The X-20 Pressure Suit undergoing testing with program pilot William Knight. Note the X-20 simulator off to the right in background. Photo Courtesy Roy Houchin via Roger McCormick and the Air Force Space Museum, Cape Canaveral Florida.

**Above Right:**

An X-20 Pressure suit that was placed up for bid during a space memorabilia auction held by Superior Galleries in November 1993. The suit label reads "A/P22 S-2(9) Flying Suit, High Altitude, Full Pressure. Mfg. David Clark, Inc. P/N S-939A. Contract #AF33 (657)-7897. Date Aug 1963. Size Special- Major J. Wood." The suit (minus the tabloid) was sold for $4,400 to a private collector. Photo Courtesy Don Pealer and Superior Galleries.

**Right:**

A close-up photo of the helmet to the above suit. A major improvement in this pressure suit design was the elimination of the neck ring which allowed the head to move within the helmet giving improved mobility and field of vision. It also resisted ballooning when pressurized to 5 psi pressure. Photo Courtesy Don Pealer and Superior Galleries.

# WHY THE DYNA-SOAR X-20 PROGRAM WAS CANCELLED

by Roy F. Houchin II

*With the political and military uncertainties between the Soviet threat and America's capabilities in space during the Eisenhower and Kennedy eras, why did the Kennedy administration cancel Dyna-Soar, a forerunner to the space shuttle? As a reusable mini-shuttle, Dyna-Soar, an acronym for Dynamic Soaring, incorporated hypersonic technology for reentry after attaining orbit with an expendable booster.[1] Air Force planners proposed to explore the feasibility of using these technological innovations as part of a conceptual test vehicle for research, reconnaissance and orbital nuclear bombardment in an exoatmospheric force structure. While Eisenhower and Kennedy permitted research on Dyna-Soar, both administrations also embraced the idea of international acceptance of reconnaissance satellite overflights. By late 1963, the Air Force planned to use Dyna-Soar as a protective weapon system for space assets. Such an idea represented a perceived military threat to the Soviets, and, as such, no longer suited the Kennedy administration's revised military space policy. Even though Kennedy officials gave excuses for Dyna-Soar's demise (it lacked attainable objectives, it became too costly and it duplicated NASA efforts), in reality, international space restrictions, Dyna-Soar's offensive nature, and the Air Force's determined support of military objectives, detrimentally influenced the program and eventually curtailed it. Today, from an American perspective, this article will focus on the international and domestic reasons for Dyna-Soar's cancellation, beginning with the Eisenhower administration.*

By implementing part of his "New Look" program in 1952, President-elect Dwight D. Eisenhower hoped to harness defense spending and to reduce East-West tensions through arms control.[2] In realizing such an ambitious program in a Cold War environment, Eisenhower needed accurate intelligence concerning Soviet intentions to evaluate their potential threat. Considering the U-2 spy plane a temporary solution, he believed space-based reconnaissance would adequately provide the required long-term intelligence. Responding to the intelligence demand, the services, especially the Air Force, felt justified in requesting fiscal support for research and development of technologies to fulfill Eisenhower's "New Look" program.[3] Indeed, the need to verify arms control and Soviet nuclear strike capabilities warranted a continuous and accurate strategic reconnaissance system. While international reality necessitated an intelligence gathering system, military logic dictated a defensive weapon, like what Air Force leaders eventually planned for Dyna-Soar, to protect American reconnaissance assets in space. Just as the defense of reconnaissance aircraft in World War I led to the development of single-seat fighter planes, Air Force leaders anticipated a similar requirement for the "high frontier" of space.[4] Besides a military concern for the defense of space assets, Eisenhower also sought diplomatic avenues through negotiations with the Soviets and international adjudication through the United Nations to establish freedom of space. When the Soviets launched Sputnik on 4 October 1957, the question of establishing an international legal precedent for satellite overflight became axiomatic, a "fait accompli" lost in the repercussions of the event.[5] The orbiting of Sputnik shocked, then galvanized the American people and Congress into committing vast resources to the nation's missile and space programs. Even though concerns for American prestige and security from Soviet space threats called for military countermeasures on the order of Dyna-Soar, the administration still advocated and directed a peaceful response to the Soviet incursion into space. In placating the proponents of space weapon systems, and in providing some insurance, the Advanced Research Project Agency (ARPA) and all three services pursued research on a variety of space weapons; but funding restrictions permitted only feasibility studies into space countermeasures.[7]

Prior to the exigency of formulating a response to Sputnik, Air Force leaders envisioned the three aforementioned exploratory roles for Dyna-Soar, but the cost of the three parallel programs to realize those goals could not be justified within Eisenhower's budgetary constraints. Therefore, Dyna-Soar became both a political and economic expedient through the consolidation of the three Air Force feasibility studies: Hywards, Brass Bell, and Rocket Bomber (ROBO).[8] The first developmental phase (Step I) of Dyna-Soar, like Hywards, involved testing of a manned vehicle to obtain aerodynamic, structural and human factor data at speeds and altitudes significantly beyond the reach of the X-15. Dyna-Soar would operate in a flight regime of 10,800 mph and 350,000 feet altitude compared to the X-15's 4,000 mph and 250,000 feet. In addition, Step I would provide a means to evaluate military subsystems. In establishing test data criteria for Dyna-Soar, Air Force leaders made a clear distinction between experimenting with a research prototype and a conceptual test vehicle. Unlike the X-15, designed to provide information for general application, Dyna-Soar was designed to provide information for the development of a weapon system.[9] The second phase of Dyna-Soar (Step II) would have produced Brass Bell, a manned reconnaissance spacecraft capable of obtaining an altitude of 170,000 feet over a distance of 5,000-10,000 nautical miles at a maximum velocity of 13,200 mph.[10] The final phase of Dyna-Soar's development (Step III) incorporated the ROBO design by using a more sophisticated vehicle able to obtain an orbital altitude of 300,000 feet at 15,000 mph. During this phase Dyna-Soar would become an operational weapon system capable of orbital nuclear bombardment, improved reconnaissance capabilities and, eventually, satellite inspection (identification and neutralization).[11]

As the early feasibility studies reached fruition in the latter years of the Eisenhower administration, the services requested support for continued development and deployment of their projects, but the President, in keeping with his earlier policy goals, resisted this pressure. After evaluating all the classified intelligence information available to him, he considered the potential threat from Soviet reconnaissance satellites and orbital bombardment capabilities to be insufficient to pursue defensive American space systems such as Dyna-Soar. Eisenhower believed reconnaissance satellites would offer the Soviets little; America's "open" society gave the Soviets virtually all the information a satellite could provide. In addition, he felt the complex technical design problems associated with the use of exotic metals, cockpit cooling and welding required in systems like Dyna-Soar made further development questionable in the near term and prohibitively expensive in the long term. More importantly, he wanted to sustain the negotiations with the Soviets over freedom of space to gain an edge in gathering critical strategic information about their "closed" society. The defensive military weapons proposed by the services, with Congressional concurrence, would jeopardize Eisenhower's negotiating position of free access to space.[12] In their talks with the Soviets during the Spring of 1958, the Eisenhower administration changed the nomenclature of their space hardware from "non-military" to "peaceful" to qualify certain future satellite reconnaissance roles within the guidelines of international space treaty protocol.[13]

In August 1958, as Eisenhower eased public unrest over Soviet achievements and continued his diplomatic initiatives for freedom in space, Senator John F. Kennedy delivered his most dramatic missile-gap speech on the Senate floor. Its impact upset Republican Senator Homer Capehart so much he threatened to clear the galleries because Kennedy's statements disclosed information harmful to national security.[14] In a speech delivered in April of the following year, Kennedy considered the main problem in our defense posture to be the inability to protect our nuclear strike force from an enemy attack. The depth of his articles and speeches suggested Kennedy's familiarity with defense and space issues. He opposed massive retaliation and recognized the dangers of SAC vulnerability inherent in the missile gap. Should the United States close the missile-gap, Kennedy still believed Americans would be vulnerable to a Soviet first strike because the United States could not guarantee the survivability of its missiles.[15] Because of Kennedy's campaign concerns for the lack of nuclear parity, the defense community looked with renewed hopes to a Kennedy win in the 1960 election; maybe then they could capitalize on the political clamor over Khrushchev's intimidations and American desires for stronger military measures by continuing the development of their weapons systems.[16]

Khrushchev's threats of Soviet retaliation against American intelligence activities became reality in May 1960 when the Soviet Union shot down an American U-2 reconnaissance aircraft, resulting in the cancellation of their missions.[17] Three weeks after the curtailment of U-2 overflights, a new generation of American early warning satellites made their debut with the launch of MIDAS 2 (Missile Defense Alarm System). On 10 August 1960, Discoverer 13, a reconnaissance satellite, provided timely intelligence and filled the vacancy of the U-2 demise. While the information provided by these new technologies confirmed Eisenhower's beliefs about Soviet potential, their operational success represented a military threat to the Soviet Union. Contrary to Eisenhower's views, many members of Congress, the public, and some Air Force officials believed the Soviets would attempt to eliminate American reconnaissance satellites through some military means.[18] Soviet verbal threats to develop an anti-satellite system capable of destroying the Air Force's new intelligence gathering satellites seemed quite credible.[19] Proponents, again, strongly considered the historic precedent for a defensive weapon system.[20] This belief fostered renewed action for Dyna-Soar and fueled political campfires for the ongoing Presidential race. Still, Eisenhower discounted the Soviet threats and sought passage of an international agreement by asking the U.N. for the cessation of all military activities in space.[21] This policy of non-military use of space, a fundamental element in the ebb and flow of Dyna-Soar's history, continued through the remainder of the Eisenhower administration, despite Khrushchev's threats, and provided the Democratic campaign with grist for its political mill.

When Kennedy took office in January 1961, U.S. satellite reconnaissance programs were already providing vital strategic information about the Soviet Union. At the same time, Soviet threats to disrupt these systems became increasingly frequent and credible. In reaction to American technological developments in satellite reconnaissance hardware, the Soviets refuted Eisenhower's notions about their potential by demonstrating a number of new capabilities. In February 1961, the Soviets placed a large (over 14,000 pounds) spacecraft into orbit to serve as a launch platform for a Venus planetary explorer. This action pinpointed American concerns over a growing Soviet ability to launch weapons from space against earth and space targets.[22] Worried about the Soviet's ability to realize their military space potential, the State Department advocated a continued reliance on Eisenhower's legacy of freedom of space through a policy of open disclosure of American launch activities. The State Department sought unilaterally to develop a climate for international acceptance of observation satellites and to pressure the Soviets into relinquishing their inherent military space advantages.[23] While the political embarrassment of the U-2 incident of 1960 represented a classic case of the consequences of non-sanctioned territorial overflight, some administration officials disagreed with the State Department's policy. Subsequently, the Kennedy administration vacillated over the legitimacy issue during the first half of 1961. In the fall, confronted with the issue of Berlin, Kennedy realized the critical importance of reconnaissance satellites.[24]

In the hopes of extracting American concessions over Berlin, Khrushchev evoked an image of Soviet missile strength by retaliation through the deployment of space weapons. To complicate matters, in October during the height of the Berlin Crisis, the Soviets broke the moratorium on nuclear testing by detonating high yield nuclear weapons.[25] Armed with improved nuclear warheads, the Soviets developed and tested a new intercontinental missile with a range of 7,500 miles and, therefore, demonstrated the means to deliver those warheads.[26] To maintain a closer inspection of Soviet research and development, and their strategic intentions, American reconnaissance satellites took on major international importance. In conjunction with the Soviet Union's offensive nuclear potential, Soviet actions reinforced American concerns about Soviet anti-satellite capabilities; a direct threat to American intelligence gathering and decision making capabilities. How could the administration protect our valuable reconnaissance assets? General Curtis LeMay, Air Force Chief of Staff, side-stepped the international agreement issue and argued for enforcing the peace through military capabilities and preparedness. To implement his initiatives, Air force leaders converted the final development phase of Dyna-Soar from orbital nuclear bombardment to a satellite inspection role.[27]

Faced with Soviet threats, the Kennedy administration responded by deliberately revealing the details of American estimates of Soviet nuclear and anti-satellite capabilities in an attempt to undermine Khrushchev's veiled verbal threats and to deflate the arguments of domestic proponents for defensive anti-satellite programs like Dyna-Soar.[28] The administration did not take this decision lightly; nevertheless, the Soviets quickly realized the implications of America's intelligence breakthroughs and unexpectedly reacted by increasing the intensity of their efforts to gain an operational anti-satellite role.[29] Responding to Kennedy's politically embarrassing revelations, the Soviets paralleled American international initiatives by agreeing to establish a permanent U.N. Committee on the Peaceful Uses of Outer Space.[30] The Soviets intended to use the U.N. politically as a platform to oppose various American space programs and deny the United States the use of its technological advantage.[31]

Throughout 1962 arguments concerning satellite overflights frequently occurred at international meetings, conferences and in the media. The Soviet position suggested America's satellite activities constituted aggressive actions; therefore, a Soviet military response would be a legitimate act of self-defense. With the growing Soviet technological capabilities for space operations, the United States considered the option of space reconnaissance becoming illegal.[32] If this occurred, the Soviets could justify shooting down our satellites just as they had shot down our U-2 in May 1960.[33] The outlawing of reconnaissance satellites would force the United States to severely limit, or end, its satellite programs. In turn, this development would hamper America's ability to monitor Soviet military developments and make the United States vulnerable to military and technological surprise.[34] America could not allow an interruption in the flow of information provided by its reconnaissance satellite network.[35]

Meanwhile, State Department discussions in the U.N. increased awareness of the potential benefits of reconnaissance satellites and reasserted the American position: peaceful uses of outer space included Earth observation. But the similarity between military and civilian uses of space placed military programs under very close scrutiny in mid-1962, especially the distinguishable role of Dyna-Soar. When the Soviets launched their own reconnaissance satellite, mutual intelligence gathering capabilities warmed East-West relations. From these developments the State Department considered correspondence between Khrushchev and Kennedy as an indication the Soviets would respond favorably to American restraint in defensive military space operations.[38]

The implications of American restraint coincided with Dr. Harold Brown's views. The Director of Defense Research and Engineering felt ambivalent toward a military role in space because, according to him, a military requirement for Dyna-Soar did not then exist.[39] He further pronounced a systematic "building block" approach to meet any possible contingency and to provide "insurance" should a need for defensive military space weapons be justified. In addition to identifying specific requirements, these efforts would shorten any time lag in full scale development.[40] This policy restricted Dyna-Soar to its Step I (research phase) before any military mission could proceed; justification for Dyna-Soar's existence was eroding.

On 3 December 1962, two months after the administration successfully avoided a nuclear crisis over Cuba, Congressman Albert Gore replied to a Soviet U.N. resolution attacking United States reconnaissance satellites. In his address he stated the United States would take whatever steps became necessary and consistent to avoid an arms race in outer space.[41] The Department of Defense took the first of these steps by cancelling one of its defensive space programs—SAINT (Satellite Interceptor). With this type of initiative from the Department of Defense, Air Force officials felt other programs in a defensive military vein might meet a similar fate. Still, they did not believe all defensive weapons systems would be sacrificed for arms control. Confident in their estimate of military necessity, Air Force leaders felt Dyna-Soar would survive.

Yet Dyna-Soar's survival depended less on military necessity and more on political acumen. A change had occurred in the administration's attitude about military uses and threats in space. The October 1963 U.N.

preliminary settlement between the United States and the Soviet Union renounced "weapons of mass destruction" and formalized these pledges in U.N. Resolution #1884. In addition, both nations now had operational reconnaissance satellites providing valuable intelligence information and neither side wished to jeopardize that balance.[43] Since Dyna-Soar had been conceived as a delivery platform for nuclear weapons and as a possible satellite interceptor, two of the primary justifications for its existence had disappeared.[44] Preempted by conciliatory treaties limiting the military use of space, Soviet efforts to prohibit American reconnaissance satellite overflights ended when both nations tacitly accepted existing territorial overflights.[45]

Through two administrations the Air Force had steadfastly supported the necessity for defensive military space systems, but both the Eisenhower and Kennedy administrations ultimately selected diplomatic options to ensure the legitimacy of reconnaissance systems. While diplomatic efforts secured the limitation of nuclear weapons in space, the question of satellite overflights became moot when both nations possessed reconnaissance satellite capabilities. Therefore, on 10 December 1963, the Kennedy administration announced the cancellation of Dyna-Soar.[46]

Two months later, before the Senate Subcommittee on Department of Defense appropriations, Secretary McNamara summarized Dyna-Soar's failure:

*The X-20 [Dyna-Soar] was not contemplated as a weapon system or even as a prototype of a weapon system. . . . it was a narrowly defined program, limited primarily to developing the techniques of controlled reentry at a time when the broader question of "Do we need to operate in near-earth orbit?" has not yet been answered. . . . I don't think we should start out on a billion dollar program until we lay down very clearly what we will do with the product, if and when it proves successful.*[47]

Contrary to Secretary McNamara's statement, Air Force leaders clearly defined Dyna-Soar's role as a military weapon system. In fact, Dyna-Soar died largely because the program's military objectives were incompatible with the administrations diplomatic negotiations. When the United States and the Soviet Union accepted mutual satellite overflight in 1963, Dyna-Soar became a hindrance, threatening to unbalance international stability. Ultimately, Air Force leaders placed military requirements ahead of political necessity and lost Dyna-Soar, and the "high ground" of space, to a peace initiative. The diplomatic quest for safe passage of American satellites outpaced military efforts to protect them. The Air Force failed to perceive the uncertainties of the political reality, but focused on the military imbalance between Soviet threats and our own capabilities. During the Eisenhower era the potential Soviet threat caused great concern among Americans who felt a loss in their security and capability to respond to the Soviets. During the Kennedy era, the Soviet threat remained high, but America's vulnerability to the threat waned as our reconnaissance satellites revealed Soviet unpreparedness and as the Soviet's became willing to negotiate the question of satellite overflight. Air Force leaders, consistently pressing for a defensive role in space, failed to recast Dyna-Soar's objectives to reflect the international environment before the administration deemed the project a diplomatic liability. Air Force planners should have shown more perceptiveness toward the political climate to attain their goals in the 1960s. Lack of political acumen postponed their hopes until the 1980s, when NASA's shuttle offered the Air Force an opportunity to explore manned military operations in space once again. ●

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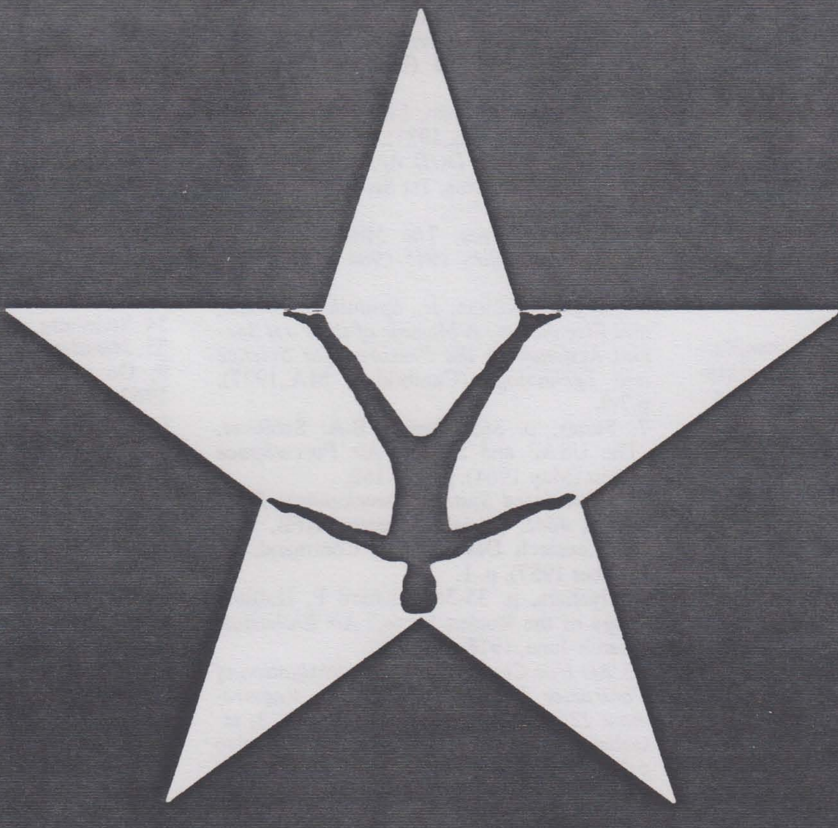
# MOURNING STAR

**by Asif Siddiqi**



**On October 24, 1960 the greatest accident in the history of rocketry and space exploration occurred. During the first attempted test of a new Soviet missile, a pad explosion produced a massive fireball killing hundreds of key soviet workers and space engineers. Called the Nedelin Disaster, accounts of the incident remained obscure for over thirty years until now. . .**

On October 26, 1960, the official newspaper of the Communist Party of the Soviet Union (CPSU) published a report on the death of one of its top military commanders. The article included the following passage:

*The CPSU Central Committee and the USSR Council of Ministers with deep regret announce that on 24 October of this year, while performing his service duties, Chief Marshall of Artillery Mitrofan Ivanovich Nedelin died as a result of an aircraft accident. He was a CPSU Central Committee membership candidate, deputy of the Supreme Soviet, Hero of the Soviet Union, deputy minister of defense, and commander-in-chief of the USSR Missile Troops. Marshall Nedelin was one of the outstanding military figures and builders of the Armed Forces of the Soviet Union and an illustrious hero of the Great Patriotic War.*[1]

What the account did not disclose was that Marshall Nedelin and hundreds of others had perished in, without doubt, the most tragic accident in the history of rocketry and space exploration. During the first attempted test of a new missile, a pad explosion resulted in a fireball that effectively incinerated and burned hundreds of individuals within close range, and devastated the entire launch area.

News of the incident was completely suppressed from both the Soviet public and the West for almost thirty years, creating an almost unbreakable veil of silence over the tragedy. Although the Soviets themselves were tight lipped about the incident, obscure hints did find their way to the Western press allowing analysts to piece together a reasonable reconstruction of the events. As early as the end of 1960, rumors surfaced that it was a booster explosion and not an airplane crash that was responsible for Nedelin's death.[2] In a March, 1961 report, the Committee on Science and Astronautics of the U.S. Congress described how "Marshall Nedelin was killed with a large group of other officials while observing a spectacular rocket launching which exploded, [although] this could not be confirmed."[3] Further implicit confirmation of the event came from Col. Oleg V. Penkovsky, the individual who had passed along defense and state secrets to the C.I.A. until he was arrested in 1962. His alleged diaries were published in the West in 1965 after he was executed, as *The Penkovsky Papers*. Penkovsky described the test of a nuclear-powered rocket which had failed to ignite at launch. A few minutes following the abort, according to Penkovsky, Nedelin and many others came out of their bunkers, when there was a massive explosion killing "over three hundred people."[4] The author notes that there was a long period of mourning declared in the town of Dnepropetrovsk, from where some of the deceased scientists had lived.

The final conclusive confirmation that the accident had indeed occurred came from the second volume of memoirs of former Soviet leader Nikita S. Khrushchev, published in 1974 in the United States. In his writings, Khrushchev makes no mention of a nuclear rocket, but does add some interesting elements to the story:

*Chief Designer Yangel just barely escaped death in a catastrophic accident which occurred during the test of one of our rockets. As the incident was later reported to me, the fuel somehow ignited, and the engine prematurely fired. The rocket reared up and fell, throwing acid and flames all over the place. Just before the accident happened, Yangel happened to step into a specially insulated smoking room to have a cigarette, and thus he miraculously survived. Dozens of soldiers, specialists, and technical personnel were less lucky. Marshall Nedelin, the Commander-in-Chief of our missile forces, was sitting nearby watching the test when the missile malfunctioned, and he was killed.*[5]

Although the account in Khrushchev's memoirs fairly conclusively confirmed the earlier sketchy reports, the Soviets remained quiet about the whole issue and refrained from any comment. The best contemporary Western assessment of the disaster was published in 1981 in the book *Red Star In Orbit* by U.S. researcher James E. Oberg. In his description, Oberg linked the explosion to a launch attempt of a planetary probe bound for Mars. The very first publication of a detailed account of the accident finally came in April, 1989, in the popular Soviet magazine *Ogonek*, authored by one of the witnesses to the accident, Aleksandr Bolotin. Further accounts were soon published in the Soviet press, and now it is finally possible for the first time to piece together an accurate account of the events of that tragic day in October, 1960.

### The Commander

Artillery Marshall Mitrofan Ivanovich Nedelin, born on November 9, 1902, was one of the most important artillery commanders both during World War II and in the post-war years. Following an illustrious service during the war, in November, 1948 he was appointed Commander of the Chief Artillery Directorate (GAU) in the Ministry of Armed Forces, with the job of directing the adoption and operation of a new generation of longer range ballistic missiles for the artillery sector. In particular, Nedelin was instrumental throughout that period, of creating and training the first long range missile battalions in the Soviet armed forces. The early missiles, the R-1 and R-2 were essentially derivatives of the German A-4 (known to the Soviets as the FAU-2) missile, but gave valuable lessons to the artillery sector in handling, fuelling and launching operations of liquid-fuelled ballistic rockets. Throughout this period Nedelin kept in close contact with the actual engineers involved in missile design such as Chief Designers Sergey P. Korolyov and Valentin P. Glushko of the Scientific Research Institute No. 88 (NII-88). Despite a rocky start to their interactions, through the 1950s Korolyov and Nedelin developed a very close working relationship, one that facilitated the fairly quick and successful realization of the launch of the world's first intercontinental ballistic missile, the R-7 in August, 1957. Earlier in March, 1955, Nedelin had been appointed Deputy Minister of Defense for Armaments, thus becoming personally responsible for the procurement of all long-range strategic ballistic missiles in the Soviet Union. As his power grew, he also apparently had access to the top leaders of the Communist Party, something that was not readily available to engineers such as Korolyov and Glushko. It is noted in his biography that:

*When it came to disputed or what seemed to be insoluble solutions at the ministerial level, Nedelin with the knowledge of the Minister of Defense turned for help directly to the leaders of the Party and the government.*[6]

Contrary to conventional wisdom, Nedelin was generally known as a very thorough and careful individual. A biographer of Nedelin recently noted that:

*He was distinguished by his extreme caution in judgements and actions, a kind of overdeveloped thoroughness. If he had to go somewhere, he tried to arrive at the station an hour before the train's departure, and he travelled in two vehicles, God forbid, one might break down.*[7]

Korolyov himself had a great deal of respect for Nedelin and had noted that when it came to questions of quality control and delivery dates, Nedelin was a demanding and 'principled' customer.[8] Famous Soviet physicist Andrey D. Sakharov also had high praise for Nedelin:

*He was a thickset, stocky man who spoke softly but with confidence that brooked no objection. He impressed me as far from stupid, as energetic and competent, and considerably more active than his predecessor....*[9]

At the end of the 1950s, when Khrushchev sanctioned the formation of a special sector of the Ministry of Defense dedicated to the operation of its new strategic arsenal, Marshall Nedelin was tapped as an obvious first choice, having extensive experience in the development and operation of the R-1, R-2, R-5, R-7, R-11, and R-12 missiles. On December 17, 1959, a new service of the armed forces, the Missile Troops, was created with Nedelin as its first Commander-in-

*Chief Marshall of Artillery Mitrofan I. Nedelin is shown (above right) soon after his appointment as Commander-in-Chief of the USSR Missile Troops. On the left is Colonel-General Vladimir F. Tolubko who served as Nedelin's First Deputy. Tolubko authored a noted biography of Nedelin in 1979 and himself commanded the Missile Troops from 1972 to 1985. Photo Source: Tolubko, V. F., "Nedelin: Perviy Glavkom Strategicheskikh," Molodaya Gvardiya, Moscow, 1979.*

Chief.[10] Under orders from Nedelin, the most qualified and competent officers were tapped from all across the nation to be inducted into the new service, the final selections being made by Nedelin himself.

### The Missile

By the time of the formation of the Missile Troops in December, 1959, the Soviet Union had in its possession only one intercontinental ballistic missile, the R-7A (the 8K74), affectionately called the 'Semyorka' (old number seven), and designed by a team under Chief Designer Korolyov at the Special Design Bureau No. 1 (OKB-1). By 1959, there were already plans at the highest level for a second generation of missiles, that would not have such limited strategic capabilities as the R-7A. One of the primary concerns for officers like Nedelin was that the R-7A would be a very cumbersome missile to use in actual wartime situations. The missile took too long to fuel rendering it virtually useless in quick reaction situations. In addition, its launch structure was relatively large and was visible to overflying reconnaissance flights leaving the pads open to targeting by U.S. bombers. The vehicle also had poor guidance capabilities, and was forced to rely significantly on expensive ground station contact during portions of its flight trajectory. To bypass these and other limitations, several proposals were floated around in the 1956-59 period that foresaw the development of an intercontinental ballistic missile which could be launched on as little as 30 minutes notice from small self-contained mobile platforms. Consequently Soviet leaders Nikita S. Khrushchev and Leonid I. Brezhnev, on May 13, 1959 formally approved the development of two unrelated missiles of the second generation. Competing for ultimate adoption by the Missile Troops, OKB-1 Chief Designer Korolyov began development of the R-9 missile (the 8K75), while Special Design Bureau No. 586 (OKB-586) Chief Designer Mikhail K. Yangel, based at Dnepropetrovsk, began work on the R-16 vehicle (the 8K64).[11]

Yangel, a protege of Korolyov's, had been appointed head of his own organization in June, 1954 to develop early quick-action intermediate range missiles such as the R-12 and R-14. By 1960, both of these missiles had flown successful test flights. Yangel's and Korolyov's missiles had one significant difference: Yangel chose to use the highly toxic and hypergolic combination of nitric acid and kerosene derivatives. Korolyov was very reluctant to use toxic fuels due to the danger in handling them. Although they could be stored in the missile for relatively long periods of time, they were also very dangerous to ground crews if not properly handled. With no interest in the 'devil's venom' (as Korolyov called nitric acid), Korolyov preferred to use the tried and tested liquid oxygen and kerosene in his new R-9 missile. Yangel however, had a successful history of using hypergolic propellants on the R-12 and R-14, making him an ideal choice to develop the R-16. Nedelin was particularly supportive of Yangel's new rocket, and with the patronage of Brezhnev, managed to bring the vehicle from the drawing boards to reality in a very short period.

The R-16, as designed in the 1958-59 period was to be the first true two-stage intercontinental ballistic missile. The first stage was powered by three two-chamber engines from the OKB-456 of Chief Designer Glushko designated the RD-218. This engine was part of a group of four that Glushko had begun working on in 1958 that used the new synthetic propellant named unsymmetrical dimethyl hydrazine (UDMH). Combined with nitrogen-derived oxidizers, the use of the propellants promised the possibility of 'storing' the missile in firing position for longer periods of time. Total sea level thrust at lift-off for the R-16 was 255.4 tons.[12] The second stage was to utilize the two-chamber RD-219 engine fuelled by red fuming nitric acid (RFNA) and UDMH. Total thrust was to be about 80 tons.[13]

Guidance on the R-16 was to be handled by a fly-by-wire inertial guidance system. It was to use a preprogrammed variable thrust/altitude history in order to maintain the required velocity and position through its long trajectory. Since real time solutions were not expected of the complex guidance equations, simple analog computers and digital-differential analyzers were planned for use with the missile in place of more advanced digital computers.[14] The initial model of the missile was to carry a single 5.0 megaton nuclear warhead a distance of 13,000 kilometers.[15] The length of the missile was to be 30.78 meters, about the same size as the famous 'Semyorka.' Base diameter was to be 3.05 meters. The leading designer of the missile was Deputy Chief Designer of OKB-586, L. A. Berlin. Another Deputy from the Design Bureau, V. A. Kontsevoy was appointed to direct and oversee the complete testing program on behalf of the engineers.

### The People

The first ground tests of the engines for the R-16 began in late 1959 at Khimki under the direction of Chief Designer Glushko. By the summer of 1960 ground crews were sent to Tyura-Tam to begin construction of a launch pad at site number 41 in preparation for the first launches of the missile later that year. By the autumn, construction of the first pad was finished, and by early October, personnel from the Yangel Design Bureau, the Missile Troops, and the State Committee for Defense Technology began to arrive at the town of Leninsk near the launch area. The test was awaited with great anticipation, not only because it was the first test of a new

*Artillery Marshall Kirill S. Moskalenko who succeeded Nedelin as Commander of the USSR Missile Troops following the latter's death in October 1960. Moskalenko remained in that position until April 1962. Photo Source: Tolubko, V. F., "Nedelin: Perviy Glavkom Strategicheskikh," Molodaya Gvardiya, Moscow, 1979.*

missile, but also because the R-16 was to take the role of the first truly operational intercontinental ballistic missile in the Soviet Union. Apart from Yangel, his First Deputy Vasily S. Budnik, Berlin, and Kontsevoy, the following senior engineers also flew in for the launch: B. M. Konoplev, a Deputy to Chief Designer for guidance systems Nikolai A. Pilyugin and G. F. Firsov, a Deputy to Chief Designer Glushko.[16] Scores of other less senior individuals from the major Design Bureaus were also on hand to direct operations.

A State Commission was formed headed by Marshall Nedelin to oversee the preparations leading up to the launch. The Commission met in early October and set the date and time for the first launch: 1700 hours Moscow Time on Sunday, October 23, 1960.[17] The Commission also included leading members of the artillery sector, all whom, like Nedelin had been involved in the development of Soviet post-war ballistic missiles. Among them were Col. Yevgeny I. Ostashov (chief of the test section), Col. Aleksandr I. Nosov (former head of the launch team), Maj.-Gen. Konstantin V. Gerchik (Commander of Tyura-Tam), and Maj.-Gen. Aleksandr G. Mrykin (the First Deputy Commander of the Chief Directorate of Missile Armaments of the Missile Troops). Both Ostashov and Nosov had played very historic roles in the launch of the first R-7 and the first Sputniks in 1957. Maj.-Gen. Mrykin was the most senior 'hands-on' officer for all strategic missile and space launches on behalf of the artillery sector, and reported directly to Marshall Nedelin. He had been involved with the rocketry program since 1945 when he had accompanied hundreds of engineers and artillery men to Soviet-occupied Germany to recover parts of German A-4 missiles. Since then, he had played a key role in the development and operations of all Soviet ballistic missiles. Recently, Mrykin was also involved in launch operations of the Sputnik and Luna launches from Tyura-Tam. According to one account he was:

> *A strong and lively individual but it is true that some complained about his lack of restraint and stern character. They said that even Sergey Pavlovich Korolyov himself was somewhat afraid of Mrykin.*[18]

The leader of the launch team for the first R-16 launch was Col.-Eng. R. M. Grigoryantz replacing Col. Nosov who had been promoted to a position in Moscow. At the last moment Nosov decided to travel to Leninsk to observe the launch, in case his experience came in handy.

There appears to have been considerable pressure on all involved to perform a successful test. Just nine days prior to the scheduled launch, Soviet leader Khrushchev had spoken at the United Nations about the might of the Soviet missile forces, emphasizing that Soviet strategic rockets were being produced "like sausages from a machine."[19] The reality of the situation was, however, quite different. The only missiles the Soviets were producing in large quantities at the time were the R-12 and the R-14, neither of which had the capability to reach the continental United States. The intercontinental R-7A had shown its limitations in a weapons context and was manufactured for the missile forces in only limited quantities. Thus, the pressure was on Yangel and his team to get the R-16 off to a successful start as soon as possible. Parity would have to be achieved in the near future.

## The Tragedy

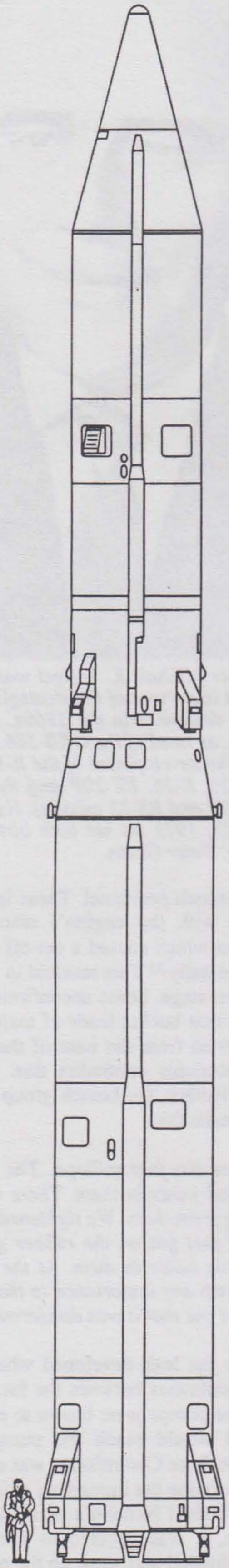
Movement of the R-16 missile (Serial No. LD1-ZT) from the assembly and testing building to the pad at site number 41 began on the morning of October 23. Once the rocket was raised on the pad, Chief Designer Yangel and numerous others walked around the missile trying to direct the whole operation. Reports suggest that the presence of Nedelin and other powerful individuals created a sense of nervousness and tension among the engineers and military personnel involved. Maj.-Gen. Gerchik, the Commander of the Tyura-Tam launch range ordered that chairs and stools be brought from the service building for Marshall Nedelin and the other important guests. They were set up very close to the launch site, so that Nedelin could observe the preparations from a close spot.[20] As the afternoon wore on, activities intensified at the pad. Late in the afternoon, several technical difficulties were encountered by the launch personnel. These included problems with the engine's automatic control system which caused a cut-off valve to open accidentally.[21] This resulted in a fuel leak in the first stage. Some unconfirmed reports suggest that bucket loads of toxic fuel had to be carried from the base of the missile. Other accounts contradict this. Capt. Stanislav N. Pavlov, the launch group chief at the time recalls that:

*Chief Designer Mikhail K. Yangel was perhaps the most important of the strategic ballistic missile designers in the 1960s. From 1954 to 1971, as head of the OKB-586, Yangel oversaw the development of the R-12, R-14, R-16, R-26, R-36, RT-20P and the MR UR-100, R-36N and RS-22 missiles. He died on October 25, 1971 on his 60th birthday. Photo Source: Peter Gorin.*

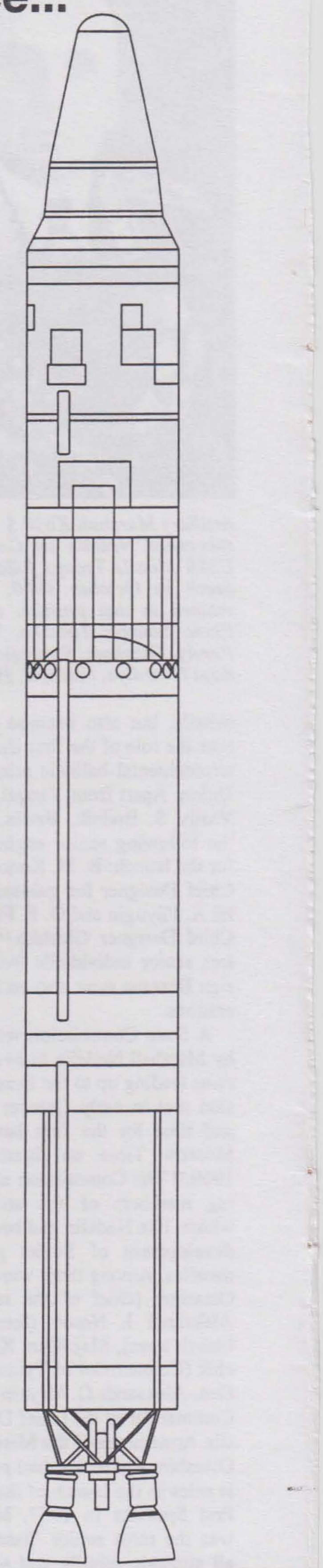
> *I did not see any fuel spillage...The [fuelling] pipes had joints in them. There was a little dripping from them. We tightened them up. Drops of fuel got on the rubber gloves and made little holes in them. At the time, we didn't attach any importance to that, but later we found out that it was dangerous.*[22]

Apparently the leak developed when the protective membranes between the fuel tank and the engine pumps were blown to ensure that the fuel would reach the pumps. A meeting of the State Commission was quickly held to determine the immediate course of action. At Marshall Nedelin's personal recommendation, it was decided to keep the missile fully fuelled and work on the repairs throughout the night.[23] The launch was rescheduled for the evening of the following

# The First Heavyweights At A Glance...



| | | |
|---|---|---|
| R-16 8K64<br>SS-7 (U.S. DoD)<br>Saddler (NATO) | **Designation** | Titan II LGM-25C<br>SM-68B |
| OKB-586 under<br>M.K. Yangel | **Prime Contractor** | Martin Company |
| 1959 | **Beginning of Development** | 1958 |
| 2 February 1961<br>(Pad explosion on<br>24 October 1960) | **First Flight** | November 1961 |
| 1962 | **Beginning of Deployment** | 1963 |
| 186 | **Maximum Number Deployed** | 54 |
| 65% "Soft" Coffin Sites<br>35% "Hard" Silo Sites<br>Warhead(s) | **Launch Site** | "Hard" Silo Sites |
| One 5 or 10 MT | **Warhead** | One 9 MT W-33<br>(inside a Mk-6 RV) |
| 10,500 / 13,000 km | **Range** | 15,000 km |
| 1977 | **Year of Retirement** | 1987 |
| 31 meters | **Total Missile Length** | 31.39 meters |
| 3 meters | **Missile Diameter** | 3.05 meters |
| 140/148 tons | **Total Missile Weight** | 149.7 tons |
| | **First Stage Engines** | |
| OKB-456 under V.P. Glushko<br>Three RD-216 derivative<br>(twin chamber) | | Aerojet General<br>Two LR-87-AJ-5<br>(single chamber) |
| 3 x 85 tons | **Sea Level Thrust** | 2 x 97.5 tons |
| 255 tons | **Total Launch Thrust** | 195 tons |
| 170 seconds | **Burn Time** | 155 seconds |
| 4 thrusters | **Steering** | Gimbaled main engines |
| | **Second Stage Engines** | |
| OKB-456 under V.P. Glushko<br>RD-219<br>(twin chamber) | | Aerojet General<br>LR-91-AJ-5<br>(single chamber) |
| 1 x 90 tons | **Vacuum Thrust** | 1 x 45.36 tons |
| 125 seconds | **Burn Time** | 180 seconds |
| 4 thrusters | **Steering** | Gimbaled main engine |
| Nitric Acid &<br>Nitrogen Dioxide | **Oxidizer on Both Stages** | Nitrogen Tetroxide |
| UDMH | **Fuel on Both Stages** | Aerozine-50 |

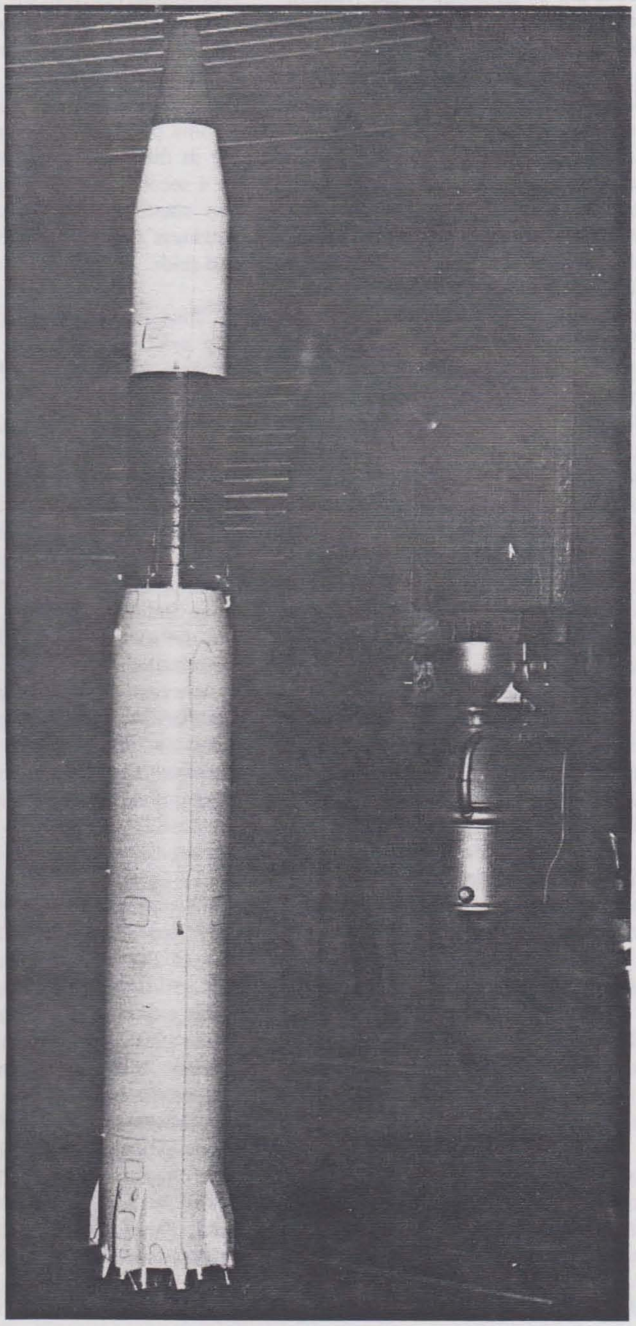


by Peter Gorin

In the late 1950s the Soviet leadership was very aware of the drawbacks of the first Soviet ICBM, the R-7 (SS-6). Unlike its American counterpart—the Atlas, the R-7 was impossible to deploy in large quantities. It was also alarming to the Soviet leaders that the U.S. had been rapidly developing two more ICBMs: Titan-1 and Titan-2. Following its typical "mirror response" pattern, the Soviet government ordered a rush development of similar missiles in 1959. The R-9 ICBM with cryogenic propellant, was seen as the Titan-1 counterbalance and was ordered "just in case." The Soviet counterpart of Titan-2 was R-16 (SS-7). Its development was conducted by the OKB-586 design bureau under Mikhail Yangel.

It was Yangel's first ICBM but his team already had a sufficient experience in designing of smaller missiles with hypergolic propellants. Simultaneously with R-16, OKB-586 was developing an intermediate-range missile known as the R-14 (SS-5). Apparently it was decided that both missiles should have as many common design features as possible. The R-14 was powered by two RD-216 engines, with a thrust of 75 tons each. That engine had an unusual two-chamber configuration. Three similar engines, with an upgraded thrust of 85 tones each, were installed on the R-16 first stage. The designations of these engines are not known, but it might have been "RD-217." The steering vanes, typical for R-14, were replaced by four small liquid propellant thrusters. The R-16 second stage was powered by another derivative of the same engine called RD-219. It was adopted for optimal use in the vacuum of space and was supplemented by another four steering thrusters. All engines were developed by the OKB-456, under Valentin Glushko.

The extensive use of existing technology considerably shortened the R-16 design period. The missile was ready for its first flight far ahead of Titan-2, which began development in 1958. Despite the "Nedelin Disaster" and later malfunctions, the missile entered service in 1962, again ahead of Titan-2. In accordance with the Soviet tradition of that time, R-16 was deployed in two major configurations: one involving a "light-weight" warhead (5 MT) and another with a "heavy" warhead (10 MT). The latter model had a shorter range. In 1961 Mikhail Yangel was awarded his second highest Soviet state award for the R-16 development.



The R-16 initially was designed for open unprotected (so-called "soft") launch pads. On May 30, 1960, the USSR adopted a decision to develop "hard" launch pads (underground silos) for all of its newest missiles. In 1963 the deployment of the new R-16U missile began in the silos. That rocket had a longer range even with the "heavy" warhead. For about fifteen years R-16 was a backbone of the Soviet Strategic Rocket Forces. A total of 186 missiles were deployed by 1967, and about 35% of them in silos. From 1969–1977 the R-16s were gradually replaced by ICBMs of the second generation.

Unlike many other older Soviet missiles, the R-16 has never been publicly displayed. Only low-quality footage of an R-16U being launched from a silo, was released in the USSR about twenty years ago. Later, a model of the missile and a full-scale mockup of the second stage engine compartment were displayed at the Soviet Armed Forces Museum in Moscow. A picture of that model (shown above) taken by the author in 1984, clearly shows four of six main nozzles on the first stage. A gimbaled steering thruster on the second stage is visible in the background. The second stage mock-up (not shown in the picture) displays the RD-219 engine mount. That exposition and the released data on the RD-216 and 219 engines helped resolve some of the R-16 design features.

Immediately after the R-16 achieved operational status, the OKB-586 began development of an improved version of the missile. The modernized variants utilized the same engines along with new avionics and larger tankage. This is how the R-36 (SS-9)—one of the most fearsome Soviet ICBMs was born. ●

Data: Peter Gorin, Daniel James Gauthier, Asif Siddiqi Illustrations: Daniel James Gauthier, FBIS day, October 24. In an ironic twist, Nedelin had just arrived from the Kapustin Yar State Central Range where he was to have witnessed a launch of the shorter range R-14 missile. Due to a malfunction, the launch of the R-14 had to be postponed, and it was decided to drain the missile of its propellants before proceeding with repairs. The standards were not applied in the case of the more powerful R-16 missile, and many have suggested that Nedelin was under severe pressure to get the missile off from Communist Party leaders such as Khrushchev, Kozlov, and Serbin, and thus capitulated to them by calling for repairs in a fully fuelled state. Ground crews carefully removed the hatches on the lower portion of the first stage, and soon began resoldering the missile's joints in a serious and obvious violation of the safety rules.[24] The repair crews worked throughout the night under search lights knowing full well that the missile could only be kept fuelled for a maximum of 48 hours before the launch would have to postponed for later in the week. The pressure on them was intense.

By the morning, the original repairs were finished, but anxiety arose once more when a second smaller fuel leak was detected. The State Commission was again convened and based upon recommendations from engineers and ballistics technicians, Nedelin decided to allow the launch to proceed as planned for that evening. As the sunlight waned on the test range, Nedelin sat himself down at one of the chairs and reviewed two platoons, graduates of the F. E. Dzerzhinsky Military Academy who were to be involved in future launch operations of the missile forces. The commanders of the units gave their reports to Nedelin, after which Nedelin "dressed them down for their slipshod formation" and then gave a short speech:

*You have come here for the first launch of an intercontinental ballistic missile that uses new fuel that is extremely promising for operation in combat units. Your presence is an honor for you. You are the first to get experience in the preparations for the launch of this newest missile under real conditions. Therefore, be attentive at your work stations. As much as possible, develop the practical skills that will be needed in your own unit.*[25]

Nedelin dismissed the units just one hour prior to the scheduled launch and sat back down on his chair approximately 17 meters from the R-16. The launch was scheduled for 1915 hours Moscow Time.

When the 30 minute mark was announced, all extraneous personnel including the emergency rescue services were asked to leave the pad area. Unbelievably enough there were still about 200 individuals, including Nedelin, who were still at very close range to the rocket. They included numerous engineers from the Yangel Design Bureau, artillery officers and soldiers, and several representatives from the government. Apparently, Nedelin's advisors had recommended that he withdraw to a bunker at that point, but he had reportedly answered, "What's there to be afraid of? Aren't I an officer?"[26] At this point, an apparently unexpected delay in the launch was announced, followed by a second delay.[27] Maj.-Gen. Mrykin who was standing near Nedelin, in a fit of nervousness approached Chief Designer Yangel and said:

*"This is it, Mikhail Kuzmich, I am quitting smoking, let us go off to the side and smoke a last cigarette."*[28]

Thus Mrykin and Yangel walked over to join Col. Aleksandr S. Matryonin, the chief of the combined rocket section in a bunker at the command post that was safe for smoking. Marshall Nedelin himself stood up and began to discuss the situation with L. A. Grishin, a top representative from the defense industry, walking between the ramp and the rocket, about 10 to 15 meters from the missile.

At exactly 1845 hours Moscow Time on October 24, 1960, while performing operations for bringing the programmed current distributor in the autonomous control system to its initial setting, a technician sent a signal to the R-16 missile. The cable's distribution system, however, malfunctioned and instead sent a spurious command to the engine of the second stage to fire.[29] As soon as the engine fired, a huge fireball engulfed the upper part of the missile. The exhaust from the second stage ignited the tanks of the first stage, exponentially increasing the potency of the blast, resulting in a massive fire explosion. At the same time, a motion picture camera that was to have taken a film of the launch was activated and recorded the tragic scene in gory detail. The technicians who were closest to the missile were instantly engulfed in the fireball and burned up in seconds. Those on the ground made desperate attempts to escape the fire and acid, only to be hit by the wave of fire that expanded like a circle around the area. V. Kukushkin of the OKB-586, who was standing close to Nedelin recalls that:

*The air wave from the engine that had fired pressed the marshall [Nedelin] against the concrete overhang of the roof near which he was sitting. The flame, apparently reached him there. The explosion lifted me up and dragged me about 30 meters along the sidewalk.*[30]

The initial shock wave from the missile saved Kukushkin's life by lifting him far enough from the fireball for him to run away with his life (although he suffered severe burns). Soon the rocket broke in half and fell on the pad, crushing anyone who might have still been left alive. At this point, the fire and the heat increased in intensity as all the propellants ignited in a crescendo. Some people were simply engulfed in the fire, others who managed to run completely burned, succumbed to the toxic gases within minutes. Some technicians remained hanging from their harnesses from special cranes as their bodies burned. Captain Pavlov, the launch group chief was one of the few lucky ones who were thrown by the initial shock wave and managed to run through the flames to safety. He was so badly burned that physicians had to cut off his clothing and boots which had become attached to his skin, while his jacket was burned to ashes.[31] The representative from the industry, Grishin, who had been standing next to Nedelin, had managed to jump over a high railing, run across the molten tarmac, jumping to the high gate of the ramp from a height of 3.5 meters, breaking both legs in the process to reach safety. Tragically, he succumbed to his burns soon after he was taken to the hospital. As the temperature raged to around 3,000 degrees, people just simply melted in the firestorm, many being reduced to ashes.

Those in the bunkers around the launch site remained safe in their protective cocoons. Maj.-Gen. Mrykin, who had saved his and Chief Designer Yangel's lives with his last cigarette, immediately tried to take some semblance of control of the situation. He quickly ordered Senior-Lt. Boris I. Klimov, the chief of the telemetry laboratory to form a group of 30 soldiers, called in from elsewhere at Tyura-Tam to report to him immediately. Mrykin issued an order to "find everything that could have remained."[32] Klimov recalls his first impressions upon entering the launch area:

*Driving up to the pad, I saw that we would not be able to manage without gas masks. But even with them on, it was impossible to work...The dead were not identified visually, but from typical personal belongings, like keys from apartments.*[33]

Another officer from the team remembers that:

*They carried the dead off the site and laid them near the medical unit. All of the corpses were in identical and somewhat doubled up poses and all were without clothes or scalps. It was impossible to identify anyone. Under the light of the moon, they seemed to be the color of ivory.*[34]

As the scene at the area quietened down, emergency medical crews were sent to scour through what remained. Scores of individuals with severe burns were taken to nearby hospitals in Tyura-Tam and Leninsk. Work was both dangerous and tiring for the crews as they worked throughout the night. By morning, the magnitude of the disaster became apparent. Among those from the Yangel Design Bureau alone, scores of designers and engineers had been killed, effectively decimating the organization. Dozens of young soldiers on their first assignment as

**No known still photos exist of the accident but a motion picture camera that was to have taken a film of the launch was accidently activated and recorded the entire tragic scene in gory detail. These stills from that footage show workers running for their lives from the intense fireball. As temperatures rose to 3,000 degrees, many were instantly engulfed in flames and consumed in seconds.**

*Photos were obtained from the film "Soviet Space The Secret Designer" and are used by permission from Rudy, Inc.

young as 19 years old were found dead. Several leading officials of the Missile Troops were also reported missing. Chief Designer Yangel was completely shaken by the tragedy and was one of many who openly wept at the incredible loss. He had to be physically restrained from going to the scene of the disaster during the explosion for his safety. Throughout the following day, medical personnel went through the grisly task of identifying the dead from whatever belongings still existed. Many individuals were simply never identified.

### The Investigation

As soon as word was received in Moscow about the magnitude of the tragedy, a special Commission was formed, headed by the Chairman of the Presidium of the Supreme Soviet, Leonid I. Brezhnev, to conduct the post-disaster operations and to determine the causes of the accident. Brezhnev left for Leninsk as soon as possible and was not present at 3rd Session of the Russian Soviet Federated Socialist Republic (RSFSR) Supreme Soviet Session that began on the morning of October 25. A Technical Commission was also created at the same time to investigate specifically the events and causes that led up to the accident.[35] Konstantin N. Rudnev, the Chairman of the State Committee for Defense Technology, who was the governmental leader of the space program, was appointed its head. More significantly, Rudnev was also the Chairman of the State Commission for the Vostok program, whose first piloted flight was then scheduled for December, 1960.

When Brezhnev and Rudnev arrived at Leninsk on October 25, they were taken straight to the assembly and testing building where an ad hoc meeting was held. Those who still remained alive (including Mrykin and Yangel) were called in to make reports. Throughout the day Rudnev and others scoured through the remains to make sense of the tragedy. The Commission also painstakingly went through records of all that had been monitored at the ground control center. Other leading figures were also flown to Leninsk to oversee the operations of the Technical Commission. According to Chief Designer Viktor I. Kuznetsov of the Council of Chief Designers, he and other personnel at the launch site were "badgered persistently by Brezhnev, who was impatient for 'conclusions' in regard to the accident and was willing to accept even casual and superficial versions."[36] By October 26, more dignitaries, such as Ivan D. Serbin, the head of the Defense Industries Department of the Central Committee, and Andrey A. Grechko, a Deputy Minister of Defense had flown in to join the investigation. Rudnev, the same day personally reported to Brezhnev on the possible causes of the accident. It was discovered that the testing of the autonomous control system of the missile was the probable cause. This system was responsible for automatic in-flight transmissions of signals and commands to the primary rocket components, such as the engines. It appears that in preparation for the impending launch, the settings of the electromechanical programming devices for the system were to be set to their initial state. As electrical power was being fed to the missile, technicians at the block house began to transmit signals to the system. Provisional measures had already been taken for appropriate blocks in the system, so that when the resetting was done, actual flight commands would not be carried out. Unfortunately one of the blocks, due to an electrical malfunction did not work. The particular block was responsible for preventing the firing of the second stage engine.[37]

Following presentation of a conclusive report on the accident, Brezhnev decided that no individual or individuals would be punished for the accident. In his opinion, punishment had already been meted out. On October 27, a funeral was held for the victims. Officers' wives went from apartment to apartment gathering flowers. By night time, a bulldozer was called in to dig a common grave by the road that connected the launch area to the local airport. In pouring rain, scores of coffins were laid into the grave as Brezhnev made a final eulogy. Speaking through his tears, he iterated that the "fallen would never be forgotten" adding that the government was now concerned with the families of the deceased. On the matter of responsibility for the tragedy, he only said:

*"And he who is guilty has punished himself."*[38]

Following the funeral, a table was laid nearby for 40 of the most important people for a small dinner. Brezhnev apparently still remained quite visibly disturbed by the whole incident.

### The Toll

Accounts differ on the number of those who perished on the evening of October 24 at Tyura-Tam. Most reports describe 165 fatalities with a possible upper figure of 200.[39] Sakharov, in his account of the accident suggests a figure of 190 individual deaths.[40] Curiously, some otherwise reliable sources cite a figure as low as 54, but this is unlikely to be true given the publication of many articles in the Soviet Union that confirm the figure of 165.[41]

Among those killed were Marshall Nedelin, Col. Nosov, Col. Ostashov, Col. Grigoryantz, Yangel Bureau Designers Berlin and Kontsevoy, Pilyugin Bureau Designer Konoplev, Glushko Bureau Designer Firsov, and representative from the industry L. A. Grishin. An obviously incomplete list of those known to have died is presented below:

Y. Alya-Brudzinsky
L. A. Berlin
I. Brytsin
G. F. Firsov
V. Geraskin
R. M. Grigoryantz
L. A. Grishin
B. M. Konoplev
V. A. Kontsevoy
M. Kupreyev
E. Mironenko
M. I. Nedelin
A. I. Nosov
V. Orlinsky
Y. I. Ostashov
V. Sinyavsky
L. Yerchenko
A. Yudin
I. Zaraysky

Among the survivors, Commander of Tyura-Tam Maj.-Gen. Gerchik was severely injured and was unable to continue his duties. His place was taken by Maj.-Gen. Aleksandr G. Zakharov in early 1961. Maj.-Gen. Mrykin, who had inadvertently saved his and Yangel's life never did give up smoking. He went on to play an important role as a member of the State Commissions for various Vostok, Voskhod, Soyuz, and N-1 launches throughout the 1960s. He died in 1972. Chief Designer Yangel of course continued to head his important design organization producing numerous powerful strategic missiles until his untimely death in 1971. Marshall Nedelin was buried with full honors at the Kremlin wall. His position as Commander-in-Chief of the Missile Troops was taken by Marshall Kirill S. Moskalenko.

Apart from the obvious physical loss of life and property, the disaster had a serious psychological effect on all individuals involved in the missile and space programs. Additionally, although there was no clear connection between the R-16 and the Vostok programs, the R-16 explosion had an indirect effect on the latter. Prior to the disaster, the first piloted spaceflight of the Vostok ship was planned for late December, 1960. Soviet journalists with access to archival material note that the flight was quietly delayed to the early spring of 1961, although there was no official decree on the postponement, and not even a mention of possible reasons for the delay.[42] Based on circumstantial evidence, and their own communications with individuals involved, these journalists clearly attribute the delay of the first human Vostok flight to the R-16 disaster.

### The Aftermath

Launchings of the R-16 itself resumed from Tyura-Tam in February 2, 1961 under the supervision of Marshall Moskalenko.[43] The flight tests were successful. The missile was eventually declared operational in 1962 and later models constituted an effective deterrent force against U.S. nuclear systems until well into the 1970s. The final R-16 launchers were dismantled in 1977. At one time the R-16 was designed to form the basis of a three-stage space launch vehicle designated the Tsiklon-1, but that program was eventually cancelled in the late 1960s.[44] The expertise in designing and launching the R-16 however gave the Yangel Design Bureau valuable experience in the development of the R-36-based Tsiklon-2 and Tsiklon-3 launch vehicles both of which continue to be used as satellite launch vehicles at the time of writing.

The R-16 disaster was immediately classified as "top secret" in the Soviet rocketry program, and all involved were forbidden to speak of it to outsiders who had not been involved. This prohibition was finally removed in 1989. Even as late as the mid-1980s, Soviet journalists who attempted to write of the disaster were told to refrain from doing so. Many of the survivors were medically discharged from the armed forces, although they were provided with a military pension. A large obelisk was built in a park near Leninsk to commemorate those who had died. It bore the inscription:

*In eternal memory of those who died while carrying out their military duty on October 1960.*[45]

Cement tablets around the obelisk still contain the names of those who were identified. There are also individual plaques nearby for many of the deceased, some with pictures of the person in question. Apparently the monument area in recent areas has suffered from lack of concern and maintenance from the local authorities. A reunion of sorts of the survivors was held in October, 1990 at Leninsk, thirty years following the accident when it was finally acceptable to mourn in public. The memorial service was held at the remains of site number 41 in front of a granite monolith that had been built to remember the dead. Many relatives of the deceased were invited to the service, and it was at this time, thirty years later, that they learned the truth about the deaths of their relatives. Stanislav N. Konyukhov, who was the Acting General Designer of NPO Yuzhnoye at the time, and a successor to the late Yangel, spoke to all those in attendance:

*No matter how far we penetrate into the reaches of space, it must be remembered that here, on this pad, a step was taken, perhaps unsuccessful and failed, but nonetheless a step on the path to space.*[46] ●

*About the Author: Asif A. Siddiqi has been interested in rocketry and space exploration since he was a young boy living in Bangladesh. He is currently completing a detailed history of the early Soviet human space programs. Asif lives in Amherst, Massachusetts and is an economist by education.* *The author would like to thank the following: Karen Bell, Mandar Jayawant, Rika Muhl and Glen E. Swanson. Thanks also to Peter Gorin for his comments.*

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3. Committee on Science and Astronautics, U.S. House of Representatives, 87th Congress, 1st Session, *A Chronology of Missile and Astronautic Events* (Washington, D. C.: U.S Government Printing Office, 1961), p. 131.
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10. Scott, Harriet Fast, "The Strategic Rocket Forces and Their Five Elites," *Air Force Magazine*, March, 1983, pp. 58-63. Note that the designation Missile Troops was changed to the Missile Troops of Strategic Designation (RVSN) in 1961. The RVSN was more commonly known as the Strategic Missile Troops.
11. Khrushchev, Sergey, *Nikita Khrushchev: Krizisi I Raketi: I* (Moscow: Novosti, 1994), p. 431. The R-9 and R-16 vehicles were given the U. S. Department of Defense designations SS-8 and SS-7 respectively, and the NATO designations *Sasin* and *Saddler* respectively.
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38. Bolotin, op. cit.
39. Radionov, op. cit., See also, Averkov, op. cit.
40. Sakharov, op. cit., p. 196.
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43. "Space Diaries of General N. P. Kamanin," op. cit.
44. Sergeyev, op. cit.
45. Bolotin, op. cit.
46. Averkov, op. cit.

# NASA HISTORY
## *News and Notes*

by
**Roger D. Launius**
**NASA Chief Historian**
**Director, History Office NASA Headquarters**

### NASA NEWS & NOTES ISSUED ELECTRONICALLY

The NASA History Office is prepared to send the quarterly *NASA History: News and Notes* via the internet to anyone with an e–mail address. It should speed distribution of the newsletter, not to mention the staff time of the History Office in preparing mailings. Anyone can be placed on electronic distribution by sending the NASA History Office an e–mail note at history@codei.hq.nasa.gov.

### NASA HISTORY HOMEPAGE ON THE INTERNET

While the staff of the NASA History Office has among its number some of the more technically challenged people working at NASA, modern times have begun to catch up with us. As a result, we have begun the creation of a NASA History Homepage on the Internet's World Wide Web. The project began last summer during the anniversary of Apollo 11, when the office put up a display on the Apollo program. That display has both still and video images, key documents, mission overviews and statistics, astronaut recollections, an annotated bibliography and interpretive works on the history of Project Apollo. It can be accessed at: http://www.gsfc.nasa.govhqpaoapollo_11.htm l. The main history home page, which will have information of a similar nature for all of NASA, is presently under construction and is now available for use—at least in a cursory form. The address for this is on the World Wide Web: http://www.gsfc.nasa.gov/hqpao/history.html. Stay tuned for more information on this subject.

### NEW NASA HISTORY BOOKS SET TO APPEAR

The NASA History Office is moving toward publication of the first volume of a projected three–volume series of essays and documents on the history of the U.S. space program. *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume I, Organizational Developments* (NASA SP–4407), is due out in April 1995. Edited by John M. Logsdon, Director of the Space Policy Institute at the George Washington University, this volume consists of introductory essays and about 150 key documents relating to the space age, grouped by topic and arranged chronologically. Two follow–on volumes are scheduled to appear in 1996 and 1997.

In addition, two other books are slated for release in the NASA History Series during the first half of 1995. One is James R. Hansen's *Spaceflight Revolution: NASA Langley Research Center from Sputnik to Apollo* (NASA SP–4308), that will appear in the spring of 1995. The second is a translation of Hermann Noordung's classic *Das Problem der Befahrung des Weltraums*, first published in 1929. It will appear as *The Problem of Space Travel: The Rocket Motor* (NASA SP–4026). J.D. Hunley, Ernst Stuhlinger, and Jennifer Garland prepared the book for publication.

Any individuals interested in being notified of these and other new books published by NASA and sold by the Superintendent of Documents can ask to be placed on a free priority announcement list. Write to Superintendent of Documents, Mail Stop: SSOM, Washington, DC 20402 and ask to be placed on Priority Announcement List N–516.

Finally, during the first quarter of 1995 the Johns Hopkins University Press will publish in its "New Series in NASA History" an administrative biography of NASA's administrator during the Apollo era. Written by W. Henry Lambright of Syracuse University, *Powering Apollo: James E. Webb of NASA* emphasizes the leadership style and method of management Webb brought to complex organizational issues. We will be sure to announce the availability of these books as they appear.

### NASA HISTORICAL DATA BOOK FOR 1979–1988 PLANNED

Periodically the NASA History Office has issued the *NASA Historical Data Book* containing mostly tabular information on NASA activities. To date, four volumes have been published, the most recent of which was Ihor Y. Gawdiak with Helen Fedor, *NASA Historical Data Book, Vol. IV: NASA Resources, 1969–1978* (NASA SP–4012, 1994). Pending the availability of funding, we anticipate contracting for a fifth volume of the work in fiscal year 1995. This volume would include information on programs, projects, and resources for the period, 1979–1988. We are still in the planning stage for this project, and this notice represents the first public statement about it. Anyone who might have an interest in compiling this work is invited to contact Roger D. Launius, NASA History Office, Code ICH, NASA Headquarters, Washington, DC 20546, telephone 202–358–0383, or at rlaunius@codei.hq.nasa.gov for more information. No firm date for release of a research announcement has yet been established.

### NASA HISTORICAL WORKS PRESENTLY UNDERWAY

At present, the NASA History Office

has 26 active book projects in various stages of completion. A schedule of books that are scheduled to appear in the NASA History Series within the next 24 months, exclusive of those already mentioned, include:

Butrica, Andrew J. *To See the Unseen: A History of American Planetary Radar Astronomy, 1946–1991* (NASA SP–4218, 1995).

Gruen, Adam L. *The Port Unknown: A History of the Space Station Freedom Program* (NASA SP–4217, 1995).

Dunar, Andrew J., and Waring, Stephen P. *A History of the Marshall Space Flight Center, 1960–1990* (NASA SP–4310, 1996).

Gawdiak, Ihor Y. Compiler. *Astronautics and Aeronautics, 1986–1990: Chronology of Science, Technology, and Policy* (NASA SP–4027, 1996).

Logsdon, John M. Editor. *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume II, Relations with Other Organizations* (NASA SP–4407, 1996).

The actual publication of these books will be announced in this newsletter well in advance of their appearance. Stay tuned for further information on these and other forthcoming books.

## HOW TO COLLECT HARD TO FIND NASA HISTORIES

Several people have recently asked us for a list of the more than 60 books published in the NASA History Series throughout the history of the agency. Because of this request we have compiled a complete list, which is available for the asking from the NASA History Office, Code ICH, NASA Headquarters, Washington, DC 20546 or via e-mail from history@ codei.hq.nasa.gov. That question is immediately followed by another, where copies of the books can be purchased. Unfortunately, most of the early publications are now out of print, and can only be obtained in photocopy form, but here is a list of currently available books in the NASA History Series:

**Reference Works, NASA SP–4000:**

Newkirk, Roland W., and Ertel, Ivan D., with Brooks, Courtney G. *Skylab: A Chronology.* (NASA SP–4011, 1977). Cost: $42.95

Van Nimmen, Jane, and Bruno, Leonard C., with Rosholt, Robert L. *NASA Historical Data Book, Vol. I: NASA Resources, 1958–1968.* (NASA SP–4012, 1976, rep. ed. 1988). Cost: $19.00

Ezell, Linda Neuman. *NASA Historical Data Book, Vol II: Programs and Projects, 1958–1968.* (NASA SP–4012, 1988). Cost: $19.00

Ezell, Linda Neuman. *NASA Historical Data Book, Vol. III: Programs and Projects, 1969–1978.* (NASA SP–4012, 1988). Cost: $19.00

Set of three NASA Historical Data Books. Cost: $55.00

*Astronautics and Aeronautics, 1976: Chronology of Science, Technology, and Policy.* (NASA SP–4021, 1984). Cost: $10.50

*Astronautics and Aeronautics, 1977: Chronology of Science, Technology, and Policy.* (NASA SP–4022, 1986). Cost: $10.50

*Astronautics and Aeronautics, 1978: Chronology of Science, Technology, and Policy.* (NASA SP–4023, 1986). Cost: $11.50

*Astronautics and Aeronautics, 1979–1984: Chronology of Science, Technology, and Policy.* (NASA SP–4024, 1988). Cost: $11.50

*Astronautics and Aeronautics, 1985: Chronology of Science, Technology, and Policy.* (NASA SP–4025, 1990). Cost: $12.50

Gawdiak, Ihor Y. Compiler. *NASA Historical Data Book, Vol. IV: NASA Resources, 1969–1978.* (NASA SP–4012, 1994). Cost: $28.00

**Management Histories, NASA SP–4100:**

Roland, Alex. Model Research: *The National Advisory Committee for Aeronautics, 1915–1958.* (NASA SP–4103, 1985). Cost: $32.00

Fries, Sylvia D. *NASA Engineers and the Age of Apollo.* (NASA SP–4104, 1992). Cost: $15.00

Glennan, T. Keith. *The Birth of NASA: The Diary of T. Keith Glennan,* edited by J.D. Hunley. (NASA SP–4105, 1993). Cost: $24.00

**Project Histories, NASA SP–4200:**

Newell, Homer E. *Beyond the Atmosphere: Early Years of Space Science.* (NASASP–4211, 1980). Cost: $15.00

Pitts, John A. *The Human Factor: Biomedicine in the Manned Space Program to 1980.* (NASA SP–4213, 1985). Cost: $19.00

Compton, W. David. *Where No Man Has Gone Before: A History of Apollo Lunar Exploration Missions.* (NASA SP–4214, 1989). Cost: $19.00

Naugle, John E. *First Among Equals: The Selection of NASA Space Science Experiments.* (NASA SP–4215, 1991). Cost: $8.00

Wallace, Lane E. *Airborne Trailblazer: Two Decades with NASA Langley's Boeing 737 Flying Laboratory.* (NASA SP–4216, 1994). Cost: $27.00

**Center Histories, NASA SP–4300:**

Hallion, Richard P. *On the Frontier: Flight Research at Dryden, 1946–1981.* (NASA SP–4303, 1984). Cost: $18.00

Muenger, Elizabeth A. *Searching the Horizon: A History of Ames Research Center, 1940–1976.* (NASA SP–4304, 1985). Cost: $13.00

Hansen, James R. *Engineer in Charge: A History of the Langley Aeronautical Laboratory, 1917–1958.* (NASA SP–4305, 1987). Cost: $30.00

Dawson, Virginia P. *Engines and Innovation: Lewis Laboratory and American Propulsion Technology.* (NASA SP–4306, 1991). Cost: $16.00

Dethloff, Henry C. *"Suddenly Tomorrow Came...": A History of the Johnson Space Center, 1957–1990.* (NASA SP–4307, 1993). Cost: $28.00

**General Histories, NASA SP–4400:**

Bilstein, Roger E. *Orders of Magnitude: A History of the NACA and NASA, 1915–1990* (NASA SP–4406, 1989). Cost: $16.00

The books in the NASA History Series listed above are available from the NASA Information Center. Contact the office at NASA Information Center, Code JOB–19, NASA Headquarters, Washington, DC 20546, or by telephone at 202–358–0000. Order by SP number. All orders should be prepaid. There are sometimes limited numbers of these books, but those listed here are currently available.

## WHAT IS THE FUTURE OF AEROSPACE HISTORY?

This is a question not without import, and one that has been discussed at length in a variety of places over the last several years. There is no consensus for this debate. We would like to encourage those working in the field to ruminate on this central question and to address it in this and other forums. Thoughtful and provocative responses to the direction of the discipline are most welcome and would provide perspective from which to plan future historical research projects for NASA and for other aspects of the aerospace history. What are the holes in the field, where are the opportunities for research, how can historians exploit new concepts and ideas to prepare challenging historical works, etc.? Your comments are welcome, both for publication in this newsletter and for discussion by the wider community of scholars. Please, let us hear from you. We can be reached at the NASA History Office, Code ICH, NASA Headquarters, Washington, DC 20546, telephone 202–358–0383, or at history@codei.hq.nasa.gov.

## AIAA HISTORY MANUSCRIPT AWARD ANNOUNCED

The history manuscript awards committee of the American Institute for Aeronautics and Astronautics has announced that Michael J. Neufeld, Curator, Aeronautics Department, National Air and Space Museum has received the

1994 history manuscript award for his study, *The Rocket and the Reich: Peenemünde and the German Army Guided Missile Program*. This manuscript is the basis for the Neufeld's book *The Rocket and the Reich* now available from the Free Press, NY (see Book Reviews).

### COMMENTS ON A CHALLENGING ARTICLE

Readers who are interested in social science theory, ecology, or the history of biology and sociobiology may want to consult the first half of Brett Fairbairn's "History from the Ecological Perspective: Gaia Theory and the Problem of Cooperation in Turn–of–the–Century Germany," *American Historical Review*, 99 (October 1994): 1203–39. He discusses the origins of the controversial Gaia theory in a contract between NASA and British scientist and inventor James Lovelock, calling for him to assist in the search for life on Mars in the 1960s.

Asking himself how to determine from a distance whether a planet bears life, Lovelock imagined Earth from space and decided that its active atmosphere with "a striking blend of gases as contradictory as oxygen and methane" showed clear signs of life, as contrasted with the essentially inert atmospheres of Mars and Venus. From there, aided by American microbiologist Lynn Margulis, he evolved the Gaia theory, denied by conventional evolutionary scientists and sociobiologists, that posits a more benevolent and cooperative natural procession Earth than is fully compatible with "'selfish' Darwinian selection."

According to Lovelock and Margulis, some environmental effects produced by the evolution of individual species benefit rather than harm other species, appearing to be altruistic rather than "red in tooth and claw." Fairbairn goes on to apply the Gaia concept to the history of cooperatives in Germany, and conceivably it can serve as a theoretical tool for other kinds of historical and sociological investigations.

### 1994–1995 FELLOW IN AEROSPACE HISTORY NAMED

Erik P. Rau is the ninth annual recipient of the Fellowship in Aerospace History. The fellowship, sponsored by the NASA History Office and administered by the American Historical Association in cooperation with the Economic History Association, the History of Science Society, and the Society for the History of Technology, is awarded in an annual competition by a joint committee of representatives from each organization.

Mr. Rau is a doctoral candidate in the Department of History and Sociology of Science at the University of Pennsylvania, where he is completing his dissertation under Thomas P. Hughes. During his fellowship period, he will be working on his dissertation, "From the Endless Frontier to the Final Frontier: The Promise and Practice of Systems Management through the Age of Apollo, 1958-1969."

Mr. Rau notes that his work explores R&D management at NASA. Specifically, he examines its emergence through debates over government participation in R&D and the consequences of the NASA model for R&D management practices in general. Project Apollo, he contends, conferred enormous prestige upon NASA. The agency became a paradigm of effective government investment in industrial R&D. Its systems management approach seemed capable of surmounting all obstacles, realizing all aspirations, and opening new frontiers. Americans reached both upward and outward, as systems management became incorporated into the Great Society programs as the means to deploy expertise toward resolving not only technical but also social problems, such as poverty. Nevertheless, he finds that R&D issues raised during the postwar era remain far from resolved. Many of the social programs had disappointing results, and cutbacks and problems at NASA have deepened public suspicion of the government's role in such activities; meanwhile, the Clinton administration promotes a high-technology industrial policy supported by federally initiated R&D programs.

Mr. Rau's study offers important possibilities for historians of science and technology. He would welcome observations and suggestions about this research project, and can be reached in care of the NASA History Office, Code ICH, NASA Headquarters, Washington, DC 20546. He is also on–line and can be contracted directly via the internet at erau@sas.upenn.edu.

### FELLOWSHIP AND GRANT OPPORTUNITIES

The Australian National University invites applications for visiting fellowships in the Humanities Research Centre in 1996. Each year the Centre concentrates upon a special theme. In 1996 the theme will be "Culture and Science." For further information contact the Centre Administrator, Humanities Research Centre, The Australian National University, Canberra, ACT, 0200, Australia. Fax (06)248 0054, e–mail: Leena.Messina@anu.edu.au.

The Department of History, Philosophy and Communication of Science, University College, London, has a three–year post-doctoral researcher position available in the history of science. For further details, contact Jon Turney, Department of History, Philosophy and Communication of Science, University College, London. e-mail: j.turney@ucl.ac.uk.

A one–year post-doctoral position is available at the Center for History of Electrical Engineering beginning September 1995, with the expectation of two one-year renewals. The Postdoc will teach one undergraduate course per year on the history of technology, medicine, and science. The main responsibility will be to work on one of the Center's research projects. For more information contact Postdoc Search, CHEE, Rutgers University, 39 Union Street, New Brunswick, NJ 08903.

### UPCOMING MEETINGS

The Society for History in the Federal Government will hold its annual meeting in College Park, MD, on March 28–29, 1995. For information contact SHFG, P.O. Box 14139, Benjamin Franklin Station, Washington, DC 20044.

The Organization of American Historians annual meeting will be held in Washington, DC, on March 30–April 2, 1995. For information contact OAH, 112 North Bryan St., Bloomington, IN 47408–4199.

### NEW BOOKS OF INTEREST TO AEROSPACE HISTORIANS

Levine, Alan J. *The Missile and Space Race* (Praeger, 1994).

Lovell, Jim, and Kluger, Jeffrey. *Lost Moon: The Perilous Voyage of Apollo 13* (Houghton Mifflin Co., 1994). A motion picture directed by Ron Howard and starring Tom Hanks is presently in production based on this book.

Nichols, Nichelle. *Beyond Uhura: Star Trek and Other Memories* (Putnam, 1994).

Petry, Michael John. Editor. *Hegel and Newtonianism* (Kluwer Academic Publishers, 1993).

Reston, James, Jr. *Galileo: A Life* (HarperCollins Publishers, 1994).

Rotundo, Louis. *Into the Unknown: The X–1 Story* (Smithsonian Institution Press, 1994).

Sharman, Helen, and Priest, Christopher. *Seize the Moment* (Victor Gollancz, 1994), about the journalist who flew aboard a Soyuz spacecraft and spent one week aboard the Mir space station in May 1991.

Sharratt, Michael. Galileo: *Decisive Innovator* (Blackwell, 1994). ●

# QUEST

## BACK ISSUES AVAILABLE FOR PURCHASE

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*They Might Be Giants—A History of Project Nova 1959-1964 Part III*; *The Russian Space Support Fleet—A Sad End*; *The Lockheed CL-635*; *Mothballed Potential*—Energia & Buran; *A Pioneer of Space: Georgi Grechko's Story*; *All Suited Up and No Place to Go*—Soviet lunar EVA suit; *More Data on the Soviet Manned Lunar Program; U.S. and Soviet Manned Lunar Landing Projects*; *Scuds for Science: The V-11-A*; *Unique Atlas-Agena Configurations.*

☐ **Vol. 2 No. 3 Fall 1993**
*Land Landings for Gemini*—NASA's Paraglider Program; *The 1963 Soviet Space Platform Project*; *The Right Stuff, The Wrong Story*—A "Hollywood History" blurs the truth behind America's second manned spaceflight; *Semyorka Family Values*; *The Hunt for Liberty Bell 7*; *ALSO: Air-Launched Sounding Rocket*; *The Anonymous Atlas H.*

☐ **Vol. 2 No. 4 Winter 1993**
*A Survey of Surveyor*—A look back at America's robotic lunar landing program; *Money Talks in Russia*; *Mercury Atlas 10: A Mission Note Flown*; *The Russian Space Auction at Sothebys in New York*; *The Viking Rocket: Filling the Gap*; *Soviet Manned Lunar Programs*; *Bye, Bye, Buran*—Soviet Shuttle made into amusement park ride.

☐ **Vol. 3 No. 1 Spring 1994**
*The X-15 Spaceplane*; *X-15 Flight Log*; *Test Pilot Elite*—An interview with Milt Thompson; *The X-15 Experience*—Milt Thompson talks about flying the X-15; *In Search of X-15 No. 3*; *Thirtysomething Vostok...*; *A History of Air-Launched Space Vehicles*; *Three Saturn Vs*—A look at the remaining Saturn V hardware; *Poland's Meteor Sounding Rockets*; *The NOTSNIK Program*—The top secret air-launched satellite attempts of 1958.

☐ **Vol. 3 No. 2&3 Summer/Fall 1994 (SPECIAL DOUBLE ISSUE)**
*Apollo 11 at 25*; *"It's Time to Go;" A Salute to Apollo*; *Spider Talk—Builders of the LM Reunite for 25th Anniversary*; *Project Apollo Bibliography of Books; A Race to the Moon: The Flight of Luna 15; Moon Shooter: An Interview with Alan Shepard; Atlas Shrugged: Future of Historic Monument Up in the Air; The German Space Pioneers: An Interview with Marsha Freeman; Project Adam: The Army's Man in Space Program; Moon Men: An Interview with Andrew Chaikin author of "A Man on the Moon: The Voyages of the Apollo Astronauts;" Footprints on the Moon: An Interview with Charlie Duke: Celebrating Apollo at Home: A Look at the Various Model Kits Produced of the Saturn V; The Secret Life of the Redstone Missile.* **NOTE: Because this is a special Double Issue of 80 pages in size, it is priced at $10.**

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# ROCKETS RED GLARE

Joel W. Powell

## Launch vehicles and their role in the history of spaceflight

## Dyna-Soar and the Development of the Titan III Launch Vehicle

In 1957, the United States Air Force embarked upon a project to develop the X-20 "Dyna-Soar," a piloted, winged space plane for military applications that was many years ahead of its time. The program was cancelled before any test flights could be conducted but the Dyna-Soar did leave behind a legacy that is still in use today: the Titan IV launch vehicle, a direct descendent of the Titan IIIC rocket originally designed for the X-20.

The Air Research and Development Command (ARDC) at the Pentagon issued a directive for development of a reusable military manned space vehicle in November 1957. In June 1958 the Boeing and Martin Companies were chosen to compete for the contract to build Dyna-Soar. The ARDC directive followed several years of studies to build Dyna-Soar. The ARDC directive vehicle concepts such as Bomi, Brass Bell and HYWARDS.

Boeing teamed up with General Dynamics (Convair) to offer the projected Atlas-Centaur booster for Dyna-Soar, while Martin proposed to use the Titan I ICBM (which was still under development) to launch their own booster-glider design. Martin planned to use a series 'A' Titan I for suborbital flights and a series 'C' vehicle for orbital missions. When the Air Force finally signed the Dyna-Soar contract on December 11, 1959, Boeing was selected to build the spacecraft and Martin was directed to supply the Titan launch vehicles. Dyna-Soar was officially known as System 620A (the X-20 designation was not introduced until 1962).

Titan I remained Dyna-Soar's launch vehicle while ARDC and Boeing completed the "Phase Alpha" design review in 1959 and 1960, but the ICBM was clearly marginal for the job of carrying Dyna-Soar on its suborbital test flights. The Air Force contemplated turning to the as-yet-unflown Titan II launch vehicle for Dyna-Soar, and on January 21, 1961, the switch was made to the more powerful Martin missile which was at least a year from its maiden launch.

In order to accommodate the delta-winged space plane, three large 15-foot fins were added to the base of the Titan II's first stage to provide extra stability during ascent. The previous Titan I design also had large fins for stability with the unwieldy payload on top.

Dyna-Soar's "Step I" suborbital tests were intended to land on the airstrip at Fortaleza, Brazil, a distance of about 3,600 statute miles downrange from Launch Complex 20 at Cape Canaveral. The suborbital glider was projected to weigh between 6,570 and 9,410 pounds. The original suborbital test series was expanded in April 1961 to include single-orbit forays from Cape Canaveral to Edwards Air Force Base beginning in April 1966. These Step IIA flights would last for 107 minutes from liftoff to touchdown. A multi-orbit capability was expected to be available in October 1967.

Titan II did not remain the Dyna-Soar booster for very long. In May 1961, Boeing proposed dropping the Step I suborbital tests to speed up Dyna-Soar development. The "Operation Streamline" proposal also recommended using NASA's Saturn C-1 booster for orbital flights. The Air Force concurred that changes were necessary and produced its own recommendations for a new launch vehicle. There were three candidates: a modified Saturn C-1, a Titan II with an advanced cryogenic upper stage and a new design called SOLTAN (Solid Titan), a standard two-stage Titan II with twin 100-inch diameter solid rocket boosters. Only the solid motors would be ignited at liftoff and the Titan II core-stage motors would not be started until just before solid motor burnout.

In October 1961, the Air Force once again reprogrammed Dyna-Soar, adopting the SOLTAN booster and increasing the diameter of the 85-foot long solid motors to 120 inches. SOLTAN also received a new name: Titan III. The Air Force declared that Titan III (System 624A) would become their standard launch vehicle for heavy payloads. Just two months after choosing Titan III as the new Dyna-Soar launcher, the Air Force revamped the master plan one more time. The Step I suborbital tests were cancelled outright and the program was directed to fly multi-orbit flights with an upgraded Titan IIIC booster.

A third stage was added to the two existing core stages of Titan III to produce the new 'IIIC' configuration. The "Transtage" was a liquid propellant system that ended up flying with the Titan III family for many years. Titan IIIC, also known as Standard Launch Vehicle 5C (SLV-5C), could lift nearly 25,000 pounds to Low Earth Orbit (LEO) with Transtage, but was limited to 21,000 pounds when carrying Dyna-Soar. This total included the spacecraft, transition section and the big Thiokol XM-92 solid escape motor which would also be used for orbital insertion on single-orbit flights. For the longer orbital missions, Transtage would remain attached to the X-20 and would be used for the de-orbit burn.

A series of eight piloted single-orbit tests were scheduled to begin in November 1965, according to the December 1961 operational plan. The Dyna-Soar Program Office added multi-orbit flights to the schedule in May 1962, commencing with the fifth or sixth manned orbital flight. The Titan IIIC, standing 152 feet tall with the X-20 glider, was intended to operate from Launch Complex 40 at the Cape.

After Titan IIIC was formally approved by Congress in October 1962, debate intensified at the Pentagon as to the military justification for Dyna-Soar, and rumors of its impending cancellation began to surface in early 1963. In September of 1963, the final program restructuring was announced, with the first piloted Dyna-Soar flight slipping to July 1966 (after unmanned test flights in January and April). The first multi-orbit mission was delayed until the ninth Titan IIIC development flight in December 1967. The initial test flights of Dyna-Soar would be air-launches from a B-52C carrier aircraft (much like the X-15 program), scheduled to begin in May 1965.

In October 1963, the Kennedy administration asked the Defense Department to justify Dyna-Soar development, which instead resulted in a recommendation to cancel the program from the offices of the Secretary of Defense and Secretary for Research and Engineering. The inevitable occurred on December 10, 1963 when Secretary of Defense Robert McNamara announced the demise of the program. In its place, the Manned Orbiting Laboratory (MOL) was established to determine man's role in military space research. MOL was to utilize a modified version of Dyna-Soar's booster called the Titan IIIM. MOL was itself cancelled in June 1969 before any flights could take place.

An unmanned lifting body test project called ASSET (Aerothermodynamic/elastic Structural Systems Environmental Tests) was the only remnant of Dyna-Soar to survive the cancellation order that so devastated Boeing in Seattle. Six sub-scale ASSET gliders, which somewhat resembled Dyna-Soar, were tested on suborbital trajectories at Cape Canaveral from 1963 to 1965.

In the end, the greatest legacy of the Dyna-Soar program was the Titan IIIC booster. Titan IIIC remained in service from 1965-1979 and the upgraded Titan 34D version was flown until 1989. The heavy-lift Titan IV rocket, direct descendent of Dyna-Soar's Titan IIIC booster is still the premiere space launch vehicle for the U.S. Air Force today. ●

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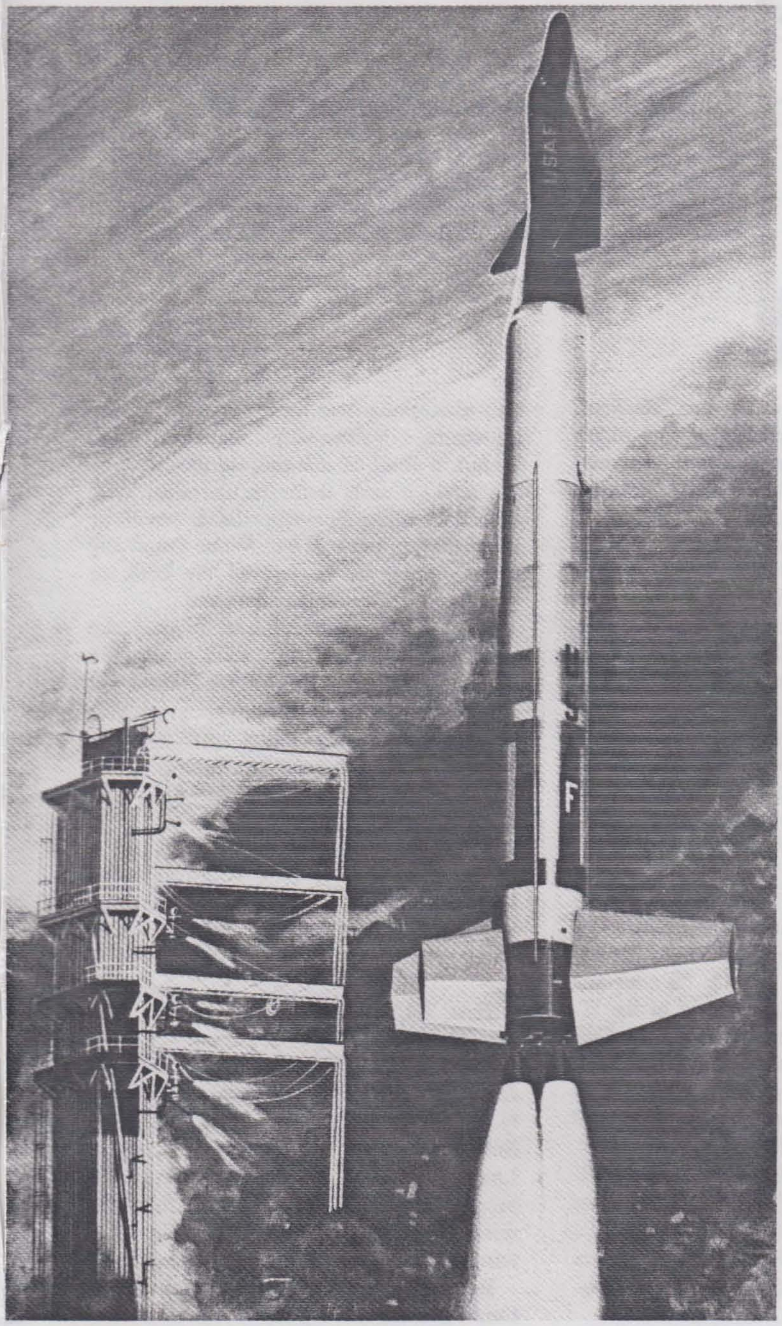
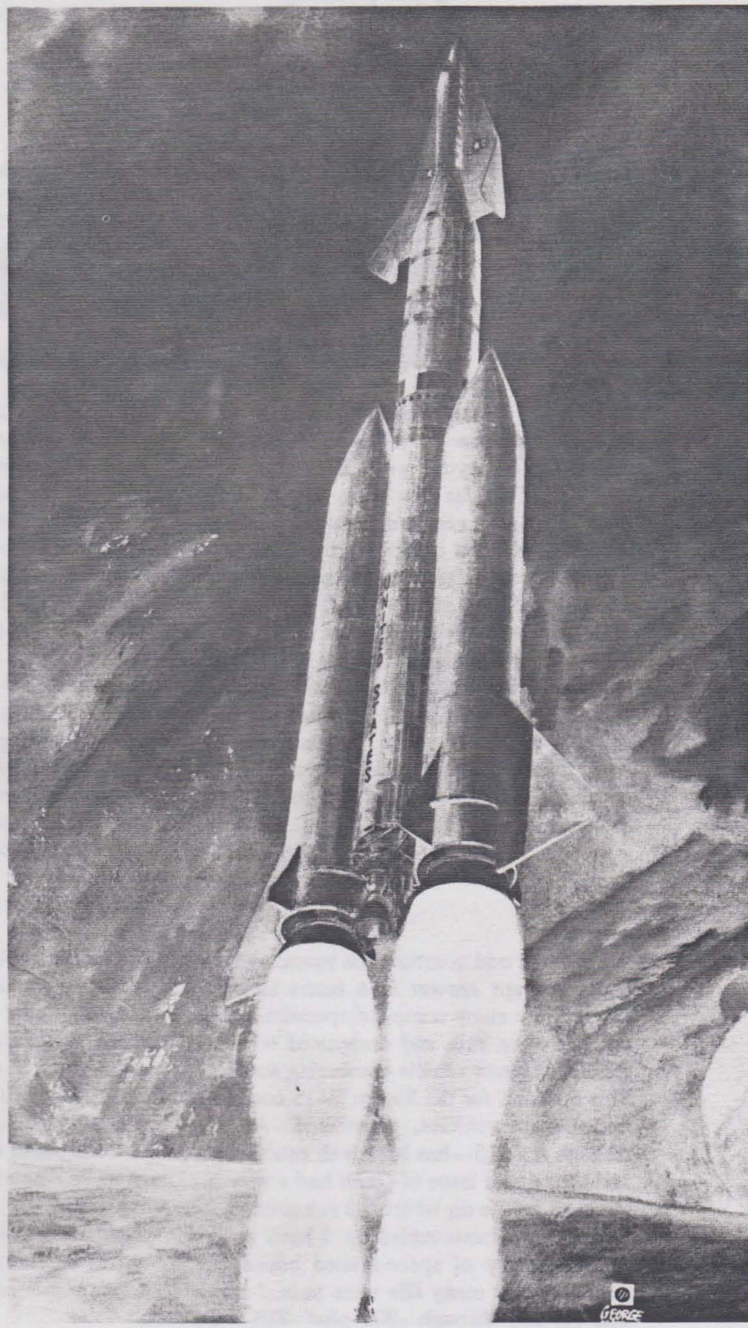


At one time or another, virtually every U.S. launch vehicle had been studied for use with the Dyna-Soar Project. Above Left: Artist rendering showing the X-20 Dyna-Soar being launched by a modified Titan II ICBM. Note the prominent fins added for extra stability during ascent. Earlier proposed was a Titan I design which also incorporated similar stabilizing fins in its first stage. These early sub-orbital concepts were eventually replaced by the more powerful Titan IIIC booster as shown in the artist configuration at right. This configuration would increase the vehicle's payload capabilities and allow Dyna-Soar to fly multi-orbit flights. Photos Courtesy Don Pealer and USAF.

**Titan IIIC Final Specifications**

| | |
|---|---|
| Height with X-20 | 152 ft. |
| Total Weight at Liftoff | 1,365,245 lbs. |
| Booster Diameter | 10 ft. |
| Total Booster Thrust | 2,360,000 lbft. |
| 1st Stage (core) Diameter | 10 ft. |
| 1st Stage Thrust | 532,000 lbft. |
| 2nd Stage (core) Diameter | 10 ft. |
| 2nd Stage Thrust | 101,000 lbft. |
| Transtage Diameter | 10 ft. |
| Transtage Thrust | 16,000 lbft. |
| X-20 Escape Motor Thrust (in transition section) | 40,500 lbft. |

**Dyna-Soar Final Specifications**

| | |
|---|---|
| Length | 35.3 ft. |
| Span | 20.4 ft. |
| Fuselage Diameter | 5.7 ft. |
| All-up Weight | 11,390 lbs. |
| Crew | Pilot (1) |
| Payload Capability | 1,000 lbs. |


# LETTERS

Enclosed is my renewal for another year of *Quest* magazine. I just wanted to let you know I'm enjoying your magazine very much and I like its new look. Maybe in the near future, we can look forward to color! Also, I purchased a copy of the "Saturn V Flight Manual" after reading the article about it in the last issue. Wow! What a find that was! A real gold mine of information. At one time I worked part-time at our main branch library and I had access to all the spaceflight Government Documents stored in the non-public areas. I didn't see this book there. Keep unusual articles like that coming. Your "Resources" column is very informative.

— Ted J. Marsowicz, Jr.
Buffalo, NY

I have an odd question that someone there could perhaps answer in a future issue of *Quest*. How many complete operational Saturn IBs were built and designated with the AS-2XX launch vehicle numbering scheme? This question for the Saturn V–15 complete operational vehicles, numbered AS-501 through AS-515—has been well established, and the sample issue of *Quest* had a very interesting article on where the remaining Saturn V components ended up. I have an extensive library of space-related books, but none tell how many IBs were built. I know that AS-201 through -208 plus -210 were launched, with -209 on display at Cape Canaveral. David Baker's huge book *The History of Manned Space Flight* mentions that AS-212 was originally intended for use as the "wet" space station that became Skylab and was later launched "dry" on a Saturn V (basically AS-513) instead. Obviously, -211 and -212 were built. Were there any more beyond the 12th IB?

— Edwin Krampitz, Jr.
Drewryville, VA

*Response:*

*In response to Mr. Krampitz's letter. The short answer is fourteen Saturn IBs were built according to "Stages to Saturn" (p. 349): SA 201-214. Mr. Krampitz correctly notes that SA-201 through SA-208 were launched plus 210 for ASTP and that SA-209, the ASTP backup, is now on display at KSC. SA-213 and SA-214 were "declared surplus, stripped and placed on lot" at the Michoud Assembly Facility which presumably means scrapped in plain English ("Stages to Saturn" p. 439). As of June 5, 1975, SA-211's S-IB stage was located at Michoud and its S-IVB stage was located at KSC. For SA-212, its S-IB stage was located at KSC and its S-IVB stage had been converted into the Skylab Workshop. Now there is a Saturn IB on display on I-65 north of Huntsville. It is possible that it is one of the two missing flight articles but I have no confirmation of which one it might be. I also have no confirmation of what became of the last two Saturns that were "placed on lot" at Michoud. They could still be there somewhere, rusting away. The only other lead that I have on Saturn IB parts comes from Doug Rewinkel (rewinkel@epvax.msfc.nasa.gov) who via the Internet, confirmed that there is "a complete Saturn IB first stage laying next to the 'T-stand' in the East Test area at MSFC. This stage is also complete (includes engines, etc,)." In addition, some Saturn test stages including an S-IVB Battleship stage are still in a test stand in the East Test Area. Clearly, more research needs to be done in tracking down the last of the missing Saturn flight and ground test stages. Mike Wright's article accounted for the Saturn V stages on display, but some stages remain missing.*

*— Thomas J. Frieling*
*Bainbridge, GA*

I have just received the Spring 1994 issue of *Quest*. It's very impressive, but I must take issue with Mr. White's review of the "Cambridge Encyclopedia of Space." I recently borrowed this book from the local library and, while scanning through it, came across a disturbing error. I cannot quote the page because I do not have the book on hand, but at one point, there is a picture of a shuttle stack at the SLC at Vandenberg AFB. Under the picture, the caption indicates that *Enterprise* (apparently the orbiter in the photo) was launched from Vandenberg... it even gives an (incorrect) date.

While I realize that any publication may have minor mistakes, this particular error is fairly significant. Most of us are well aware that *Enterprise* was never launched from anywhere, Vandenberg included, and though it could be the only serious error in the book, it casts doubt on the other facts presented in the Encyclopedia. It would be interesting to know if Mr. White found any errors during his review of the book or whether it was an isolated incident.

Also, on an unrelated topic, I would like to congratulate the editor on his acquisition of another fine space magazine, *Countdown*. Along with *Quest*, it would seem to give CSPACE Press the ability to completely cover the "past, present and future" of the exploration of space. I look forward to future issues of both publications.

— Joshua Powers
Executive Director,
International Space Link

First, let me compliment you on your magazine, which helps fill a literary gap previously filled only by *Spaceflight* and the *Journal of the British Interplanetary Society*. I do notice a certain number of gremlins—for instance, the statement in Roger D. Launius' Summer '94 article on the Apollo program that Apollo 10 was an Earth-orbital mission—but I presume these will be filtered out with time.

Regarding Apollo, let me ask one question. I see that you've reprinted the one existing still photo of Neil Armstrong on the lunar surface taken by Buzz Aldrin, as uncovered in the pages of *Spaceflight*. Does anyone know whether there exist any color photos of the Surveyor-3 craft on the lunar surface taken by the Apollo 12 crew? Alan Bean, of course, burned out the color TV camera before it got a chance to see the Surveyor; and, as I understand it, on the second moonwalk, the crew completely forgot to switch over to color film for their closeup photos of Surveyor, as they were supposed to do. Thus, all the photos of Surveyor on the surface I've seen were black-and-white. On the first moonwalk, though, they did use color film and I wonder if they might have gotten at least one or two long-distance color shots of Surveyor (which was visible from the vicinity of the LM). Does anyone out there know?

— Bruce Moomaw
Cameron Park, CA

*Good question. I do recall reading post-flight reports on Apollo 12, specifically those that center upon the results of the Surveyor (i.e. hardware returned, etc.). The report that I remember viewing included all the photos taken of the EVAs to Surveyor and none of them were in color. However, I am sure there must exist long-distance photos taken from the vicinity of Intrepid looking out over Surveyor crater. How about readers? Has anyone else seen close-up color photos taken of Surveyor 3 during Apollo 12?*

*—GES*

I do disagree with Daniel Gauthier's speculation about the lunar mapping crew—Apollo 18. If Deke Slayton had been given a chance to assign that crew (*Deke gave up the crew assignment job in early 1972*), he would have stuck to the rotation, which means that two of the three candidates should have been Dick Gordon and Vance Brand.

Now, by the time the Apollo 18 assignments could be made several things happened: Brand had already been assigned as backup commander to AAP (Apollo Applications Program). I don't think there was any way to have him do both...especially since the ASTP mission was then on the books, and he would have a chance at that flight.

Further, Dick Gordon had already gone around the Moon. He retired from the Navy in January 1972 and left NASA to go into business. So, in spite of the rotation, I think you can eliminate Gordon-Brand. But, Joe Engle is available, having been passed over for Apollo 17. He has to be the first candidate for Apollo 18. Further, Deke himself was back on flight status as of March 1972. He told me he planned to assign himself as commander of the next available mission.

As for the third crew member, this would have been a good place for a scientist-astronaut. And Joe Allen had not only done a good job as the first "mission scientist" for Apollo 15, he was a particular favorite of Deke's and other managers at NASA.

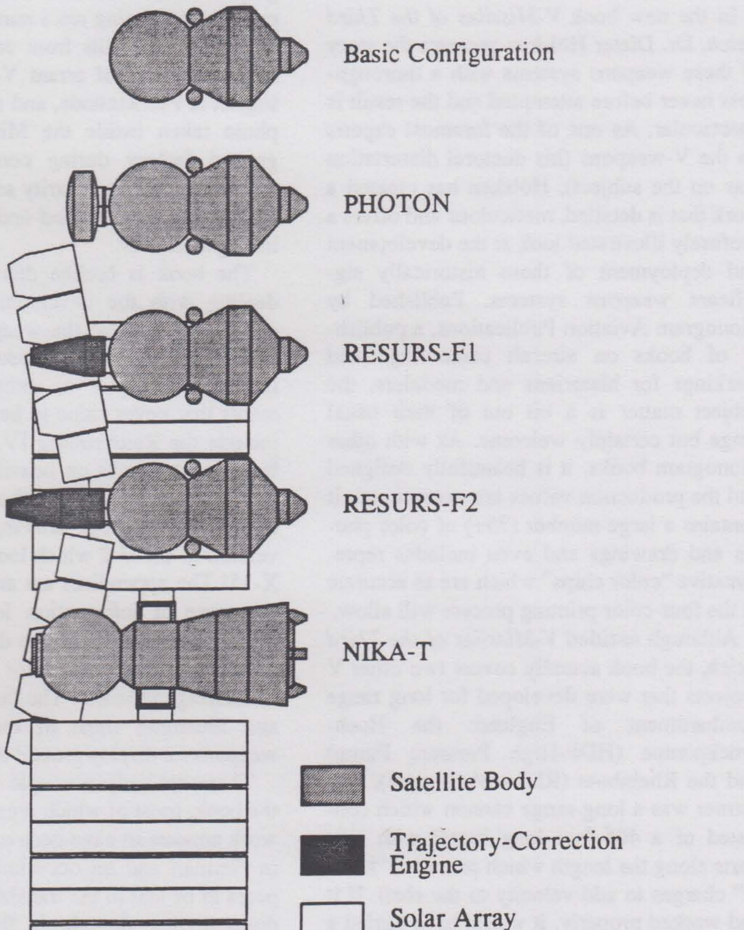
So I think the crew would have been Slayton-Engle-Allen. (It's all rookies, but so what? There is no lunar landing involved). The backup commander could have been Cernan and the backup scientist Schmitt. (They would just be coming off Apollo 17 and would save NASA the trouble and expense of training a whole new crew). The logical choice for Engle's backup would be Evans, come to think of it. (Meaning someone else would have to fill in the backup job on ASTP, but that could have been Weitz).

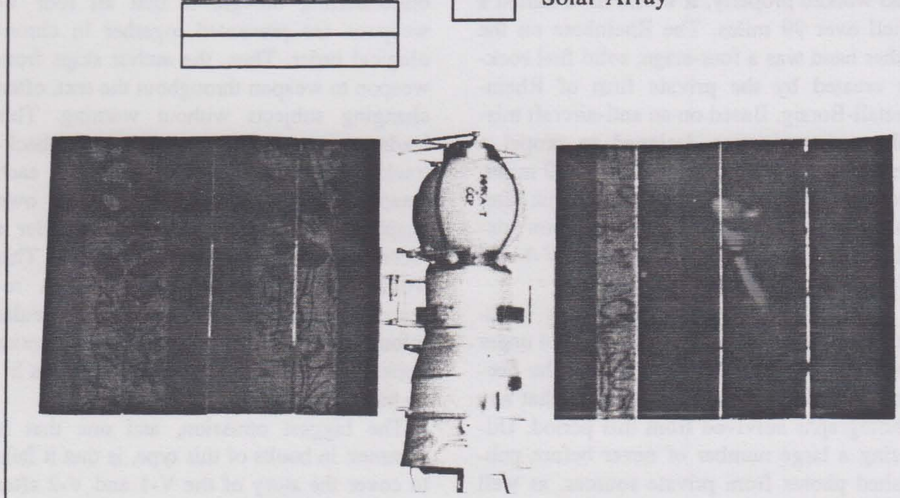
Anyway, this may be a bit torturous, but it's how those decisions got made.

—Michael Cassutt, co-author of *Deke*

Sir,

With great interest I read the article of Mr. Daniel James Gauthier, "That Thirtysomething Vostok..." (*Quest*, Spring 1994, p. 32). But I have one question concerning the separate maneuvering (trajectory-correction) engine. Some of the Vostok-derived photoreconnaissance satellites which are now offered for commercial use were presented at ILA '92 and '94 (see drawing below). The Photon and Resurs-F satellites have the same basic configuration: the old Vostok design which has been enlarged a little bit and uses now a "stretched" double cone instrument/engine module. Further equipment like a battery box or a maneuvering engine is separately attached to the spherical re-entry capsule. Nika-T has still such a Vostok re-entry capsule but the instrument/engine module is more Soyuz-like. In opposition to Mr. Gauthier's sketch, the ILA Nika-T model (see photo below) does not show a separate engine. Probably the deorbit and the maneuvering engine are combined in one engine as it has been done with the Soyuz spacecraft. I think that Nika-T and all other satellites with a Soyuz-like instrument/engine module do not need a separate maneuvering engine. So my question is, has Cosmos 1426 (Vostok 0) really both? — Carsten Wiedemann, Germany



by Stewart W. Bailey

They were balky, they were unreliable and they were deadly, yet they held promise for a future in which one of man's longest held dreams would come true. From them would spring both the terrors of nuclear ICBMs and cruise missiles and the benefits of satellites, space stations and interplanetary space travel. They were Nazi Germany's Vengeance weapons and from their humble beginnings they went on to pioneer technologies that would change the world.

In the new book *V-Missiles of the Third Reich*, Dr. Dieter Hölsken presents the story of these weapons systems with a thoroughness never before attempted and the result is spectacular. As one of the foremost experts on the V-weapons (his doctoral dissertation was on the subject), Hölsken has created a work that is detailed, meticulous and offers a profusely illustrated look at the development and deployment of these historically significant weapons systems. Published by Monogram Aviation Publications, a publisher of books on aircraft camouflage and markings for historians and modelers, the subject matter is a bit out of their usual range but certainly welcome. As with other Monogram books, it is beautifully designed and the production values are exceptional. It contains a large number (75+) of color photos and drawings and even includes representative "color chips" which are as accurate as the four-color printing process will allow.

Although entitled *V-Missiles of the Third Reich*, the book actually covers two other V projects that were developed for long range bombardment of England: the Hochdruckpumpe (HDP-High Pressure Pump) and the Rheinbote (Rhine Messenger). The former was a long-range cannon which consisted of a 405-foot long barrel with side ports along the length which provided "kicker" charges to add velocity to the shell. If it had worked properly, it would have hurled a shell over 99 miles. The Rheinbote on the other hand was a four-stage, solid fuel rocket created by the private firm of Rheinmetall-Borsig. Based on an anti-aircraft missile project, it was designed to propel a small warhead to ranges of up to 120 miles. Both projects were canceled sometime after the SS took control of V-weapon deployment, presumably because the V-1 and V-2 made them redundant.

As the author points out in his introduction, all of these projects were kept under extreme secrecy restrictions during the Second World War, and it is amazing that any photographs survived from this period. Utilizing a large number of never before published photos from private sources, as well

## V-Missiles of the Third Reich: The V-1 and V-2
### by Dieter Hölsken

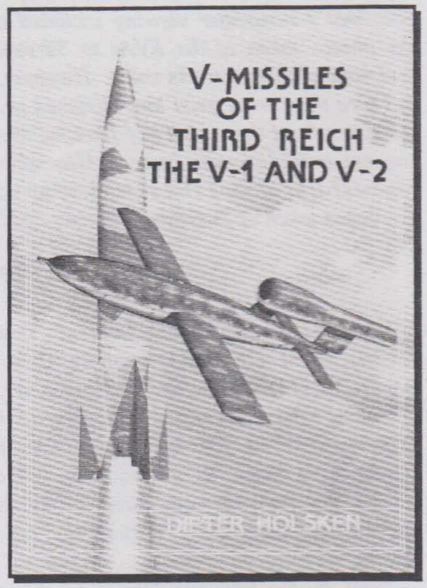
352 pp., hrdbd., 450+ photos and illustrations, $49.95. Published 1994 by Monogram Aviation Publications, P.O. 223, Sturbridge, MA 01566; PH: 1-800-826-6588.

as more famous archive shots, Hölsken was able to put together an incredible photographic record of these four weapons. Especially interesting are a number of rare color photos and stills from color movie film including those of errant V-2s returning to impact at Peenemünde, and an unusual color photo taken inside the Mittelwerk underground factory during construction. Also noteworthy for their rarity are other shots of V-1s being air-launched and V-2s suffering in-flight failures.

The book is broken down into sections dealing with the development, production and deployment of the weapons as well as one on Allied counter-measures and a rather interesting chapter on projected developments that never came to be. Some of these include the Reichenburg IV, a manned V-1 for suicide attacks on heavily defended targets (some did fly before the war's end) and even some concept drawings for a cruise version of the V-2 which looks a lot like the X-15! The appendices are an absolute treasure trove of information for modelers, as they contain details on the different variants of the missiles, and color illustrations of camouflage schemes. The last appendix lists and illustrates most of the surviving V-weapons on display around the world.

There are only a couple negatives about the book, most of which are minor. First, the work appears to have been originally written in German and on occasion something appears to be lost in the translation. A bit more disconcerting though, is that all four V-weapons are presented together in chronological order. Thus, the author skips from weapon to weapon throughout the text, often changing subjects without warning. This leads to some confusion and a lot of backtracking. It might have been better if each weapon's story was presented in its own chapter(s), which would give the reader a more coherent history of each project. This would also make it easier from a researcher's point of view, to find particular information without searching the entire book. (The index could also have been a little more complete.)

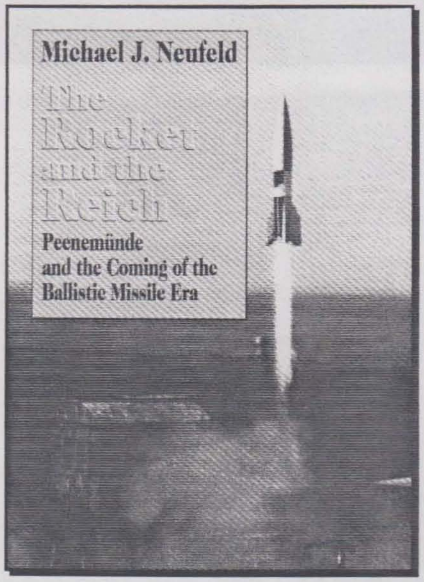
The biggest omission, and one that is common in books of this type, is that it fails to cover the story of the V-1 and V-2 after




the war. Although Hölsken does acknowledge the U.S. production of V-1 copies (the JB-2 Loon) and the launch of V-2s at White Sands, his coverage is limited to no more than a couple paragraphs or so. Granted, the book is about missiles of the Third Reich, but a lot of important research and experience was gained with these weapons after the war and its a shame that this part of their legacy was left incomplete.

Overall, however, this is an incredible study of Nazi Germany's Vengeance weapons and is a must-have volume for any serious enthusiast of missiles and early spaceflight technology. It is a bit expensive with a retail price of $49.95, but once over the "sticker shock," the quality of information and level of illustration will delight and amaze even the most hard-core rocket enthusiast. It is unlikely there will ever be another publication that can match the thorough coverage found in Dr. Hölsken's *V-Missiles of the Third Reich*. ●

*Editor's Note: I would like to add accolades to the above review and point out that this is the single best book that I have yet seen which covers solely the technological development of the V-weapons. As far as a pictorial history of the program, this book cannot be beat for its extensive photo content, many of which have never before been published and are beautifully reproduced. In defense of the price, it should be noted that this is a large, oversize coffee table hardbound volume measuring 12 1/4" x 9 3/8" x 1" in size and, as such, is well worth the price. One look through this book and readers will not be disappointed in its investment for their libraries... I guarantee it!*




## The Rocket and the Reich: Peenemünde and the Coming of the Ballistic Missile Era

**by Michael J. Neufeld**

368 pp., hrdbd., 30 photos $25.
Published 1995 by The Free Press, A Division of Simon & Schuster, Inc., New York, NY.

Never in the field of human conflict have so many paid so much, for so little. In paraphrasing a famous Winston Churchill speech, one can sum up the story of Germany's V-2 missile, a weapon which showed great promise, but for a variety of complex reasons failed to deliver during its short operational lifetime. In his new book *The Rocket and the Reich*, Michael J. Neufeld, Curator of World War II History for the Smithsonian's National Air and Space Museum, explores those reasons and examines how decisions involving the V-2 program had a significant impact on both the Allied and Axis causes in that war.

The story of the V-2 is fairly familiar to anyone who has studied rocketry, yet the story that Neufeld tells is far from a rehash of what has been written many times before. He states in the preface that his intention is to offer a balanced, readable history based on archival sources, rather than just memoirs and uncritical overviews that simplify the relationships between the scientists, soldiers and political leaders of the Third Reich. Using many previously unpublished documents, as well as archival files that had been misfiled for several decades, he looks closely at the pros and cons of what will always be a controversial weapons system.

For enthusiasts of rocketry and spaceflight this book may prove to be somewhat of a disappointment. While some sections deal with the technical difficulties which had to be solved in order to make the liquid fuel rocket work, the bulk of the book is devoted to the often ruthless political maneuvering that took place inside the German government with regard to the program. While extremely well researched and documented, the story is a bit dry and is probably of more interest to historians of the Nazi regime, as it paints a detailed picture of the struggles to control the project and what it cost the German economy. Although not a technical treatise on the V-2, *The Rocket and the Reich* is valuable as an insight into the mindset of the engineers, Army officers and Nazi leaders who created it and the impact of its development on the German state.

Neufeld begins, appropriately enough, with the early amateur rocket groups and the "space mania" that swept post-World War I Germany. Although not often publicized in other histories, these groups were driven "out of business" by the German Army, who looked upon the rocket as a potential weapon to circumvent restrictions put in place by the Treaty of Versailles. With the rise of National Socialism in the early 1930s, the Army was able to make use of the Party's secret police to take control of rocketry in Germany, intimidating the amateurs to either become part of the Army's program or be arrested. This control over the development of liquid fuel rockets would become an Army obsession for over a decade, often overriding common sense and good military doctrine.

The author goes on to examine how, under the leadership of General Walter Dornberger and the sponsorship of General Karl Becker, the Army's Ordinance Section was able to set up a research and development program built on a core of former amateurs under Wernher von Braun. Using their influence in re-arming Germany, they succeeded in pushing the idea of the missile as a long-range bombardment/terror weapon to the Nazi leadership, thus securing funds for the research and development center at Peenemünde.

From its founding in 1936 to its abandonment in May 1945, Peenemünde was more than just the center for liquid fuel rocket development; it was a center of political controversy. As Neufeld points out, the nature of the Nazi government was not that of a monolithic, totalitarian state as it's often portrayed, but rather many feuding bureaucracies, all of which wanted a piece of the Reich's resource pie. As one of the largest users of resources (both material and human) the rocket program at Peenemünde was the target of many factions in the government that wanted to either control it, diminish it or dismantle it. After the beginning of World War II, the Army's Ordinance section increasingly spent most of its time and efforts protecting the rocket program, often to the exclusion of other projects which might have had more impact on the course of the war. Eventually, their efforts came to naught as control of production and deployment was wrested away, first by the Armaments Ministry, then later by Heinrich Himmler's SS.

While these political battles form the basis of the work, *The Rocket and the Reich* also examines the darker spectre of the slave labor used to build the V-2. As the war's declining fortunes placed an ever larger drain on German manpower, prisoner labor became more and more important to the Reich's weapons production. Neufeld shows how slave labor was used to mass-produce the V-2, and how in the concentration camps supporting the Mittelwerk underground factory, the human death toll came to exceed that of people actually killed by V-2s fired in anger.

At the same time, there is an undercurrent attempting to connect von Braun and his development team with the tragedy of the concentration camps and slave labor. Although Neufeld finds no physical proof to implicate them directly in the practice, his study of archival records shows that von Braun and other scientists were aware of it, and allowed it to go on as a means to reach production quotas. Then again, to protest such policies in Nazi Germany was to flirt with imprisonment, torture and death, so it is doubtful that any of the scientists and engineers could have done much to avert the mass deaths which were tied to missile production. In essence, Neufeld concludes that von Braun "made a pact with the devil in order to build larger rockets."

In the end, *The Rocket and the Reich* is a lesson in the cost of misguided technological development, since the V-2 was a very costly failure. It cost the German economy as much, proportionally, as the Manhattan Project did the U.S., yet the results were ridiculously pathetic. The total explosive tonnage of all V-2s launched against enemy targets was less than that dropped by Allied bombers during any single large raid against a German city. Yet at the same time, the resources devoted to building the V-1 and V-2 Vengeance weapons, cost the equivalent of 24,000 fighter planes; planes which could have crippled or possibly stopped the Allied bombing campaign against the Reich. Ultimately, the V-2 did live up to its creators' claims as a weapon to shorten the war...but it did so in the Allies' favor. ●

*Stewart Bailey is a graphic designer and free-lance aviation writer/photographer whose work has appeared in "Quest" as well as "Air Classics," "Air Combat," "World Airpower Journal" and "Michigan Business." He is currently working on a book on the V-2 designed for scale modelers.*

## The year is 1962...
## The place is Cape Canaveral, Florida...
## The eyes of thousands turn skyward as a column of flame soars to the heavens...

## "All systems are A-OK!"

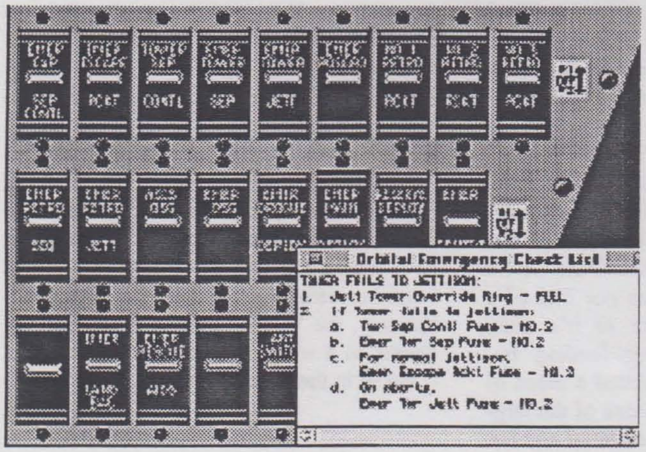
A-OK! The Wings of Mercury is the most realistic space simulation yet produced for a personal computer. *A-OK!* is not a game but a very realistic simulation of a Mercury-capsule for the Apple Macintosh series of computers, (a Windows version will be released in 1996 and a Power Mac version later this year). A-OK! accurately duplicates every switch inside a Mercury capsule. Add to this the digitized sound effects (launch, splashdown, thruster firings and verbal Capcom communications) and out-the-window graphics, make this program a real must for any would be John Glenn.

Those expecting a quick arcade game will be disappointed. The serious space enthusiast will love the realism and challenge of flying a Mercury spacecraft.

You can select two missions, a 15-minute suborbital mission or up to a 6-hour orbital mission in 3 modes (Easy, Average, Difficult). In the easy mode, or chimp mode, you are a passenger as the Mercury capsule performs all steps necessary for launch and recovery. The difficult mode requires you to perform every function an actual Mercury astronaut would do.

As the documentation explains, the Mercury capsule was not very user friendly! If you eventually master the operation of the Mercury spacecraft and seek an even greater challenge, the program is able to simulate failure scenarios in which you must decide to abort or stay with the mission and fix the problem. For example, let's say the capsule's timer fails to fire the retros on time. Can you hit the manual button at the right moment to avoid landing an additional 1,000 miles downrange? If the average or difficult mode is too challenging you can always sit back and enjoy the ride in chimp mode.

After mastering the many check-lists for an orbital mission, you will have the same level of know-how that the original seven astronauts needed to operate a Mercury capsule. I enjoyed the complete control panel of the Mercury spacecraft which was updated in version 2.0 to give a three-dimensional look. The panel is very realistic and accurately depicts all the details particular to John Glenn's Friendship 7 space capsule. I did miss the usual views of the outside of the vehicle which are standard with flight simulators. In addition, the control of the spacecraft using its attitude thrusters was difficult. The thrusters are fired by moving a joystick and I found it hard to judge at what point they would fire. Hopefully future versions of the program will improve upon these items.



The newest version (Version 2.0) was significantly slower than the earlier version 1.0 when run on my 030Powerbook 180. No significant speed difference was noted on my 040 equipped Quadra 605.

A possible future simulator of the Lunar Module is possible if *A-OK!* sells well. I recommend *A-OK!* for anyone who has a Mac and is interested in finding out whether if he or she has the right stuff. ●


**System Requirements:** Color Macintosh (68020 & up), 8 Meg RAM, 8.5 Meg disk space, System 7.x, Quicktime 1.6
**Recommended:** 68040 or PowerMac, 16 Meg RAM, Sound Manager 3.0, a joystick.

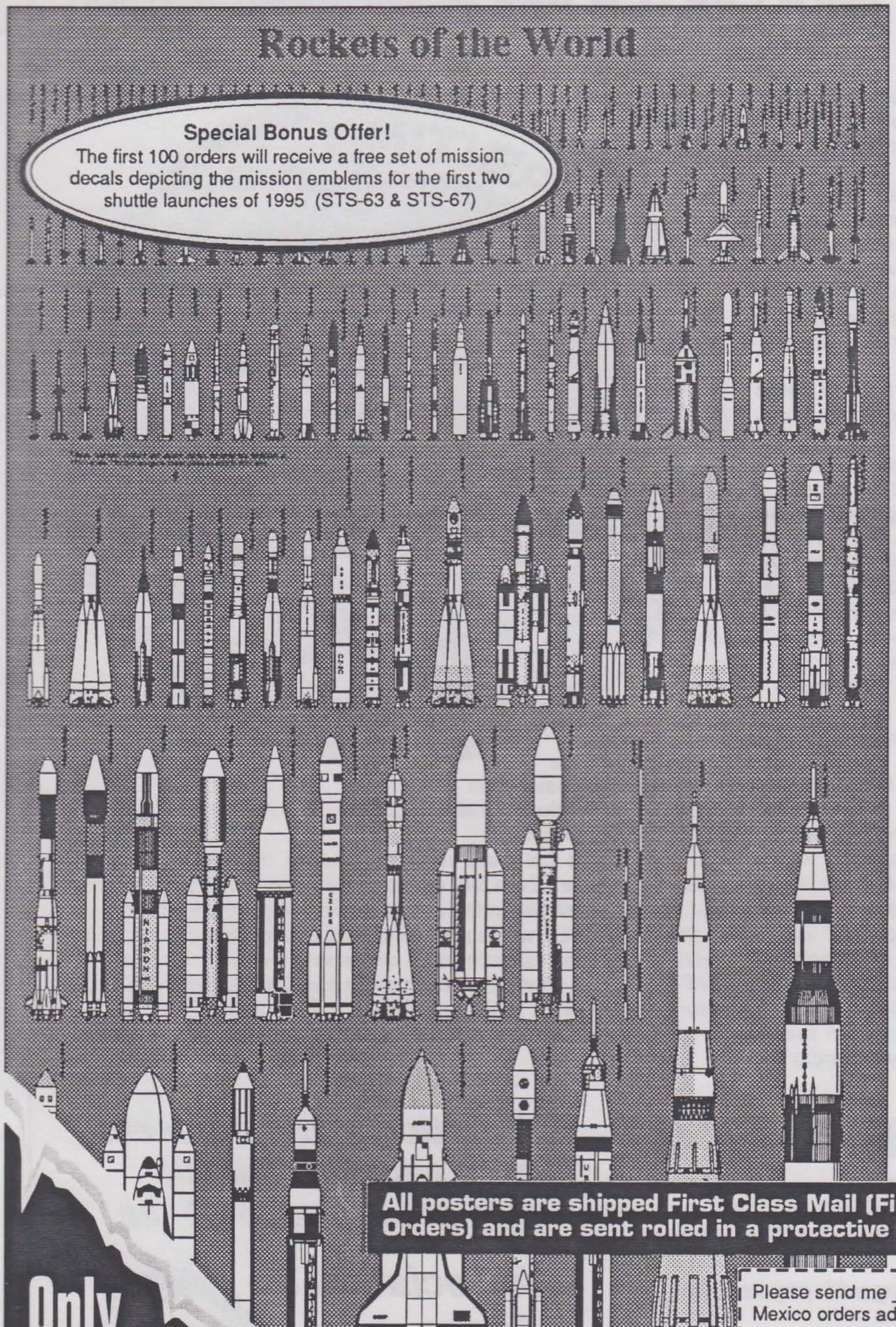
A-OK! is sold by Innovative Technologies! for $49.95 plus $3.95 for shipping and handling. Those owners of version 1.0 who wish to upgrade can do so for only $14.95 plus $3.95 shipping and handling. Visa/Mastercard accepted. New World Technologies can be reached at:

**Innovative Technologies**
**156 17th Avenue**
**Brick, NJ 08724-1814**
**PH: 1-800-977-2234**

# ROCKETS OF THE WORLD POSTER

**SPECIAL OFFER!**

**A full-color 22" x 34" poster depicting 155 rockets from around the world**




Readers have asked about them and now they are available. For all rocket enthusiasts young and old, this item is an absolute must have. Both **Quest** and **Countdown** readers alike will appreciate the painstaking detail illustrated in each of the 155 rockets, all drawn to 1/300 scale in full color. Rockets from over a dozen countries are shown side by side along with each country name and the name of the rocket in this fabulous 22" x 34" color poster. From Robert Goddard's original 1926 liquid-fueled rocket and Sergei Korolyov's 1933 GIRD-09 to the massive Saturn V and N-1 manned lunar landing boosters of the 1960s, this poster offers an excellent portrayal of the historical development of manned and unmanned rocketry. The poster even depicts the newest launch vehicles to enter into service including Ariane 5, H-II, PSLV, DC-X, Taurus and LLV-1.

## A GREAT EDUCATIONAL TOOL

The details shown in each rocket make this poster an excellent educational tool for classroom use. Each poster is shipped with a poster guide listing the name of each rocket, its first year of service, the country in which it was developed and the rockets primary use.

## GREAT FOR MODEL BUILDERS

Model rocket enthusiasts can use the poster as a guide for scratch building their favorite scale rocket model as the 1/300 scale provides excellent detail.

**All posters are shipped First Class Mail (First Class Air Mail for all Overseas Orders) and are sent rolled in a protective mailing tube**

**Only $10** Plus Shipping & Handling*

* All U.S., Canada & Mexico Orders add $3 per order for Shipping & Handling. All Overseas orders add $5 per order for Shipping & Handling.

Please send me ______ poster (s) at $10 each. All U.S., Canada & Mexico orders add $3 extra per order. All Overseas orders add $5 extra per order. MI residents add 6% sales tax. Total amount enclosed: $ ______ Please include a check or money order and mail to: **CSPACE, P.O. Box 9331, Grand Rapids, MI 49509-0331**

NAME: ____________________

ADDRESS: ____________________

CITY: __________ STATE: ______ ZIP: ______

COUNTRY: ____________________

# EXACT REPLICAS OF THE USAF MANNED ORBITING LABORATORY (MOL) PATCH ARE NOW AVAILABLE !

After the Dyna-Soar X-20 program, the Air Forces second venture into manned spaceflight was the Manned Orbiting Laboratory, better known as MOL. Begun in 1963, MOL was a proposed series of five or more two-man flights in polar orbit to begin in late 1968. Air Force astronauts were to use surplus Gemini spacecraft (Gemini-B or Blue Gemini) attached to a new, cylindrical laboratory, with the whole complex launched aboard a Titan III rocket from Vandenberg Air Force Base in California. The missions, which were to last up to thirty days, were to involve military reconnaissance.

The Air Force announced that it would select and train twenty astronauts, designated "aerospace research pilots."

Budgetary problems (made worse by the costs of the Vietnam War) eventually cut the number of planned flights to four and postponed the first manned mission until 1972. (One unmanned test of a MOL/Gemini-B took place in November 1966). When it became apparent to the Air Force that MOL essentially would be duplicating the effort of the NASA Skylab program, and that unmanned reconnaissance satellites had developed to the point where manned presence in space was unnecessary, MOL was cancelled in June 1969.


As part of a new *Quest* series of articles on the History of Manned Military Space Initiatives, we will be covering extensively the full history of the MOL Program. In conjunction with that study, we have been able to reproduce the official MOL program emblem based on one of the original program patches given to MOL pilot and shuttle astronaut Karol J. Bobko who let us borrow his patch for reproduction.

Available only through *Quest* Magazine, we are proud to announce that these accurate, full-color, high-quality reproductions of the official MOL program patch are now available for purchase. Each fully embroidered patch is 4-inches in diameter and is stitched with Air Force blue and metallic silver thread. As shown in the above full-size photo reproduction, each patch reads "Manned Orbiting Laboratory" and "United States Air Force" with a stylized helmeted aerospace research pilot next to a globe encircled by a MOL orbit vector. The traditional astronaut "shooting star" arcs across the center emblem.

The only public display of such a patch is at the USAF Museum in Dayton, Ohio where an identical patch can be found sewn onto the right shoulder of a MOL suit in their pressure suit exhibit.

Until now, such a patch has never been available for purchase and as such, each patch will make a fine addition to your own space patch collection. Order yours today!

## MOL PATCH ONLY $6

**Add $1 per order for shipping anywhere in North America**
**Add $2 per order for shipping anywhere Overseas**

**Send your order along with payment to:**

**CSPACE PRESS**
**P.O. BOX 9331**
**GRAND RAPIDS, MI 49509-0331**

***A portion of the proceeds from each MOL patch sale goes to support the***

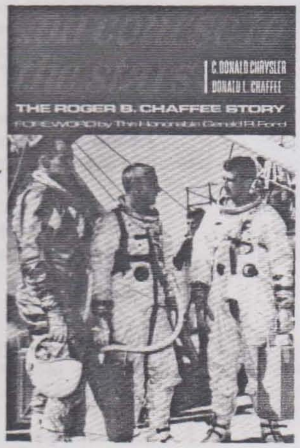
***Association of Space Explorers™***

# HAS ANYONE SEEN THIS PATCH?


Hey all of you space patch collectors out there (I know you're out there). Has anyone seen this patch before? If so, we would like to hear from you. One of our readers uncovered this patch (we've never seen it before) sewn on an old lab coat at NASA's Kennedy Space Center. We have seen patches associated with the Lunar Quarantine Facility in Houston but we have never heard the term "planetary quarantine" associated with any of NASA's programs. Something must have been big enough to warrant the creation of this small emblem and patch. The patch measures approximately 4-inches in diameter and is composed of four colors: red, white, navy blue and sky blue. If readers have any information on this patch, write us and we will publish your story in the next issue of *Quest* (we might even throw in a free "Rockets of the World" poster for your help). You can reach us at:

**CSPACE, P.O. Box 9331, Grand Rapids, MI 49509-0331**
**FAX: 616-452-5538 EMAIL: CSPACE@DELPHI.COM**

## FOR SALE RARE Autographed copies:



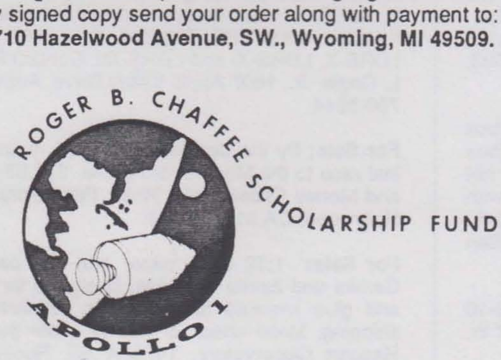

## *...On Course to the Stars: The Roger B. Chaffee Story*

### By C. Donald Chrysler and Donald L. Chaffee

On January 27, 1967 astronauts Virgil I. "Gus" Grissom, Edward H. White, Jr. and Roger B. Chaffee lost their lives due to a tragic fire during the Apollo 1 "plugs out" pad test.The only rookie among that crew was 31-year-old Roger B. Chaffee and the story of his life has been told in a book co-authored by the astronaut's father Don Chaffee. *...On Course to the Stars* was originally published in 1968 and has long since been out of print. A valuable collectors item, Don Chaffee is offering personally signed copies of the book for $25 each (add $5 per order for shipping and handling in North America or $10 per order for shipping and handling for all overseas orders). Proceeds from the sales of each book go to support the Roger B. Chaffee Scholarship Memorial Fund which was established shortly after the astronaut's death to provide an annual engineering college scholarship to an outstanding high school student. To order your personally signed copy send your order along with payment to:

**Don L. Chaffee, 3710 Hazelwood Avenue, SW., Wyoming, MI 49509.**

**Proceeds From Book Sales Go To Support The Roger B. Chaffee Scholarship**




# *Glen's Stuff for Sale*

Its amazing how things accumulate! I have been going through some of my files and pulled items that I have duplicates of or no longer need. I thought I would post them for sale in hopes that readers might be interested in buying. Besides, its tax time and the extra money will come in handy.

I only have one of each item unless noted otherwise so perhaps the best way to assure that you will get the item you want is to FAX or EMAIL your order ASAP. I will set items aside on a **first come first served basis** and hold your order for one week from the time the order is received. If payment is not received during that time, the order will go to the next person and so on. Please make sure that you include the correct amount for shipping listed for each item with your order. This is especially critical for overseas orders where the postage can be expensive. To order write FAX or EMAIL:

**CSPACE PRESS**
**PO BOX 9331**
**GRAND RAPIDS, MI 49509-0331**
**FAX: 616-452-5538**
**EMAIL: CSPACE@DELPHI.COM**

**ABOVE and BEYOND: The Encyclopedia of Aviation and Space Sciences:** (I Thought I would start with the best first). This is a 14 volume hardbound set originally published in 1967 by New Horizons Publishers, Inc. As quoted in the editor's preface of Volume 1, the series is "the world's first complete encyclopedia of aviation and space." It was designed primarily for young people and the general reader but I love it as an excellent resource tool for rare photos (of which there are hundreds contained in its pages!). I have an extra set that is in very good condition (you think I would let go of it if it was the only set I had!). The first **$100** gets a real gem. North America (NA) postage add $25 for shipping; Overseas (OS) orders (we'll have to talk for this set is heavy); **Strategic Defenses: Ballistic Missile Defense Technologies Anti-Satellite Weapons, Countermeasures and Arms Control,** softbound report by the Office of Technology Assessment, First Edition 1986 published by Princeton University Press, 146 pgs, this report was undertaken by the OTA at the request of the House Armed Services Committee and the Senate Foreign Relations Committee and initially released on 9/24/85, $45 plus $5 shipping NA, $10 shipping OS; **We Reach the Moon** by John Noble Wilford, paperback, 332 pgs, photos, $10 plus $5 shipping NA, $10 shipping OS. **Appointment on the Moon** by Richard S. Lewis, paperback, 568 pgs, $7 plus $5 shipping NA, $10 shipping OS; **Men of Space Vol. 2** by Shirley Thomas, hardcover, 1st edition, 1961, $20 plus $5 shipping NA, $10 shipping OS; **We Seven** by the Mercury Astronauts, hardcover, 1962, 375 pgs, $15 plus $5 shipping NA, $10 shipping OS; **First on the Moon** by Neil Armstrong, Michael Collins and Buzz Aldrin, hardcover, 1970, 511 pgs. $20 plus $5 shipping NA, $10 shipping OS; **Rockets, Missiles, and Men in Space** by Willy Ley, paperback, 1969, 668 pages and photos, $10 plus $5 shipping NA, $10 shipping OS; **A Close Look at the Moon** by G. Geffrey Taylor, signed, hardcover, 95 pages and photos, 1980, $45 plus $10 shipping NA, $10 shipping OS; **Stuffed Snoopy Astronaut Doll** circa 1969 complete with space helmet and NASA space suit $50 plus $10 shipping NA, $15 shipping OS; **Gemini Seat Cushions**—a real rare item! imprinted with a flaming Gemini re-entry with the words "Welcome Home Jim" and "Hillard's Oil." My guess is that they could have been from a welcome home parade for Jim McDivitt (Gemini 4) or Jim Lovell (Gemini 7 or 12). Have only 2 for sale (found the things at a flea market and kept one for myself). They are in mint condition (i.e. never been sat on). $50 each plus $10 shipping NA, $15 shipping OS.

**Apple Newton Message Pad 110:** (I know its not space but its for sale!) Still under warranty. Includes manuals, software, power supply, padded carrying case and Macintosh Connecting Kit 2.0. A steal at $400! (price includes shipping for NA, overseas add $30 for shipping).

I have more stuff for sale. If you are looking for something in particular, let me know. I will try to post more items for sale in future issues as space permits.

# *YourSpace* Reader Classifieds

*YourSpace Reader Classifieds* is available as a free service to all subscribers for purposes of publishing announcements, wants, trades or disposals of space-related items. *QUEST* also encourages advertising subscriber interests in order to get in contact with others of same interests. Please limit your ad to approximately 50 words (including name and address) and only one ad per person per issue. All ads are reviewed for suitability for publication but *QUEST* assumes no responsibility for statements made or the quality of items appearing in the classifieds. Type or print clearly your ad and send, FAX or email it to: *QUEST Magazine*, Reader Classifieds, P.O. Box 9331, Grand Rapids, MI 49509-0331; FAX: 616-452-5538; E-mail: CSPACE@DELPHI.COM.

**Information Wanted:** Upper Atmosphere Rocket Research Panel 1947-1957. Photo copies OK but should be primary sources: members, monographs, memos, briefs, abstracts, program proposals. Interested in rockets, instruments, experiments and P.I.s. Also government agencies represented on panel (ABMA, NRL, NAS, etc.), university participation, authorizing legislation and program summaries. Contact: H.A. Faske, 3275 Morrow Drive, Cortland, OH 44410-9306.

**In Search Of:** Early issues of *American Modeler, Young Men* and *Air Trails* magazines; Model rocket catalogs, kits, newsletters for sale or trade. Write: Bob Kreutz, 506 Hunters Road, Bricktown, NJ, 08724-4614 or phone: (908) 892-9148 (Fri-Sun or Weekends).

**Wanted:** Space paintings & sculpture 1950s to 1980s, Moon Landings, Rocket lift-offs, etc. Looking for good, non-professional pieces. Also, watch for my new book *Collecting Man's Race Into Space* published by Schiffer Publishing. Available in bookstores worldwide. Write: Stuart Schneider, P.O. Box 64, Teaneck, NJ 07666.

**Shuttle Press Kits & Patches For Sale:** Complete collection of Space Shuttle press kits from STS-1-STS-61. Both NASA & Contractor publications. Hard to find patches,decals & pins. Please write for catalogs: Andrew Parris, 16202 El Camino Real, #801,Houston,TX 77062.

**For Sale:** Personal collection of space and aircraft-related materials collected over the past 40 years. Included are space and missile kits, other rare kits, space-related books, magazines, newspapers, memorabilia and similar aviation materials. Also for sale: *Space Frontiers* original printing back issues: Vol. 3, Issues 1-6; Vol. 4, Issues 1-5. Issues are $2.50 each ppd. Send SASE for detailed lists to: Ted Talay, 169 Carnegie Drive, Newport News, VA 23606.

**Information Wanted:** Data on the A4 (V-2) planned follow-ons, A4-B, A9, A10, A11. Dimensions, specs, documents. Also looking for V-2 manuals and paraphernalia. Data on the Atlas ICBM Models A-D, dimensioned drawings and color schemes. Will reimburse for photo and copying costs. Write: Steve Scherbinski, PO Box 3065, Kalamazoo, MI 49008.

**Star Track** by David Wilson: A fine astronomy book covering the seventy stars within 30 light years of Earth with full data on each star and how to calculate star positions from the star base of your choice. $13 postpaid. Write: Lorien House, PO Box 1112, Black Mountian, NC 28711-1112.

**For Sale:** All kinds of space related items.Press Kits from unmanned missions. Mercury, Gemini, Apollo,Shuttle Flight Plans/Press Kits.Videos from V-2 to Shuttle.NASA Select Video. Blue Light Special on Hubble Repair Videos. For more information call or write: Bucky Meadows, 1439 Providence Avenue, Springfield, OH 45503; PH: 513-399-2347.

**For Sale:** Revell 1:144 Discovery Space Shuttle with boosters (box not sealed-all parts) $25; Revell 1:144 Enterprise & Space Lab (box not sealed-all parts) $25; Monogram first lunar landing (box not sealed-all parts) $25; GIJOE Space Capsule Set (1st version with suit,mint condition with box) $600; GIJOE doll/flight overalls/boots (no box) $75. Robert R. Hast, 7207 Snowden Road, Apt. #1111, San Antonio, TX. 78240.

**Information Wanted:** Information concerning the JB-1 thru JB-10 guided missile program, especially the JB-2 "Loon." Contact Paul W. Esterle, 1270 Volunteer Parkway, Apt. F-22, Bristol, TN 37620.

**For Sale:** Out of print and difficult to locate books about the space program and related subjects. Write or call for free catalog: Knollwood Books, P.O. Box 197, Oregon, WI 53575-0197; PH: (608) 835-8861.

**Wanted:**Amateur spaceflight historian looking for contractor desktop models,8 x 10 color/B&W photos & program histories of all U.S. IRBM, ICBM,expendable satellite/probe launch vehicles 1957-present. Send list/prices to: Arthur W. LeBrun,17412 Burdie Lane,Orange,CA, 92669.

**Russian Space Items For Sale:** First man in space 30th anniversary medal issued by Baikonur Cosmodrome and minted from metal of flown spacecraft. Fragments of Soyuz T-11. Large Gagarin and Energia/Buran pins. Vostock and MIR pocket calendars, Russian space videotape. Write for free catalog: Cosmodrome/ Spaceport Enterprises, 24 Sheridan Street, Lawrence, MA 01841.

**Space Data Base System:** The ultimate space data base systems. For IBM only. No other software required. Space 2000 covers all countries from 1926 through NASA plans in 2012. CATSAT includes all US Space Command Cataloged items. Book versions also available. Write or call: SAR, Inc., P.O. Box 49446, Colorado Springs, CO 80949; PH: 719-260-0500.

**Wanted:** Decals in relation to payload carried on shuttles put out by private contractors. Send xerox and your price to: Ray DuBeau, 658 Babcock, Elmhurst, IL 60126-1868.

**Space Trading Cards:** Have a few complete sets of Series #2 & #3 of the SPACE SHOTS SERIES for $19 per set. Have tons of dupes for same and some from Series #1. Your list for mine. Please send a SASE to: Dennis L. Rodgick, 601 Bayberry Lane, Imperial, PA 15126.

**Astronaut Autographs For Sale:** Genuine signatures of U.S. astronauts. Mercury-Shuttle. Write for free catalogue: Adam Harwood, 1414 West Aries, OK 73003-5826.

**Missile, Space and Rocket Used Books:** Send your name, address and phone number for a free catalog. Also include notice if you have either a MAC or DOS computer because I am considering sending the catalog out on disk. Write: Richard H. Jackson, PO Box 93, Mount Vernon, VA 22121-0093; E-mail address: Richard_Jackson@CSGI.COM.

**Rocketry Videos:** Interested in rockets and rocketry? These exciting, two-hour videos covering the annual "nationals" of high-power rocketry will show flying "model" rockets as large as 850 lbs. and 34 ft. tall! Each video is recorded in hi-fi stereo sound fully titled with hi-fi stereo music. VHS, $20 ppd., CK or MO. Videos available include: LDRS-X, LDRS-XI and LDRS-XII. Contact:Point 39 Productions, Earl L. Cagle, Jr., 1607 Apple Valley Drive, Augusta, GA 30906; PH: 706-790-5544.

**For Sale:** By the designer, in limited quantities, LIFTOFF! the original race to the Moon board game. $19.95 ppd USA orders. Checks and Money Orders only. Write: Fritz Bronner, PO Box 3241, North Hollywood, CA 91609-0241.

**For Sale:** 1:32 scale paper "cut and paste" models of Mercury, Gemini and Apollo capsules. Designed for school use, inly scissors and glue required for assembly. All three for $2 plus 50 cents shipping. Make check or money order payable to: Ken Cameron, Haggart Observatory, 14708A SE Rupert Drive, Milwaukie, OR 97267-1207.

**Space Patches:** The number one space collectable. Over 300 different designs. NASA, ESA, USSR, Canada, Space Probes, Special Projects, Military. Also tie tacs, decals, medallions, etc. Illustrated brochures, $2 (refundable). Write: SPACELAND, P.O. Box 540775-A, Merritt Island, FL 32954.

**Space Shuttle "Barf Bag" Wanted:** Serious collector is seeking a space sickness bag from the Space Shuttle for his collection. Dr. Niek K. Vermeulen from the Netherlands owns world's largest collection of airsickness bags. Would also like more "barf bags" from airlines to add to his collection. If you can help write him at: c/o Frank Woldorf's Air Historical Exhibits, 5369 S Siesta Lane, Tempe, AZ 85283; FAX: 602-756-2735.

**National Association of Rocketry:** Come explore the world of model rocketry and join the world's largest organization dedicated to this hobby. Each one year membership includes a year's subscription (six issues) to *Sport Rocketry:The Official Journal of the National Association of Rocketry*. Membership categories and fees are: Junior Membership (Under 15) $20; Leader Membership (Under 21) $20 and Senior Membership (21 and over) $35. Subscriptions are available to the magazine only at $24/year, 1st Class/ Airmail/Foreign are optional. For more information call 1-800-262-4872 or write: National Association of Rocketry, P.O. Box 177, Altoona, WI 54720.

**Space Autograph News:** A new bi-monthly publication covering who's who, values, authenticity, availability, addresses, etc., in the field of astronaut autographs; available for $15/year ($20 international). Also available is **Autograph Research: Early Astronauts**, a special report on the Mercury, Gemini and Apollo astronauts and their signatures; available for $7 ($10 international). Write: Mike Johnson, 862 Thomas Avenue, Dept. Q, San Diego,CA 92109-3940. Satisfaction guaranteed.

**Revell Saturn V Kits For Sale:** Factory new Imported Revell of Germany 1994 1/96 scale Apollo/Saturn V plastic models for $125 each. Factory sealed never opened! Write: Donald D. Pealer, 10061 Rio San Diego Drive, Apt. #304, San Diego, CA 92108; PH: 619-281-0270.

**Information Wanted:** Soviet satellite fragmentation; who knows details about the Soviet Cosmos 699-type and Cosmos 862-type satellites which often disintegrated on orbit? I need information about structure, shape and size which are important to find out the number and the size of orbital debris. Write: Carsten Wiedemann, Institute for Spaceflight-Technology (IfRR), Hans-Sommer-Str. 5, D-38106 Braunschweig, Germany.

**For Sale:** Apollo Moon Flight Globe. Rare collectible. Made in 1970. Globe is 6" tall and comes in original box with information sheet showing all manned and unmanned lunar landings. Mint condition, limited supply. $15.95 each plus $4.75 for shipping. Also NASA astronaut autographs & other space collectibles for sale. Write: Hank Molesky, 1915 VanderVort Road Road, Lutz, FL 33549; PH: 813-949-2429.

**Author's Query:** I am researching a book on the Apollo Applications Program and would like to hear from anyone who worked on the program in its various stages – Apollo X, Apollo Extension Studies and on through Skylab. I am particularly interested in studies done on extended lunar exploration and dual launch Saturn V missions. Any anecdotes, documents, insights and the like are welcome. Reply to: Thomas J. Frieling, Bainbridge College, Hwy. 84, E. Bainbridge, GA 31717; FAX: 912-248-2589; e-mail: tfrielin@catfish.bbc.peachnet.edu

**For Sale:** To highest bidder. The official American Space Flight Silver Anniversary Medal Set. 25 coins issued by the National Space Society minted by the Franklin Mint. Send your bid to: Richard Boucher, 1100 Mohawk Trail, North Adams, MA 01247-2953.

**International Space Academy:** Space studies in your home at your pace. We offer certificate of Astronautics. Contact: Space Academy, PO Box 542327, Merritt Island, FL 32954; PH: 1-800-TO-SPACE.

**Cosmonaut Spacesuit For Sale:** Dated 1963, complete and in very good condition. Similar to "Golden Eagle" suit. $25,000/offers. I also collect suit patches, USA/USSR. Contact Chris Smith at PH: 706-323-9443 for details.

**LIFTOFF! An Astronaut's Dream:** a children's book by Astronaut Mike Mullane. 100 pages with illustrations. Children's Book Council 1995 Outstanding Science Trade Book. Autographed hard cover: $20, soft cover: $10. Overseas airmail add $10 each book. Send check or money order to Mike Mullane, 1301 Las Lomas Rd., NE, Albuquerque, NM 87106.

**New Launches Table:** *Worldwide Satellite Launch* began monthly publication in February 1993 giving detailed orbital data, spacecraft descriptions and mission details for new launches, updates for earlier launches, etc. Subscription for 1993 launches £60 sterling. For further details write: Molniya Space Consultancy, 30 Sonia Gardens, Heston, Middx TW5 OLZ, England. Tel/fax +44-81-570-3248.

**US/Russia Joint Mission Patches:** MIR-18 Primary Crew, MIR-18 Backup Crew, NASA/SRA Shuttle Mir Phase Once, Apollo-Soyuz Test Project 20th Anniversary and more. Send $1 for complete listing of Cosmonaut patches. Write: H.P. Exterprises, 1126 W. Ocean Ave., Lompoc, CA 93436. PH: 805-735-1322.

**Space Data Bases:** Shareware collection of U.S. space launches (Sounding Rockets, Missiles, and Satellite). Over 11,000 listed with details. For Apple II (AppleWorks required), Macintosh (MicrosoftWorks required) and MS DOS (MicroSoft Works Required). Cost $40 plus $4 shipping. Write: Spaceworks, P.O. BOX 6246, Bridgeport, CT 06606.

**Collector Seeks Books and Fellow Enthusiasts:** Collector and amateur historian seeks pre-1958 books and magazines on early rocketry and space travel concepts. Duplicate items also available for sale or trade. I am also interested in corresponding with fellow enthusiasts. Please contact: Michael Ciancone, 18425 Saratoga Trail, Strongsville, OH 44136; PH: 216-572-6016.

**Information Wanted:** I am doing research on the manned space programs of the Air Force during the late 1950s-60s which include X-20A Dyna Soar and Manned Orbiting Laboratory (MOL). I need information, photos or drawings that you would care to share. I especially need information on the Gemini B spacecraft and Lab Module, plus info on the Titan III M Launch Vehicle. I will reimburse all for photocopy and postage costs. Write: Terry Smith, 459 Lawson, Fayetteville, AR 72703-1860; PH: 501-521-7161.

**Visit Baikonur Cosmodrome!** See manned launch. Visit Cosmonaut Training Center and more. Trip cost: $2,800. Includes: roundtrip air from New York, roundtrip air Moscow/Baikonur, full tour program, hotel and meals, all transfers. For more info and free video preview write: Cosmodrome/Spaceport Enterprises, 24 Sherdian ST, Lawrence, MA 01841, FAX: 508-975-8582.

**History of Space Collection:**This is a 20" x 26" framed collection of postal covers & patches telling the history of spaceflight.Collection includes 8 special event postal covers & 6 colorful embroidered patches all set within a mat black aluminum frame.Each event cover is hand mounted with clear acetate corner protectors and is postmarked in a different historical space location.Beneath each patch and cover is a narrative description of major space events. $89 plus $10 for shipping & handling (inside US).For more information or to obtain a photo of this collection call/write: Moments In Space,2691 Rebeiro Avenue,Santa Clara,CA 95051.PH: 1-800-735-4821.

**Rocket Collectors:** Subscribe to the "Rocket Collector's Journal," a quarterly publication for rocketry collecting. A high-quality, two-color, 4-8 page newsletter about rocketry collectibles that's packed full of model and high power historical information. The journal will also include a collectors directory with for sale and/or trade items. Wanted: contributing writers to submit articles on rocketry collectibles, personal stories and related topics for the journal. Send a self-addressed stamped envelope for article ideas. Subscription: $16/yr., $22 outside of U.S. and Canada. Make check payable to: Dan Sagstetter, c/o Photo Design Graphics, 4432 N. Fourth Street, Columbus, OH 43224-1035. PH: 614-268-6927; FAX: 614-268-3247.

**International Space Link:** An organization for space enthusiasts offering networking with other members, NASA documents & materials plus a monthly newsletter called *The Shuttle Enthusiast*. Contact: ISL,P.O. Box 778, Dept. A, Rex, GA 30273 or Internet: joshua.a.powers.19@nd.edu.

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