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The Navaho Project - A Look Back

by James Gibson

WHAT WAS IT?

Fifty years ago, on July 13, 1957, one of the most important American missile programs came to an end. It had begun immediately after the fall of the Third Reich. It ended at the beginning of the Cold War with the Soviet Union. Its accomplishment was the development of the technology that won the Cold War and landed men on the moon.

Navaho is the oddball when it comes to the history of guided missiles. Most programs either are successful, or are cancelled and fade into obscurity. Such missiles as the ASALM (Advanced Strategic Air-Launched Missile), the Typhoon, and the Skybolt failed to be deployed and produced little technological advancement. Even several deployed missiles had short life spans because of technical difficulties and left little of a technical legacy.

Navaho, however, was both a failure and a major triumph. The technology it developed actually made possible the vehicle that made the Navaho obsolete before Navaho could be deployed. In the process, Navaho built the company that would then lead this nation to the moon and development of some of the most historically important missile and space systems ever conceived.

And yet, when the Navaho began, its concept was nothing more than a "Winged V-2" that glided into its target at super-sonic speed. From this highly uninspiring start would come a vehicle twice as long as the V-2, eight times the mass, powered by two liquid fuel engines producing three times the engine thrust and a range of over 2,240 miles. And that was just the scaled down prototype G-26.

Photo from the James Gibson Collection
G-26 Vehicle No. 14 being completed at the Downey facility. The jack placed under the guidance section kept the vehicle level during assembly. Otherwise, the short nose gear would make the nose droop. The tails of the missile were so high, the main landing gear had to be retracted and the missile pulled out on a low dolly. The four foot diameter ramjets are the largest to have ever flown to this

In the past fifty years, much has been written about the accomplishments of the Navaho program. Articles about the creation of the Rocketdyne Division in Canoga Park and how the engines developed there powered the Atlas ICBM, which made the Navaho obsolete in 1957. In the years that followed, Rocketdyne engines made possible the Apollo Saturn V, the Delta Rocket and even the Space Shuttle.

Other articles discussed the Autonetics Division, another offshoot of the Navaho program. These articles noted how the electro-mechanical and guidance technology developed for Navaho found its way into other "manned" air and spacecraft and into Navy nuclear ballistic missile submarines.

And still more articles reviewed the supersonic aerodynamic research accomplished by the program. One researcher recently even contacted the author regarding references to X-10 flight test data being used in the aerodynamic design of the Mach 3 XB-70 bomber.

But only a few articles and one book have ever been written about the program itself. This is due to the secrecy that the program worked under for over a decade. Articles by Dale Meyers and the author described aspects the program, but few knew the entirety of the program.

Hence, we get to the point of this article, written fifty years after the program was cancelled. What was the ultimate operational vehicle, the G-38 or XSM-64A going to be like? Fifty years after it was cancelled, the final vehicle is still the greatest enigma of the Navaho program. The vehicle all this technological advancement was leading up to has never been fully described. Even those who worked on the program in 1957 can barely describe what truly was to be the Navaho. That is until now...

THE BLACKEST OF PROGRAMS

When people talk of black programs they truly mean the Navaho. The author has met NAA engineers who today know they were working on the program but, because they were not cleared, never saw an X-10 or a G-26 until after the program was cancelled. Even the name "Navaho" was top secret as was the missile designations by both the company and the U.S. Air Force. And the biggest secret of them all was the final vehicle, the G-38. At the time the program was cancelled, its shape and dimensions were known only by a select few. And when the program was cancelled, the design was filed away.

In the decades that followed, people have pieced together some of the facts regarding this vehicle. That it used a Kerosene and LOX fuel mixture; that the booster would have three liquid fuel engines instead of two, and that the air vehicle would have a single tail. But these facts alone can't describe the vehicle properly. It's like the old story of six blind wise men who were asked to describe an elephant!

It is the secrecy regarding this vehicle that has undermined the full legacy of the Navaho program. Whenever historians look at the accomplishments of the program they tend to look at the technology of the G-26 instead of the final vehicle. The G-38 is so much more than an upscaled G-26; the two hardly are in the same category.

The G-26 used 18-8 and 17-7 Stainless Steel for both its skin and structure. The G-38 would also have these materials, but its wings were to be made using the newly developed 6A14V Titanium. The titanium forging technology and the heli-arc welding technique for assembly that was developed for the Navaho would later be used in the assembly of the legendary A-l 1/A-12/SR-71 blackbird family of high-speed aircraft.

The G-26 used Alcohol/LOX fuel for the booster, same as the earlier German V-2. The G-38 would use Kerosene/LOX, a Rocketdyne research developed high-energy fuel combination which greatly increased the thrust levels. It was this Kerosene/LOX combination that would make possible the Atlas, Thor, Delta and Saturn launch vehicles.

The G-26 used jet vanes to direct the direction of booster engine thrust just as on the V-2. The G-38 would use gimbaled engines, a very new development in liquid fuel engine technology. Gimballing was another technology that Atlas would benefit from, as well as the Saturn V, and finally the Space Shuttle Main Engines. Many people have noted the similarity of the Shuttle main engine systems to the earlier G-38 cluster.

To grasp the immensity of the project, here are the specifics of the operational vehicle that North American Aviation was attempting to design and build in 1957.

As indicated, the G-38 was a massive guided missile. Compared to the G-26 the G-38 was almost 30 longer, 6 feet greater in height from tip of tail to tip of booster fins, 14 feet greater in wingspan and a whopping 83% heavier. The all up vehicle was 11 feet longer and again weighed more than twice as much. And yet the G-38 was to be a semi-mobile weapon system.

The Navaho G-38 would be assembled at a main depot located at a U.S. Air Force base from which it would be launched. When called into action, the missile would be moved on its erector to an

SPECIFICATIONS {G-38}

Dimensions

Missile
- Length: 87 ft.-7 in.
- Height: 15ft.-3.5in.
- Wing Span: 42 ft.-9 in.
- Weight: 119,424 lb. (launch)

Booster
- Length: 92 ft.
- Diameter: 6 ft.-6 in.
- Weight: 179,000 lb. (launch)

Combined
- Length: 95 ft.-2 in.
- Height: 26 ft.-7 in.
- Weight: 298,500 lb

Performance

Missile
- Speed: Mach 3.25
- Altitude: 58,000 to 82,000 ft.
- Range: 5.220 nmi. (6,011 mi.)
- CEP: 6,000 ft. at 6,000 mi.

Booster
- Altitude of engine burnout: 58,800 ft.
- Altitude of ramjet start: 62,700ft.
- Altitude of vehicle separation: 70,000 ft.

Propellant Capacity (gallons)
- Missile: 11,510 Kerosene
- Booster: 7,426 Kerosene
  12,182 Oxygen

Propulsion

Missile: Two XRJ47-W-7 Wright Aeronautical Ramjets
- Thrust: 40,140 lb. at 45,000 ft.
  5,940 lb. at 85,000 ft.
- Specific Impulse: 1,564 sec

Booster: Three XLR83-NA-1 liquid fuel rocket engines
- Maximum Thrust: 405,000 lb.

Guidance

Missile: Autonavigator - N6B
Flight Control - P3A

Booster: Controlled by missile guidance

isolated launch site on base. Essentially, it would be deployed at one of many launch sites, erected, fueled and then fired. The Air Force projected that it would take 8 hours to do this, 16 if the vehicle had to assembled.

Yet, can you imagine trying to move this monster by road. Even with the tail and wings off, the vehicle would be quite a load. The booster alone was 92 feet long. As for the missile, it was 140 inches across without the wings, which is just under the width of an Abrams tank.

Eventually, fixed hardened launcher proposals were made. Called Navahogans after the Navaho word for home, these launchers were similar in design to the later Atlas coffin launchers used by the Air Force. From these launchers the Navaho could have been fired within 20 minutes of a launch order.

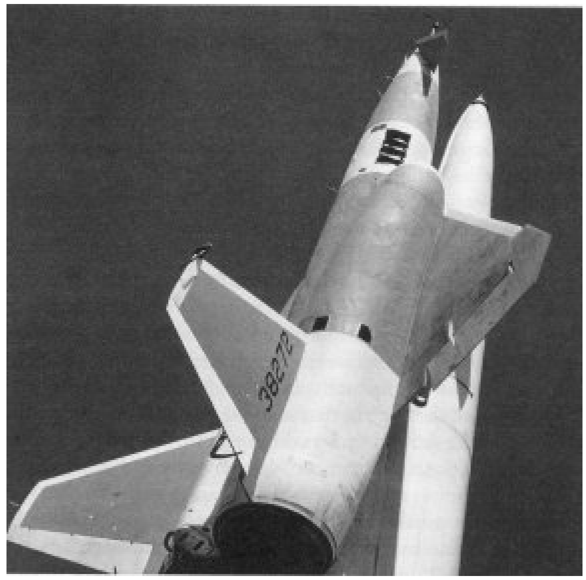

Photo from the James Gil/son Collection

G-26 Vehicle No.5 (8272) in close-up on the pad at Complex Nine. The metal hook on the rudder measured control surface deflection. Note that the covers are not on the instrument compartment. The structural rings give the appearance of being vents.

THE WARHEAD

Of course, the movement issue was not the real problem with the Navaho vehicle. The issue that would kill the program was the variety of warheads it could carry.

Navaho was capable of carrying multiple classes of nuclear warheads according to old documents. Even though the Navaho was huge, the warhead selected had a major effect on the vehicle's range. The Class B warhead weighed 15,000 lbs and cut the range of the Navaho to 5,078 miles. The newer Class C warhead at 7,000 lbs was necessary to give the Navaho its full range of 6,000 miles. These old documents don't even state what the range would have been with a class D, but an estimate of 6,350 miles can be assumed.

Though capable of carrying extremely heavy warheads, this fact was a detriment to the Navaho G-38, not a virtue. Being able to carry a class "B" bomb like the 5 megaton Mk-21 thermonuclear warhead had very limited value in 1956. By that time, both Class C and Class D warheads had been deployed with equal yields but greatly reduced weight. Of particular note were the Class D's which weighed in at less than 1,500 lbs. The Atlas warhead was just such a lightweight Class D warhead.

Navaho had the edge in that it could carry over ten times the payload of the Atlas; but it didn't need to. Someone, late in the program, proposed that the Navaho be turned into a drone bomber, dropping multiple warheads during its one flight. But the idea was impossible, given that the vehicle stayed structurally stable due to internal pressurization. To try and open a bomb bay at Mach 3.25 would literally tear the vehicle apart during the initial delivery.

If the weight of the Hydrogen Bomb had stayed over 7,000 lbs, Navaho would have won out over the Atlas. But miniaturization was a major activity in the 1950s. Even Navaho was caught up in this effort with solid state circuitry in its guidance and flight control systems. The development of solid state electronic systems was one of the reasons the Hydrogen Bomb shrunk in size.

THE TECHNOLOGY THAT MADE IT POSSIBLE

Even though the vehicle was killed by warhead developments you have to take note of everything that came from the Navaho program. To make even the G-26 work, required a number of technological breakthroughs that were essential in the making of the subsequent Apollo moon vehicle.

The author feels the comment made in the official Air Force history of the program stated it best. The by-products of the Navaho program deserve more consideration than could be granted in this abbreviated treatment of the missile development process. Apart from the serendipitous benefits of the technical program, the Navaho effort directly and immediately contributed to several major programs that (at the time this is written) bulked large in the nation's defense. Both the B-70 and the abortive F-108 programs drew heavily on Navaho air-frame developments. The SM-65 Atlas—and for that matter, probably most of the United States rocket vehicle effort—relied on engines originally developed for the Navaho. The guidance system found widespread application in both air vehicles and elsewhere—including nuclear-powered submarines for example. Launch techniques, instrumentation processes, test range procedures, manufacturing devices, management innovations—all these, and many other facets of the Navaho program influenced the course of other major programs undertaken by the three armed services of the United States. For obvious reasons, it proved impractical in most instances even to hint at later applications of Navaho technology.

Fifty years later the author can hint at several other programs the historians in 1961 couldn't predict. The Apollo Saturn V first stage used liquid Oxygen-Kerosene engines built by Rocketdyne. It also used the Navaho technique to attach the insulation fiberglass to the LOX tank. The later Delta II, III, and IV expendable launchers, the Atlas until recent years, and the Space Shuttle all use Rocketdyne engines. Rocketdyne would in fact make the engines for all the important space launch vehicles including the Redstone that carried the first U.S. satellite and the first American Astronauts.

Other programs benefited from the Navaho guidance technology. Hound Dog used a reduced capacity Navaho guidance with star tracker inputs. The Polaris and Poseidon ballistic missile submarines, in turn, used an enlarged unit called the N-7 to accurately track their locations. The A-5 Vigilante also used Navaho guidance and flight control technology to make it an accurate bombing and reconnaissance aircraft. Even the Northrop Snark used an early Navaho N-2C as a backup guidance unit.

As the Air Force history put it, "North American proved that inertial guidance could be based on a 'local-level vertical gyro concept' in which the gyros and accelerometers were always oriented to the local gravity vector. The concept established by MIT, and generally accepted at the time North American began work on the N-6, was to keep the gyros fixed in relation to vertical space. Without doubt, the Navaho guidance program had produced results of considerable benefit to the Air Force and the nation. As for the N-6A, the end product of the work in the SM-64 program itself, it was apparent that the prototype systems available for test in 1957 were significantly better then any comparable systems produced by parallel or competing programs."

Other Navaho developments were chemical milling, solid state electronics, the airborne digital computer, heli-arc fusion welding, plymetal (stainless steel honeycomb material), and aluminum honeycomb.

And yes. Cape Canaveral owes Navaho for the development of most of the liquid oxygen safety procedures, the first radar tracking system at the base, radar controlled cameras for documenting flights and basically the general testing processes used today.

OF COURSE THE MYTHS WILL CONTINUE

And what do I mean about the myths? Well for one, the myth of launching an F-108 or an X-15 from the back of a Navaho booster. Most recent models of these proposals used the G-26 booster in their depictions. The real booster proposed for these methods was the G-38.

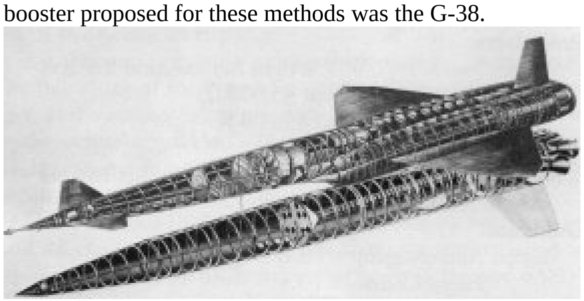

Illustration from the James Gibson Collection

Think about it. The X-15 concept was supposedly intended to put the X-15 into orbit. To put a 3,000 lb Mercury capsule into orbit required a 260,000 lb Atlas ICBM with a take-off thrust of 360,000 lbs. The X-15 weighed ten times that of a Mercury Capsule or 33,000 lbs. Add to that a disposable ablative heat shield like that tested on the X-15A-2 and you get a payload of at least 37,000 lbs on top of the 76,000 lbs of the G-26. Total takeoff weight would therefore be over 113,000 lbs. The G-26 booster’s 240,000 lb thrust just barely gives the same amount of over thrust as the Atlas Mercury combination.

A G-38/X-15 combination, however, is more plausible. The combined weight of 200,000 lbs would give a two to one thrust to weight ratio. This is why the originally drawings of the concept show a three engine booster instead of a two engine.

As for the F-108 Rapier, well the numbers are quite specific. The F-108 weighed 200,000 lbs fully loaded. Add to that the all up weight of a G-26 booster of 76,000 lbs and you have a total mass at takeoff of approximately 276,000 lbs. The maximum thrust of the G-26 booster was only 240,000 lbs so to make it work at all would require the G-38 booster.

Of course, even with the mighty G-38 booster the whole concept wouldn't have worked. To make it work would have required the installation of the G-38 autonavigation and flight control system into the X-15 or the F-108. Then electronic connections would have had to be made between the booster and its payload. Otherwise, the G-38 booster had no guidance inputs.

The idea of using the G-38 booster for these projects was just as bad as the proposal to turn the G-38 into a satellite booster. The G-38 structure was not designed to carry a payload on the nose; this is why all the F-108 and X-15 drawings show them in piggyback mode. Add to this the fact that the engine thrust was only for 100 seconds while an Atlas operates for at least five minutes. Finally, some form of guidance system would have to be devised to control this launch vehicle.

Probably the greatest myth perpetuated by the secrecy of the Navaho program is the Russian Navaho or Burya.

CAN WE STILL LEARN FROM THE NAVAHO?

The answer to this last point is, "Yes". Even more so today than forty years ago when Apollo engineers were reviewing existing Navaho technology as they were preparing to send men to the moon. Technology developed in one program may be applicable to new programs or applications. But already built examples will not be as effective as newly designed items based on that same technology.

Today we are trying to turn the components of the Space Shuttle into two new space systems. Called the Orion project, there is the manned Ares 1 vehicle and the unmanned Ares 5 heavy lifter. These two vehicles are to be the means by which we will again land humans on the moon.

Unfortunately, the concepts may fall victim to the same problems that insured the G-38 booster could not be used for other projects. The load paths on the Ares 5, which is built from the Space Shuttle fuel tank, were designed for piggyback carry. Either extensive work will have to be done to strengthen the upper portion of the tank to carry the payload without collapsing, or extensive analysis done to prove that the present design will work.

There is also the addition of engines at the base of the tank to propel the vehicle into space. Again, the base of the tank was never designed for thrust loads in that area. Like a beer can being pressed on both ends, the whole tank could crush if the compressive loads are too high.

Then, there is the issue of guidance. Or more specifically the guidance commands for the solid motor gimbals. Like the G-38 in which the guidance unit coordinated the gimballing of the three motors with the aerodynamic surfaces of the G-38, in the present Shuttle design the Shuttle guidance computers coordinate the solid motor gimbals with the gimballed engines of the Space Shuttle to achieve flight control. The new Ares V will need a guidance computer added somewhere on or in the tank area that will coordinate the new motors and the solid rocket gimbals.

Of course, there will be no coordination in the Ares 1 since it only has one solid rocket motor. The guidance inputs also came from the Shuttle through the tank to the solid rocket motor. Some additions like an electronics tunnel will need to be added to carry the guidance inputs from the new Crew Exploration Vehicle (CEV) on top of the stack down to the engine gimbaling units.

Furthermore, the long solid rocket motor casing was also never designed to carry compressive loads. It was designed to restrain the internal explosive force of the burning solid rocket fuel. And this internal explosion will be greater in the new Ares vehicles since an additional two segments of solid propellant will be added. The first flight of this vehicle will be most interesting.

We need to realize that the real worth of a vehicle or a program is not the final vehicle but the technology developed to create it. To build Navaho, North American Aviation gave American Aerospace: chem-milling of aluminum, titanium forging, heli-arc welding, advanced aerodynamic data, solid state circuitry, long term inertial guidance, and numerous other technologies that are today baseline in the industry. The Shuttle program provides a wealth of

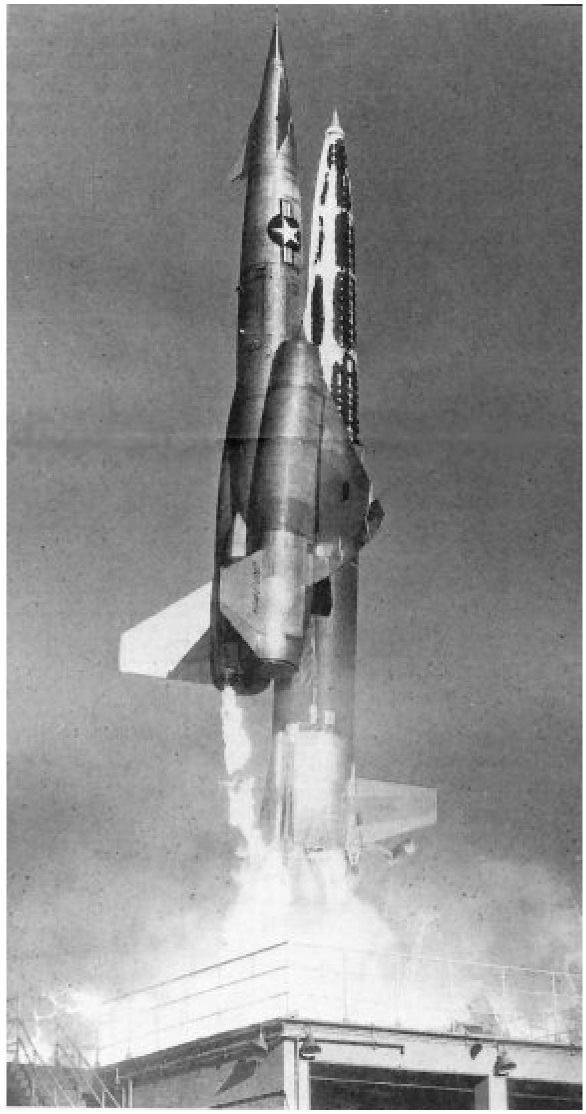

Photo from the James Gibson Collection
Fifty years ago, on July 13, 1957, the Air Force cancelled the Navaho program. Although cancelled, the Air Force agreed to five more G-26 launches to gather data on the high environment encountered at Mach 2.75. These flights were known as the Fly-Five Series. After completion of these flights, the Air Force authorized the RISE (Research Into Supersonic Environment) program to expend the remaining G-26 missiles. The second flight of the RISE program occurred on November 18, 1958. Missile G-26 No. 4 (s/n 55-4222) and Booster No. 4 were successfully launched but the vehicle broke up at 77,000 feet. This was the last G-26 launched and the RISE program was cancelled.

technology and research into the design of a reusable space vehicle, particularly in how to build for maintainability. Much of this work, however, will not be used in the CEV because they intend to use as much of the present design as possible.

About the Author: James Gibson is currently assigned to the Materials and Process Engineering group at the Boeing Huntington Beach Division. He is a published author of two very comprehensive books: The Navaho Missile Project and Nuclear Weapons of The United States. As an engineer, he has worked on the International Space Station, Delta launch vehicles, and the Space Shuttle. James is the son of William Frederick (Hoot) Gibson]r. who spent thirty-five years as a stress engineer at the Downey facility. The senior Gibson is a veteran of the Navaho, Apollo and Space Shuttle programs.