

NAVAHO SUPERSONIC "PILOTLESS BOMBER": U.S. SPACE TECHNOLOGY INCUBATOR

The Navaho project, an effort to develop a supersonic, intercontinental-range, ramjet powered "pilotless bomber", was a failure in the sense that more than \$300 million (1950s dollars) was spent and no missiles were deployed. The project did, however, foster the development of North American Aviation's Rocketdyne Division. Rocketdyne developed a series of advanced liquid rocket engines for Navaho's boosters. When ballistic missile funding became a priority, Rocketdyne's already-in-production engines were used. An early Navaho rocket engine found its way into the Redstone missile. Modified versions of the more powerful Navaho G-38 rocket engine powered Atlas, Jupiter, and Thor. Navaho's booster engine, heavily modified over the years, had, by 1998, boosted more than half of all U.S. space missions.

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Fourth XSM-64 (G-26) Navaho test launch, Cape Canaveral LC 9, June 26, 1957.

The Navaho project, conceived during the late 1940s, went through several metamorphoses. An early Navaho concept, a canard-configured, delta-winged, dual ramjet powered intermediate range cruise missile boosted by a new, tail-mounted liquid rocket engine, entered the hardware phase and was nearing test flight when the effort was shelved in early 1950s. The missile rocket engine, based on captured V-2 engines given to NAA, survived to power the U.S. Army Redstone ballistic missile.

In the early 1950s, the Navaho project coalesced into a new three-phase effort. Phase 1 involved the design, construction, and test flight of several X-10 turbojet powered, remotely controlled vehicles. X-10 tested Navaho's radical canard-configured-delta-wing-with-canted-twin-tail aerodynamics at supersonic speeds; first at Edwards AFB, California, and then at Cape Canaveral. X-10 also tested Navaho's gyroscopic all-inertial autonavigator/autopilot by flying under its own control on a prescribed course for extended periods. X-10 "pilots" would control the vehicles during take off and landing from a ground station and from a chase plane. Aerodynamically slick, and powered by two jet engines, X-10 at one point set a speed record for turbojet powered aircraft. Landing and radio control failures destroyed several X-10s, however.

Phase 2 included the design, development, and test of the 2,500 mile range Mach 2.75 XSM-64 (G-26) "pilotless bomber". A powerful twin-thrust-chamber liquid rocket booster propelled the supersonic missile to ramjet startup speed about one minute after a vertical launch. Four thrust vector control vanes extending into the G-26 booster exhaust provided pitch/yaw/roll control during the boost phase. The booster drag-separated upon burnout.

Navaho G-26 launches began on 6 November 1956, months before most of the ballistic missile pads at the Cape were in operation. Ballistic missilery soon caught up with and passed Navaho, however. The first two G-26 flights failed and the third ended abruptly with a massive on-pad explosion.

By the time the fourth XSM-64 (G-26) test launch (shown above) commenced from Cape Canaveral Launch Complex 9 on 26 June 1957, the project was nearing cancellation. This flight, involving Booster No. 8 and Missile No. 3 (AF53-8270), failed when the missile ramjets did not ignite after the boost phase. Some sources blame the failure on a booster malfunction. Other sources blame it on the ramjets.

Phase 3 of the Navaho project involved the development of the 5,000 mile range Mach 3.25 XSM-64A (G-38) intercontinental range missile. A much more powerful three-chamber liquid rocket booster would have boosted the bigger G-38 missile to ramjet startup speed. The booster engines would have gimballed

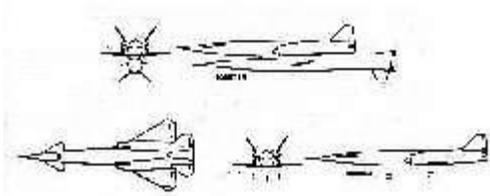
to provide pitch, yaw, and roll control during the boost phase. G-38 never flew, but NAA built some booster and missile hardware and extensively tested the rocket engines.



An XSM-64 (G-26) on Cape Canaveral LC 9

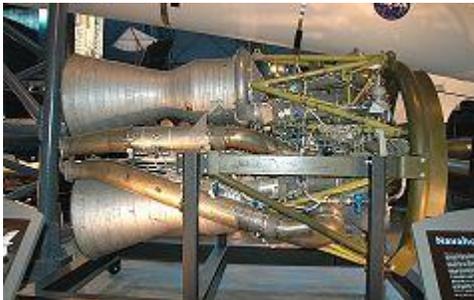
One of the first nine Navaho XSM-64 (or G-26) test missiles is shown on Cape Canaveral Launch Complex 9. The missile is shown encased within its erecting tower, a structure built by the Food Machinery Corporation. That company would in later years be called FMC. Early Navaho missiles, like this one, featured red and white paint, with USAF serial numbers painted on their vertical stabilizers. The boosters were painted white, with North American Aviation (NAA) booster numbers on the fins. The photographer was facing east/northeast when this image was taken. Navahos rose vertically, then pitched toward the ocean with the missile on top and the booster beneath.

When the Navaho program was cancelled, the Air Force authorized NAA to continue G-26 test launches under the "Fly Five" program. Five G-26 booster/missile sets were launched during this effort by the end of February 1958. At least three of the missiles survived the booster phase and started their big Curtiss-Wright ramjets. One of the missiles completed half of a flight, but suffered a ramjet flameout when it turned around to head back toward the Cape. The tests showed that Navaho could have been made to work, given sufficient time and money. The tests also showed, however, that the complex system probably would have been less reliable than ballistic missiles.



XSM-64 (G-26) Diagram

This diagram of the XSM-64 (or G-26) "Navaho Strategic Missile" shows that the canard-configured, delta-winged missiles were to be recovered through the use of glide brakes, drag chutes, and tricycle landing gear. Whether or not any of the eleven missiles launched were equipped with landing gear is unknown. If so, and if any had survived their test flights, they would have landed on the Cape Canaveral Skid Strip adjacent to Launch Complex 9/10. None of the G-26 missiles made it back to Canaveral, however.



XLR71-NA-1 G-26 Booster Propulsion Unit at Smithsonian

The G-26 missile/booster combination stood 83.8 feet tall at launch. When configured for a missile recovery R&D test flight, G-26 weighed 135,320 pounds at liftoff. The 76.4 foot-long booster was equipped with a North American Aviation Rocketdyne XLR71-NA-1 power plant composed of two 120,000 pound thrust engines that burned for 65 seconds. The booster carried 4,076 gallons of alcohol in its aft cylindrical tank and 3,977 gallons of LOX in its tapered forward tank. It weighed 75,320 pounds at launch and 7,920 pounds empty.

Two Wright XRJ47-W-5 ramjet engines, designed to provide 8,050 pounds of thrust each, powered the 67.8 foot-long G-26 missile to Mach 2.75 at 55,000 feet. The missile had an all-moving forward canard, a 28.2 foot wingspan, 425 square feet of wing area, and stood 16.3 feet tall on its landing gear. At launch,

the missile weighed 60,000 pounds, including 5,024 gallons of JP-5 fuel. The missile weighed 23,490 pounds empty.

Early Navaho test flight missiles were to be equipped with a radio command guidance system for flight and recovery control. Later flights would use NAA's advanced inertial auto-navigator/auto-pilot system, designed to direct the missile to a target 2,500 miles away. The planned R&D flight test profile involved a rocket boost to an altitude of 47,900 feet, where the ramjets would start and the booster would separate. The missile would begin its supersonic cruise at 58,100 feet. As it used up fuel, it would gradually gain speed and altitude. When it was 425 nautical miles from the Cape, the missile would initiate a 90 nautical mile radius, 180 degree turn that would point it back toward the Cape. Near the end of its flight, the G-26 would reach 74,500 feet. After ramjet shutoff, the missile would dive toward the Cape Canaveral Skid Strip for a landing. G-26 would average Mach 2.75 during the flight. The entire test would cover nearly 1,100 nautical miles in about 45 minutes.

Nonrecoverable flight test G-26 missiles would have weighed less and would have been capable of one-way flights to a range of 2,325 nautical miles.

The final two Navaho launches supported the Research In Supersonic Environments Program (RISE). RISE was meant to provide data for NAA's XB-70 and X-15 projects, both then in the design stage. Both RISE flights failed, however, and the project was halted.



Project RISE Navaho Prelaunch

This photograph shows one of the final two Navaho XSM-64 missiles standing on Complex 9. The unpainted booster hints that this most likely was the last Navaho launched on 18 November 1958. Both Navaho RISE missiles were unpainted, but the first RISE flight used an older, white-painted booster.

When RISE began, more than a year had passed since the Navaho project had been cancelled and six months had passed since the last Navaho test flight. By then, NAA had probably already reassigned many of the more than 600 Navaho Cape Canaveral flight test personnel. Seven remaining G-26 missile/booster sets were assigned to RISE, but no engineering design effort was allocated for the never-perfected birds. NAA shipped the Navahos as needed to the Cape from the Downey plant.

When RISE was cancelled, at least one Navaho was at the Cape and the rest were in California. The Downey G-26 sets were later reportedly damaged in a rainstorm roof collapse and scrapped. It is likely that the G-26 already shipped to the Cape was stored in one of NAA's Cape Canaveral hangers ("E" or "F"), then later donated to the Cape Canaveral Air & Space Museum when it opened in 1964. Early photos of the Museum show the Navaho unpainted and in RISE markings. The Cape Museum's G-26 is likely composed of parts from Missile No. 10 and Booster No. 15.

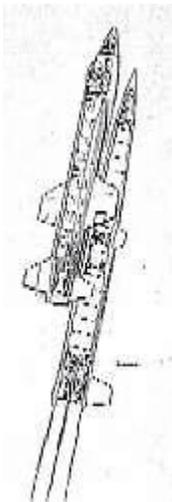


By 1994, corrosion had attacked the fuselage and wings of the Cape Canaveral Museum's XSM-64 (or G-26) Navaho missile. Small plants had taken root in the booster's intertank section. The Navaho was subsequently removed for restoration, returning to a new display site near the Cape's south gate in 1998.

Soon after RISE was cancelled, Launch Complex 9/10 was bulldozed to make way for Minuteman Launch Complex 31/32. The Minuteman complex was oriented on a slightly different azimuth, so a small portion of the Navaho launch site remained outside the fence, including the massive Launch Complex 9 concrete hard stand. Today, it sits next to a Cape access road, covered in vines and largely forgotten.

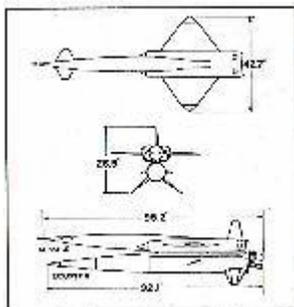
Ironically, the remains of another NAA/Rockwell product rest nearby, within the Complex 31/32 fence line. Stored there are shattered remains of shuttle orbiter Challenger.

X-15/G-26 Booster Concept



After Sputnik 1, U.S. aerospace companies launched a blizzard of "get to space quick" proposals. NAA proposed using leftover Navaho boosters to launch one of its newly completed X-15 rocket planes to the edge of space. Engineers also looked at converting the boosters into space launchers by fitting upper stages to them. Some effort was apparently made to see if G-26 or G-38 Navaho boosters could be used to launch USAF Pioneer Moon probes.

In the end, none of these proposals panned out, and all of the Navaho hardware in California was scrapped by Government order. NAA designers were especially troubled to see the G-38 boosters scrapped. They were, at the time, easily the most powerful rockets in the U.S. Their scrapping occurred in the days following Sputnik 1.



XSM-64A (G-38) Diagram

This diagram shows the never flown XSM-64A (or G-38) intercontinental range Navaho. When Navaho was cancelled on 11 July 1957, the first G-38 booster was undergoing structural tests and several G-38 missiles were nearing completion. The G-38 had a trapezoidal, almost elliptical, mid-wing, instead of the G-26 low-wing truncated delta. A single vertical stabilizer replaced twin, canted tails, and the forward canard assumed a trapezoidal shape.

The G-38 missile/booster combination would have stood 95.2 feet tall at launch and weighed 298,500 pounds. The 92.1 foot-long booster would have been powered by a North American Aviation Rocketdyne XLR83-NA-1 power plant composed of three 135,000

pound thrust engines that burned for 110 seconds. The booster would have carried 7,246 gallons of kerosene in its forward tapered tank and 12,182 gallons of LOX in its aft cylindrical tank. It would have weighed 179,076 pounds at launch. Two Wright XRJ47-W-7 ramjet engines designed to provide 11,300 pounds of thrust each powered the 87.6 foot long missile to Mach 3.25 at 45,000 feet.

Both the forward canards and the vertical stabilizer were all-moving control surfaces. The 42.7 foot span wings had all-moving triangular wing tip ailerons. Speed brakes were located in the aft part of the fuselage. The bulk of the missile was constructed of titanium or corrosive-resistant steel.

Operational G-38 missiles were designed to reach targets 5,220 nautical miles away in 170 minutes, gradually gaining altitude until beginning a terminal dive from 82,300 feet. Developmental G-38s would have been equipped with "bicycle" landing gear, including a nose wheel, aft skid, and wing tip skids, for unpowered, chain arrestor assisted landings on the Cape Skid Strip.



G-38 Missile Recovery Arrangement

This NAA/USAF drawing shows how a G-38 missile would have returned to land on the Cape Skid Strip. If any G-26 missiles were so configured, none ever made it back to the Cape to test the recovery system design.



G-38 Model

In the mid-1990s, this NAA-built G-38 see-through model resided in a dusty back corner of the Planes of Fame Fighter Jets and Air Race Museum in Chino, California.

XSM-64 (G-26) Test Flight Record

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      Date  Missile-   Serial No.  Result
          Booster No.
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1.  11/6/56  M1-B3     AF52-10989  Pitch rate gyro at 10s
2.  3/22/57  M2-B6     AF52-10990  Early booster shutdown
3.  4/25/57  M5-B7     AF53-8272   Exploded on pad
4.  6/26/57  M3-B8     AF53-8270   Ramjets fld (bster mlftn?)

- 7/12/57 -- Navaho program cancelled (&"Fly-5" authorized)-

5.  8/12/57  M4-B9     AF53-8271   Ramjets failed after 566s
6.  9/18/57  M6-B10    AF54-3095   OK for 450 nmi
7.  11/13/57 M7-B11    AF54-3096   Destroyed at T+75s
8.  1/10/58  M9-B13    AF54-3098   Ramjet flmout at 1075 nmi.
9.  2/25/58  M8-B12    AF54-3097   Booster cutoff at T+20s
  
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-- End of "Fly-5" -- Seven G266 vehicles remaining were --
-- assigned to RISE program -----

10. 9/11/58 M12-B4 AF55-4223 Ramjets failed to ignite
11. 11/18/58 M11-B14 AF55-4222 Control fail at booster
burnout

-- RISE program terminated -----

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Five G-26 vehicles remained at the end of project RISE. The Cape Museum's G-26 is likely composed of parts from Missile No. 10 and Booster No. 15.

Thirty-two turbojet-powered Navaho precursor X-10 test flights were completed altogether, by about a dozen X-10 vehicles. Some of these flights were at Edwards AFB. Some were at Cape Canaveral. All but one of the X-10s were destroyed. X-10 serial No. GM-19307 is now at the USAF Museum at Dayton, Ohio.

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