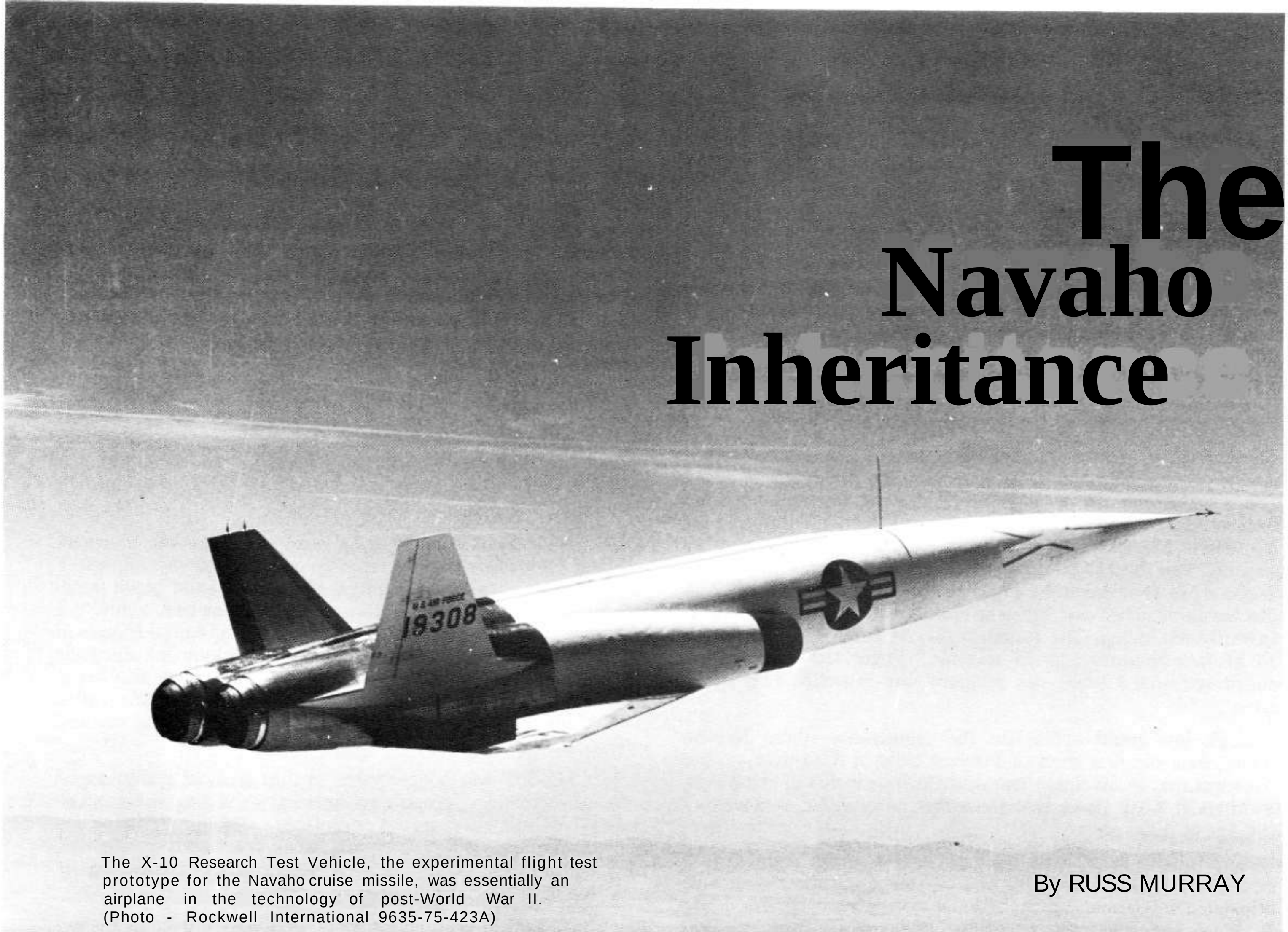
The Navaho Inheritance



The X-10 Research Test Vehicle, the experimental flight test prototype for the Navaho cruise missile, was essentially an airplane in the technology of post-World War II. (Photo - Rockwell International 9635-75-423A)

By RUSS MURRAY

The surge of progress — from the conventional airplane to the supersonic air weapon system and to the rocketed space vehicle — came not so much from strictly aircraft engineering but more from a daring departure into advanced missile technology. A chief contributor to this progress was a pioneering missile program called the Navaho.

For all of the sensation of the Space Age, the Navaho has received scant acclaim, but as a begetter of advanced aerospace technology, it was the Daddy Of Them All. From Navaho technology the United States founded its strategic missile defenses, and went into space, and to the moon. Navaho technology likewise blessed the march of aeronautics.

The first turbojet craft to cruise in excess of mach 2 was a product of the Navaho missile development program, and so was the first aircraft to demonstrate prolonged flight up along the thermodynamic ridge at mach 3. True, no pilot was aboard, but these were full-sized, controlled-in-flight, aerodynamic ground-to-air vehicles.

The Navaho missile system development program was initially contracted to North American Aviation, Inc. by the U.S. Air Force in 1946. The program became controversial in the early 1950's, opposed at first by adherents of the manned bomber who resented the program's sizeable intrusion into the air defense budget, and who scoffed at so wild a dream as a supersonic, nuclear-armed, automatically-guided intercontinental missile. Later it was the missile factions themselves who joined in scorning the Navaho, claiming the program was commanding priority funds that would otherwise benefit their own pet projects, particularly interceptor and ballistic missiles. Even within the guided missile community it was argued that a modestly subsonic contemporary, the Snark, was the only sensible approach to the intercontinental weapon.

In the Age of Space, which has come so rapidly in the history of Mankind, a mere seven decades after the advent of the age of powered flight, it is well to look at the transition steps. One airplane, though not strictly man-bearing, was the Navaho, which was the essential link between air-borne, air-breathing vehicles and the spaceships dependent neither upon air for support nor on sustenance as an ingredient of fuel.

The Navaho program came and went swiftly in the little more than a decade from the end of World War II to Sputnik. It happened in the era of technological transition, and surely today it has affected all our lives, however indirectly it may seem.

Toward the end, the cruelest criticism came from rival launch crews at Air Force Missile Test Center, Banana River, Florida when the Navaho stalled in its development flight test program in late 1956. "Never-go Navaho," they smirked, and indeed the big bird was then experiencing an incessant run of malfunctions, misfires and flight failures.

Pointing the the Florida skies, the Navaho was the most impressive missile standing at the time. It was a piggyback vehicle, nearly 100 feet long and weighing about 300,000 lbs. Its 405.000 lb. thrust booster was the most powerful extant, and affixed to it was a twin-ramjet cruise missile designed for three times the speed of sound at 80,000 feet.' The enormity of the ambition made the flight test misfortunes all the more mocking.

Through eight months of late 1956 to 1957 only four countdowns reached the point of ignition. The first flight, November 6, 1956, lasted only 26 seconds before destruction. Following ten unsuccessful launch attempts, the second flight finally went off on March 27, 1957; total air time was four minutes and 39 seconds. The third flight on April 25th went but a few inches. An errant signal shut down the engines at the moment of lift-off, and the Navaho lurched and sat right back down on the launch stand, violently exploding. The fourth flight, on June 26, 1957, lasted all of four minutes and 29 seconds.[2] Flight test development ended unfulfilled when the program was cancelled two weeks later.

Though few could appreciate the significance, these Navaho flights were the first steps of the first child of Aerospace, no less consequential to the Space Age than the four flights of the Wright Brothers at Kitty Hawk that December morning in 1903 were to the Age of Aviation.

Unsurprisingly, there was a trace of German accent in the expression of the Navaho. The idea of a two-stage transoceanic missile originated in German research in the closing years of World War II. When the Allies uncovered the cache of German technical documentation at war's end, they found impressive projections of advanced missile design concepts for extending the potency of the V-2 rocket weapon. One of the down-the-line versions was an A-9/A-10 vehicle consisting of a 440,000 lb. thrust A-10 carrier rocket, boosting an A-9 rocket, that was similar to a V-2 with wings.[3] A 2600 mile range with one ton of munitions was anticipated; the intended target was the mainland of America!

While the A-9/A-10 was being considered in conceptual engineering'by the Germans in 1944 there was a minor organizational assignment made at North American Aviation's Inglewood, Calif., plant. The concept and the organization were destined to meet shortly.

North American Aviation produced more than 43,000 military airplanes during the War, including 15,000 AT-6 Texan type trainers, 10,000 B-25 Mitchell medium bombers and 15,000 P-51 Mustang fighters. It was so occupied with warplane production that not until late 1944 could time be found to look into the emerging rocket and jet technologies. This was also the time when war orders were dropping drastically, and company employment was plummeting from a peak of 92,000 on its way down to a post-war low of 5000. North American set five engineers to catch up on the jet and rocket advances. Their work was closeted behind a locked door marked Technical Research Laboratory and in late 1945 captured German documentation began arriving — theory and data not only on rocket and jet aircraft, but fascinating ideas and information on missiles as well.

Adjudging rocket technology as too cantankerous for manned interceptors, and shunting jet aircraft data to the Preliminary Design Group (where the German swept-wing theory for breaking through the sonic wall was inserted into the design of a straight-wing P-86 jet) the Technical Research Laboratory concentrated on missile concepts.

In December 1945, North American's Technical Research Laboratory submitted a proposal to the Air Force for the conduct of a study program to forward German missile technology. The Laboratory proposed a three-step effort. First, they would evaluate adding wings to the basic V-2 rocket to increase its range from 186 miles to about 375 miles. Next, they would investigate replacing the V-2's rocket propulsion system with turbojet or ramjet power for a much longer cruising range. Later, technology willing, they would undertake the design of a "gigantic starting rocket" for boosting the jet-engined, winged V-2 on an intercontinental trajectory.

On April 22, 1946 the Air Force approved an initial letter contract to proceed with their proposed effort. The study was coded Project MX-770, one of five missile development programs to be awarded to industry.[4] The letter contract for $864,360 was amended in July by adding over $2 million, for a gross commitment of $2,389,470.

With a highly talented staff now grown to 43 (including 12 doctorate and 18 masters degrees represented), the Technical Research Laboratory became the Aerophysics Laboratory and began familiarizing themselves with the technology. Picking over a few V-2 engines received as war booty, and firing experimental engines in an unused corner of the North American parking lot alongside what is now Los Angeles International Airport, they also began the design of a small 13-foot rocket-powered missile called NATIV for the purpose of providing field experience in test and operations.

Project MX-770 was concentrated in four areas of study: supersonic aerodynamics; propulsion systems; stabilizing and control; and a catch-all category of structures, metallurgy, launching systems and warheads.[5] The early work was highly productive, particularly in the development of electronically-operated equipment for stabilizing and control.

Electromechanical accomplishments were passed over to the aircraft design groups where advanced automatic fire control and flight control systems were developed, thus North American engineers integrated the first comprehensive, powered flight control system into its F-86 fighter series. Providing automatically compensating forces for good handling throughout the speed range, the powered flight control system was a principal reason for the Sabrejet's mastery over the MiG-15 in Korean air combat.

While steering its advanced missile technology toward aircraft improvement, the Missile Project dismissed one avenue of research that was a possible consideration for future bombers: nuclear propulsion. The nuclear rocket was looked into but was abandoned as too far-fetched for the time, circa 1946. The government agreed and cancelled this part of the project. "The chief 'undertaker' at the funeral was a careful, competent report by scientists at North American Aviation concluding that the nuclear rocket did not seem applicable to ICBMs." [6] North American retained its nuclear scientists and turned them to commercial and utility reactor research, and effort which continued as an adjunct to the Aerophysics Laboratory missile development project.

In the Summer of 1948 the Aerophysics Laboratory, now grown to 500 people on the strength of its progress and a new objective, was moved to Downey to share quarters with the Electro-Mechanical Division in what had been the Vultee plant of Consolidated Vultee Aircraft Corp. The new objective was the XSSM-A-2, a ground-launched, ramjet-powered, 1000-mile range cruise missile.[7]

The German missile and rocket research accomplishment before and during the war has been rightfully glorified, but the United States also had its period of brilliant creativity in advanced missile technologies. America's moment was shorter, far less funded, much less attended, and without the incentives of a national urgency, but it was no less generative. America's Peenemunde was a wartime aircraft factory set amid the post-war housing tracts in the Los Angeles suburb of Downey.

In two years — from mid-1948 to mid-1950 — in this Downey operation, North American Aviation and its government and industry associates produced inventions and developments that left the German wartime missile examples well behind and evolved a whole new order of technology. In this brief period the Missile Project succeeded in the major redesign of the liquid rocket propulsion system to increase thrust levels by nearly one-third and to create a powerplant with growth potential for space capability.

The Missile Project also conceived and developed a gyro-stabilized, automatic guidance and control system called the Inertial Autonavigator which would accurately and continuously position a missile in space without ground command.

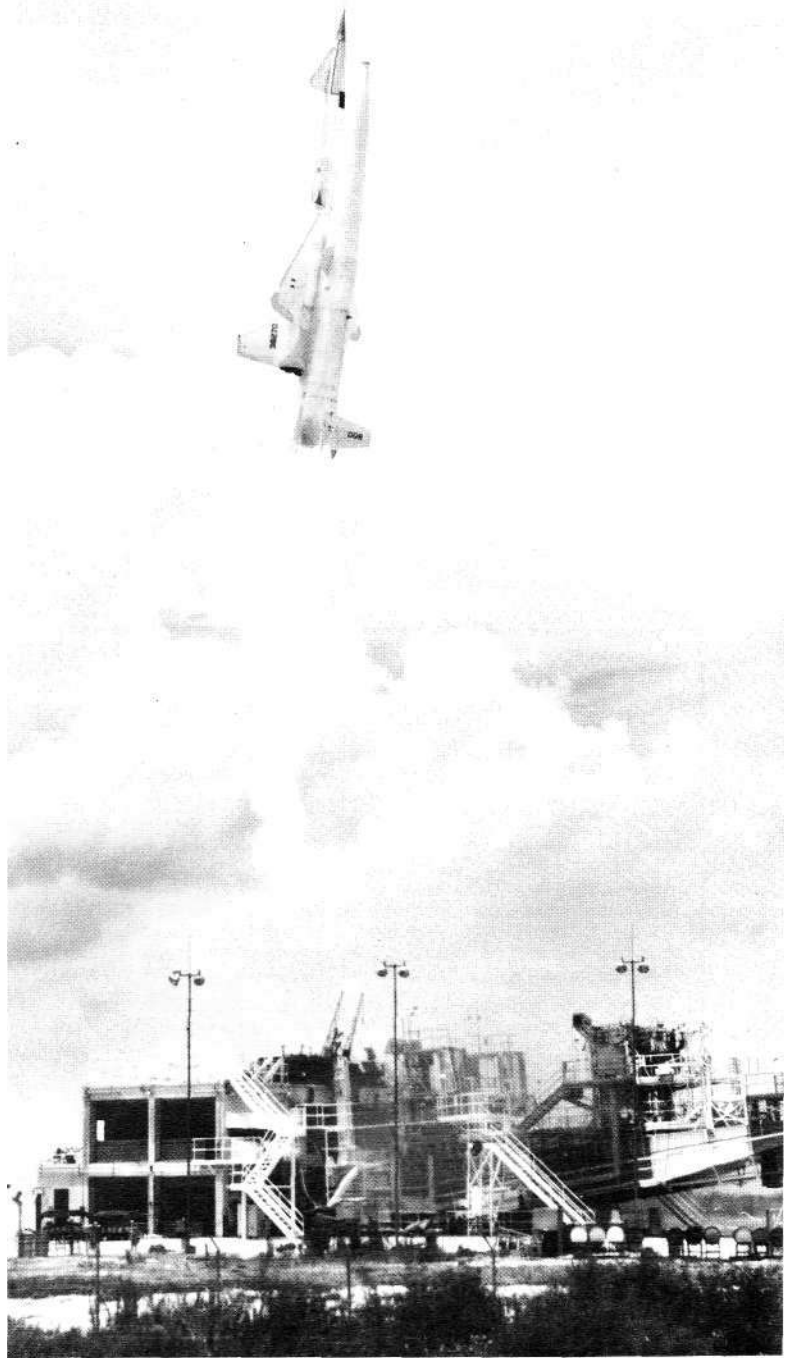
There were other impressive accomplishments in subsystems, flight dynamics and structures and materials, including titanium forming. The nuclear project engineers contributed a break-through with the assembly and operation of the first water-boiler type reactor in the Downey laboratory. The NATIV missile field test program was successfully completed in 1948 when the abundant new technology surfaced, and the XSSM-A-2 1000-mile missile development was simply overwhelmed by the rapidity of technical advances. In June 1950 all of the Downey invention and development was combined into a comprehensive concept of a super weapon — the supersonic intercontinental missile, Weapon System 104A — the Navaho.

The Navaho program objective called for: "A ground-to-ground, guided missile, capable of carrying a heavy special warhead over a maximum range of 5,500 nautical miles at supersonic speed (Mach No. 2.75 or higher), with a radius of error at the target of 1,500 feet or less for 50 percent of the missiles launched."[8]

Few, if any, major programs were ever commenced with so little evidence of applied technology. The Navaho was based on Downey discoveries, many of which were not yet explored, and there were large open gaps for systems not even approached. However, there was a great enthusiasm at all levels of the program, both inside North American's Aerophysics Laboratory and with the Air Force. In contrast, the giant Apollo lunar landing program that was to come along a decade later was based upon known technology, and mainly involved expansion of the then "state of the art."

The Navaho propulsion system was in June 1950 a test apparatus that only one month before had its first full 75,000 lb. thrust firing over a minute — 64.5 seconds. The autonavigator was a laboratory example that also just a month before had been taken up in an aircraft test bed for its first airing. The required advanced structures had been exposed only as test panels, and the flight regime had only been brushed by rocket probes.

Navaho development was planned to be carried out in three succeeding phases. First, a prototype cruise missile would be constructed and flown to check out aerodynamics and test operating systems. Following about a year behind, a booster/cruise missile combination of abbreviated capability (2500 nmi. range)



Above —the XSM-64 Navaho being launched at the Air Force Missile Test Center, Banana River, Florida, circa 1956. The initial flight test program was fraught with failures, but in terms of technology demonstration, it was epochal in the history of space flight.

Left — North American's earliest rocket engine test firings were conducted in this wartime bombshelter modified for observation of the firings. It was in the parking lot adjacent to the now Los Angeles International Airport. An early liquid rocket engine is shown on the stand at left.

would be produced to serve as a flight test development vehicle, this intermediate missile system would lead, in the third phase, to the appearance of the ultimate 5500 nmi. Navaho weapon.

The prototype cruise missile, the X-10 Research Test Vehicle, was completed in 1953. Its fuselage was a pointed slender shaft, 70 feet long, bulged at the aft section with side inlets and bays for two Westinghouse J-47 turbojets with after burners. The turbojets were substituting for the developmental ramjets intended for the operational cruise missile. The X-10 had a Vee-tail with elevons that sprouted from the nacelles at the root of the 28-foot-span delta wing. The X-10 had a retractable tricycle landing gear, and was controlled by a radio command system; later, an automatic takeoff and landing system and an autonavigator would be installed.

The first flight of the X-10 research test vehicle was made at Edwards Air Force Base on October 14, 1953, a flight that lasted 31 minutes and 40 seconds, and a speed of Mach .75 and an altitude of 20,900 feet were recorded. Within a year nine more flights were made, eight of them successfully recovered. On the tenth flight, the X-10 hit Mach 1.84, a local Edwards AFB jet speed record. After five more flights at Edwards, an inertial autonavigator was installed and the flight testing was transferred to the Air Force Missile Test Center in Florida.

On the 19th flight of the program, the X-10 reached Mach 2.05.[9] Not only was it the first turbojet to fly twice the speed of sound, the X-10 was also the first air vehicle to fly a complete mission under the control of the autonavigator.

The products of X-10 flight research were directly applied to another wildly ambitious North American program, the NACA/Air Force/Navy X-15 aerospace research rocketplane. Thus, the X-10 was the forerunner and fundamental data source for the development of the X-15 and the attainment of manned hypersonic aerospace flight.

There were 27 flights in all in the X-10 test program, and they proved out the aerodynamics, systems and structures for the ramjet-powered cruise missile of the second phase, the booster-launched flights of X5M-64.

The booster/cruise missile combination of the second phase of the Navaho development was called the XSM-64, and in the Fall of 1955 versions began arriving at the AFMTC launch site in the fall of 1955 for integration and tests preparatory to flights the following year. The final 5500 nmi. version of the Navaho, the SM-64A, was coming along in production behind it. In mid-1955, the SM-64A booster was static fired at 415,000 lbs. thrust — five and one-half times the power exhibited with the experimental engine when the program was started only five years before.

A major policy change in the United States military posture came in the next two years. The Navaho program was cancelled on July 13, 1957 while the XSM-64 intermediate version was in flight test. The U.S. had succeeded in shrinking the size of the high-yield, thermonuclear warhead, enabling ballistic missiles to carry it over intercontinental distances, and in this new policy of "massive retaliation" it was ordained that only ballistic weapons would be emphasized. There were other factors involved; primarily 1957 was a year of severe defense budget austerity. Something had to go, and the Never-go Navaho went.

As a last gesture, the XSM-64 Navaho flight test missile systems that were through production at the time of program cancellation were authorized to be flown and expended in a Fly Five and a RISE (Research In Supersonic Environment) technology advancement exercise. Seven post-program flights were launched, with mixed success.

The high points of these concluding flights were noteworthy: on September 18, 1957 an XSM-64 cruised 500 nmi. at Mach 3; on January 10, 1958, another flew 1075 nmi. with extreme accuracy under autonavigator control. The last XSM-64 Navaho flight was on November 18, 1958.[10] But by then visibility of the program was lost in the dazzle of the early ICBM and space shots.

The Navaho program had cost about $700 million, averaging roughly $100 million per year. For all this expenditure, the government never did get its super weapon, the 104A. Instead, what it did get was priceless technology for achieving the ICBM on time, besting the Russians in space, and a second generation of missiles and space systems to dominate the 1960's. Perhaps all this may be equated to the survival of the Free World.

The yield of the Navaho development cannot be precisely accredited, for technical invention takes from many sources. But foremost, the initial Navaho rocket engine concept was used in the Redstone missile, and the Redstone was the first-stage power which placed the first U.S. satellite, Explorer I, in orbit, and also launched the first two American astronauts. The Navaho-original propulsion systems were used in the Thor intermediate range ballistic missile, the first U.S. operational IRBM. Navaho propulsion was adopted for the Atlas, the nation's first operational ICBM. Thor and Atlas became the workhorse boosters of the U.S. space program, including the Atlas-launched Project Mercury orbital flights.

The inertial autonavigator that was developed for the Navaho was one of the truly profound inventions of aerospace. The Navaho autonavigator was quickly adapted to the AGM-28 Hound Dog missile. It was a version of the Navaho autonavigator that guided the nuclear submarine NAUTILUS on its historic under-ice cruise to the North Pole. The same autonavigator was incorporated in a radar-equipped bombing-navigation system for the Navy's A-5 Vigilante.

NAVAHO OVERVIEW

The Navaho Program was a whole series of contracts between the U.S. Air Force and North American Aviation, Inc. beginning in March 1946. Though the Program ended in July 1957, the aftermath of the technologies stemming from it are continuing. During this long period there many nomenclature changes which along with the security classification of the project, did little to help the outsider understand the program.

It was initiated as Project MX-770, and ultimately became the WS-104A. Some of the early designs were designated XSSM-A-2 and XSSM-A-4. Later they became XSM-64 and XSM-64A. Still later they were identified as XB-64 and XB-64A. The Company called these designs G-26M and G-26B (for Missiles and Boosters), and G-38M and G-38B, to eliminate the need for classification of certain documents when the Air Force model number was used.

The first flight test missile had only one designation: NATIV, which stood for North American Test Instrumentation Vehicle.

At the time of the termination, the company was working on five primary contracts, plus a vast number of minor but related contracts. Here is a list of the five major contracts, and the work which was underway at the time of the 1957 termination:

Contract No.	Date of Contract	Description of Work
W33(038)-ac 14191	March 29, 1946	Basic R&D Design, Fabricate and Test: 13 X-10 Missiles 5 Autonavigators
AF33(600)-22873	Dec. 23, 1952	Design, Fabricate and Test: 10 XSM-64 Missiles 13 XSM-64 Boosters 5 XSM-64 Autonavigators
AF33(600)-28469	Feb. 10, 1955	Research and Development
AF33(600)-29051	Jan. 11,1955	Design, Fabricate and Test: 12 XSM-64 Missiles 21 XSM-64 Boosters 6 XSM-64 Guidance Units
AF33(600)-31194	Sept. 23, 1955	Design, Fabricate and Test: 9 XSM-64A Missile 12 XSM-64A Boosters 21 XSM-64A Guidance Units

"Cradle of the Cosmic Age." The Space Division plant at Downey, California as it was in 1951 with the flightline of Vultee Field still in use. This former manufacturing plant of the Vultee Aircraft Corp., later Consolidated-Vultee, was taken over by North American Aviation in the postwar period. Beside being the birthplace of the Navaho, it was also the homestead of the Apollo Command Spacecraft, (Rockwell Int'l 820-1071, Downey)

Navaho invention opened avenues of advanced product potential that caused North American Aviation to break-out three new divisions in 1955-56 to explore their value.

Autonetics, which originated as the Navaho electromechanical laboratory, carried the guidance and electronics forward into a new generation of strategic systems: Minuteman, Ships Inertial Navigation Systems, and a multitude of avionics packages for the Century-series fighters.

Atomics International remained comparatively small, but did follow through with its research to develop the first reactor to operate in space and make notable contributions to the fast breeder-reactor technology.

Rocketdyne expanded the Navaho liquid rocket propulsion system to the Saturn family, with types that ultimately produced 1.5 million pounds of thrust. Power born out of the Navajo took Man out of the gravitational field of the Earth, free to explore the universe. This is an event which some scientists have referred to as epochal in evolution as the fish leaving the sea.

Before the decade of the Seventies is out, the National Aeronautics & Space administration will launch an airplane called the Space Shuttle. Actually a combination airplane and spacecraft, it will take off vertically, go into orbit, and later will fly back to earth and make a regular runway landing. Routine flights to orbit and return will follow in the early 1980's. The Space Shuttle looms very large in the aerospace industry's future. Where does the Navaho come in? At the very beginning.

ACKNOWLEDGEMENT

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REFERENCES

1. Von Braun, Wehrner and Ordway, Frederick I. *History of Rocketry Space Travel.* Thomas Y. Crowell Co., New York, 1966.
2. North American Aviation Inc. Inter-Office Letter dtd. May 25, 1960, by L.J. Wiley, subject: "Chronological Order of Events — XSM-64 Flight Test Program,**
3. Hutzel, Dieter K. *Peenemunde to Canaveral.* Prentiss-Hall, Inc., New Jersey, 1962
4. Crawford, A.W. "History of the Navaho Program — 1946 through early 1951" North American Aviation, Inc., unpublished.
5. Ibid.
6. U.S. Atomic Energy Commission. *Nuclear Propulsion for Space.* One of series, "Understanding the Atom." Library of Congress Card No. 67-61704.
7. Op cit: "History of the Navajo Program."
8. Ibid.
9. Oakley, Ralph B. "Weapon System 104A Chronological List of Major Milestones." Unpublished tabulation.
10. Op cit: "Chronological Order of Events etc."

ABOUT THE AUTHOR

Russ Murray has been a writer in the aerospace industry for 20 years, specializing in market presentations and proposals. A graduate of the University of Pittsburgh, he began his career with North American Aviation's Columbus Division, was later a Market Executive Assistant with Space & Information Systems Division. He has also been a consultant with other firms, is currently Marketing Specialist with Actron Industries of Monrovia.

Murray says his interest in aviation is "wholly emotional — not academic," and was kindled by childhood sights of doughty little Boeing F4B-4's, Major Al Williams' power dives, and other of the mid-1930's aerial scenes. Special presentations on J.H. "Dutch" Kindelberger and J.L. "Lee" Atwood are currently being converted into book form.