

GREAT EXPECTATIONS

North American's Exotic Advanced X-15 Concepts

PART I

By Dave Stern

The X-Plane Birthed

One of the most successful ongoing NACA-NASA projects is their experimental research aircraft series. A highlight was the stunning success of the NASA/USAF backed North American Aviation hypersonic X-15 research program. The "X" program was birthed during a secret conference on December 18, 1943, in Washington, D.C., where Mr. Bob Wolf, Bell Aircraft assistant chief design engineer, made the case for a gas turbine powered "high speed flying laboratory."¹

Bell's XP-59A twin-turbine powered jet fighter had been flying at the secret Muroc Dry Lake Test Site since September 29, 1942. (Bell test pilot Robert Stanley performed three unofficial "high-taxi" lift-offs between one and two feet above the dry lake surface - thus actually flying before the official October date.)

Larry Bell having flown in the "up front" instrumented open cockpit and passenger seat of the XP-59A at the Muroc Dry Lake facility was pleased with the flight tests. He and his engineers were confident they



Overall design parameters of XS-1 are noted in this photograph displaying the ogive nose, bullet-shaped fuselage and straight wing layout. (Tim Whetstone, Lawrence D. Bell Aviation Museum)

could design and construct a high-speed research aircraft to confirm advanced engineering and construction techniques, and contribute to America's high-speed aircraft database. On December 29, 1943, Larry Bell sent a letter to Dr. George W. Lewis, director of the NACA's aeronautical research division, suggesting a high speed flying laboratory.² Douglas Aircraft had been offered a contract to build such an aircraft but refused. So, on November 30, 1944, Bell's Bob Woods visited Major Kotcher at Wright Field and accepted the contract for what became their Model 44 or XS-1 also known within the USAAF as Project MX-524 cum MX-653.³

Further meetings with NACA and USAAF officers of the Air Technical Services Command at Wright Field fleshed out the airplane's parameters; it would penetrate the so-called "sound-barrier" or high-Mach numbers to approximately 800 mph, using liquid fuel rocket engines as a power source. On December 4, 1944, Robert Woods and chief test pilot Robert Stanley took an oath of secrecy and initiated the XS-1 project.⁴

The meetings included Bell Aircraft engineers Bob Woods and Benson Hamlin (a young excellent engineer engaged in designing the XS-1, who later teamed with chief engineer Casey Forrest to design the stillborn Bell X-16 high-altitude reconnaissance aircraft, and the exotic classified hypersonic SR-126 Robo or Rocket Bomber during the late 1950s, Hamlin



Maj. Chuck Yeager USAF pilot who flew X-1 through the so called "sound-barrier" discusses his air-adventures with Lawrence D. Bell's somewhat exotic high-speed projects. (Tim Whetstone, Lawrence D. Bell Aviation Museum)

worked at the Boeing Co. on their Dyna Soar Project., Paul Emmons and Dr. Vladimir Morkovin, Maj. Ezra Kotcher and Captain Pierce.⁵

No high-thrust turbine engines were available but one offered solution included a mixed-powerplant installation consisting of a ring of liquid fueled rocket engines around a single turbojet engine.⁶ All parties finally agreed to use the Reaction Motors, Inc., four-barrel XLR-11 liquid-fueled rocket motor generating approximately 6,000 pounds thrust to accelerate XS-1 to Mach 1.0 and, hopefully, beyond.

Thus was born the first rocket research aircraft although Jack Northrop's MX-324 subsonic rocket-powered flying wing (powered by Reaction Motors XCAL-200 burning liquid monoethylaniline),⁷ initially flew on July 5, 1944, at Harper Lake, Calif., with test pilot Harry Crosby bravely lying on his belly.⁸ The accumulated aerodynamic database gained from the XS-1 would be applied to near-future military turbine, rocket, and ramjet powered fighters, bombers, plus air-breathing cruise missiles - the latter being essentially an airplane.

Subtle publicized denigrations have mentioned the Bell XS-1 engineering team's simplistic design approach; i.e., to give nose blending into a somewhat chunky bullet shaped fuselage using a conventional straight wing planform. Bell engineers logically and correctly chose to design the XS-1 that correctly addressed aerodynamic pressures, stability and control to smoothly transition from the transonic speed range into the unknown region of Mach 1.0 and achieve higher speeds.

No supersonic wind tunnel or other high-speed database existed during the XS-1's initial wartime gestation, yet Bell engineers succeeded in achieving the requested performance goals by using two wing thickness/chord ratio choices - an 8 percent and 10 percent wing.

That the X-1 aircraft was nearly vice free, inherently stable and easily breached the sound barrier (X-1-2 serial 46-063 was modified into the X-1E and achieved Mach 2.24 speeds), again, with a straight wing;⁹ this alone is testimony in and of itself to the Bell engineer's somewhat intuitive and then current engineering approaches - a quite reasonable design configuration for the mid-1940 period.

Flying Hot and Hypersonic

The USAF understood the need for high-speed research and in 1947 they awarded Lockheed a contract to build the X-7 series of pilotless drop-test aircraft using incrementally larger ramjets to achieve high-altitude sustained-supersonic speeds.¹⁰ The X-7 also paralleled NACA Lewis Flight Propulsion Laboratory and Langley Research Center research aircraft flights, rocket launches and supersonic wind tunnel research programs, to increase engineering approaches applicable to the supersonic military aircraft appearing on the drawing boards.

In 1951, Dr. Walter Dornberger, ex-commandant of the German Peenemunde Rocket Research Center, was hired by



Bell X-1E number 2 X-1 (46-063) modified for high-speed flight. During its final flight on October 8, 1957, X-1E attained the quite impressive speed of Mach 2.24, a high achievement for mid-1940s technology and straight wings. (Ira G. Ross Aerospace Museum collection)

Larry Bell as a Guided Missile Specialist. Dr. Dornberger convinced Larry to propose an intercontinental range ballistic missile for the USAF; they rejected it since the USAF had allocated sparse funds to other firms developing them.¹¹

Instead, Dr. Dornberger persuaded the USAF to fund a project that combined the characteristics of both a ballistic rocket and an aircraft for long-range reconnaissance. Bell Aircraft funded its initial 1951 studies for their exotic piloted hypersonic ultra-high altitude reconnaissance-bombardment boost-glide aircraft, that was immune to interception by missiles or aircraft.

It interested the USAF enough to award funds in 1953 for MX-2145 cum MX-2276 the Bell engineering team baptized as "BoMi" (Bomber Missile), an aircraft radical enough to qualify as a space-plane. The BoMi Project was such a highly secret and tightly controlled project that nearly all Bell employees, outside of the design team and the aviation community, were totally unaware of its existence. BoMi was so beyond any near or long-term "X" research aircraft's performance and contemporary 1950s engineering expertise, that if approved for production and operational use by SAC, it would require at least a decade to actually develop. Consequently BoMi and other classified high-speed aircraft and cruise missile projects necessitated manned flight experience and data from a research aircraft flying at hypersonic speeds albeit for mere seconds.

With no advanced hypersonic engineering design criteria or advanced materials available to initially design BoMi, Bell engineers literally cut their own path, creating aerodynamic solutions while drawing from existing aeronautical knowledge.

The only engineering data available to the Bell team during early BoMi studies (Bell initiated BoMi design studies in 1951) and other supersonic and hypersonic projects were four secret NACA volumes of accumulated aeronautical research data, plus descriptions of upcoming high-speed research projects. The volumes contained no solid data for manned sustained



The prototype and number one X-15 (66670) beginning a journey from its birthplace to Edwards AFB on the high desert. (NAA photo)

hypersonic flight vehicles operating within and above the sensible atmosphere such as BoMi.

They were distributed as controlled-copies delivered only to the very top engineering executives of the major aeronautical firms. In Bell's case the NACA sent their four-volume set of research data to be controlled by Mr. Roy Sandstrum, Vice President of Engineering.¹²

Throughout the late 1940s up to 1951, Bell engineers were slowly digesting supersonic data derived from the X-1-1, X-1-2 (cum X-1E) and X-1-3, including the upcoming X-1A.¹³ It was tedious work as Bell employees slowly crunched the data by means of CPC machines (Card Programmed Calculators at 100 calculations per minute).

This radically changed when IBM Corp. introduced their *electronic engineer* machines that rapidly digested and transformed research data into aerodynamic calculations that Bell engineers applied to their AGM-63 Rascal, BoMi and a series of sub-orbital and fully orbital hypersonic vehicle studies.

The archaic term IBM *electronic engineer* referred to a computer - their initial model 650 Magnetic Drum Data Processing Computing Machine (a.k.a. Model 701 with a whopping memory storage of 20,000 digits stored in 2,000 separate "addresses" in a magnetic drum; it spit out 100 punch-cards per minute) with Bell taking delivery of one unit in early 1955.¹⁴

Both Government and industry had already purchased the 701 computer and quickly applied them to solving difficult engineering and performance problems with various missile and boost-glider projects. North American Aviation purchased an IBM 650 machine serial number 10 in October 9, 1953, several years before Bell installed their unit, and immediately applied it to their aircraft and missile projects.

To engage in short-duration and sustained hypersonic flight required advanced mathematics, aerodynamics and new materials technology, advanced methods of stability and control

- all utilizing the new computers to solve difficult problems. The really esoteric problems concerning hypersonic vehicles were aerodynamic structural heating studies initially titled "warm structures," later changed to "hot structures." They refer to a vehicle's thermal expansion, contraction, twisting and warping of internal-external components; other hot areas were the fuselage, airframe, wing and control surfaces, but included stresses sustained while flying at intra-atmospheric altitudes or outside the sensible atmosphere, yet fully protected a human crew, its reconnaissance equipment and weapons.

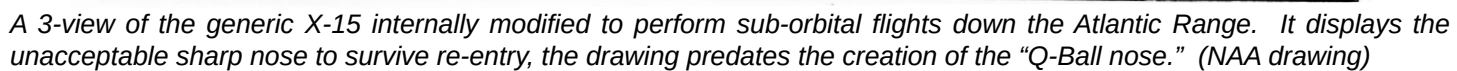
During sustained intra-atmospheric flight and hypersonic reentry from space, airframes would endure sonic vibrations, thermal expansion-contraction, the warping of similar and dissimilar metals plus a limited duration metal fatigue life throughout the airframe - in general, survival in a rapidly fluctuating super hot and cold environment. All of this was applicable to a manned hypersonic research aircraft as well. The USAF and NACA-NASA requested contract bids to build and fly a hypersonic research aircraft culminating in the high-point of the X-plane series when on September 30, 1955, North American Aviation won the X-15 hypersonic research aircraft contract; it went on to earn an honored place in U.S. and world aeronautical history.¹⁵

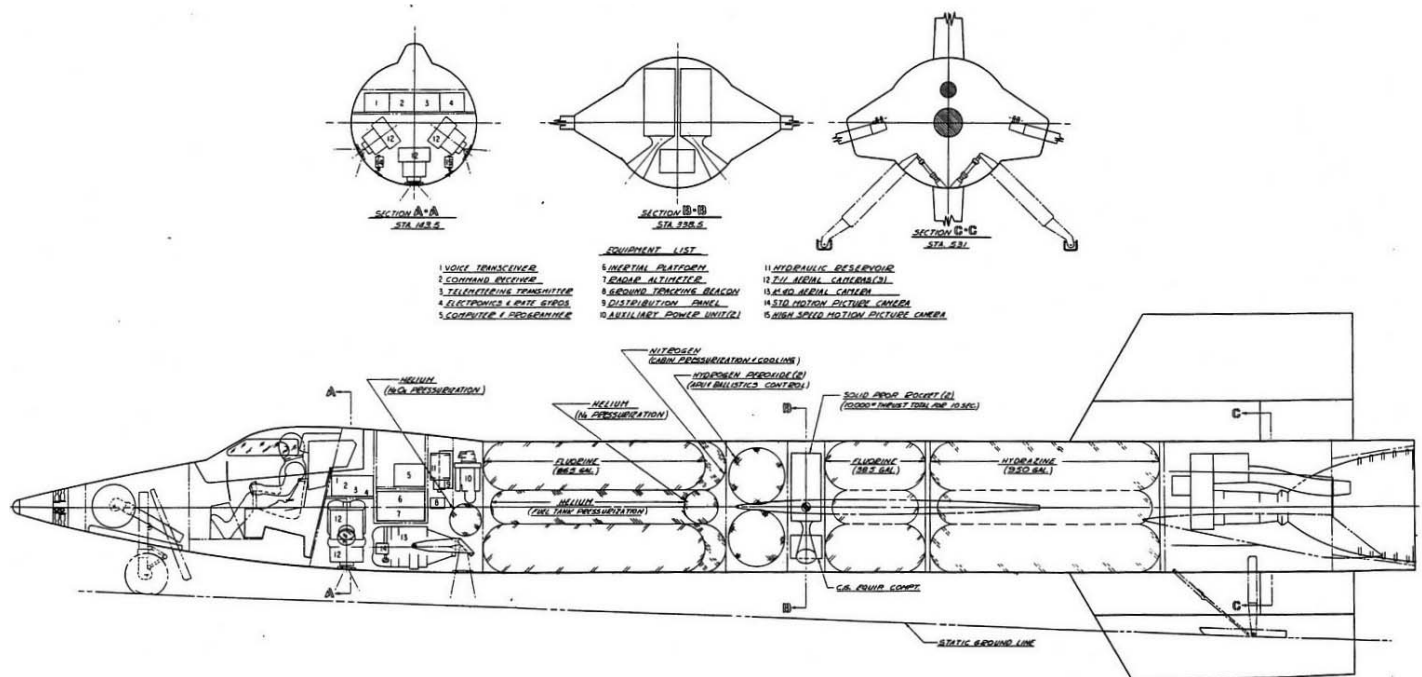
On October 15, 1958, one year and 11 days after the Russians surprised the world and shocked our government and military services by launching *Iskustvenyi Sputnik Zemli I* (artificial companion of earth or Sputnik I), North American Aviation's Los Angeles plant rolled out the first of three Model NA-240 X-15-NA research aircraft in preparation for its trip to Edwards AFB.¹⁶

Space Fears

Sputnik I impressed the world and mildly shocked American military and some civilian egos when the three-ton Sputnik II was launched. However, the real shocker was Sputnik III, a

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A drawing of the internal layout of the Orbital X-15B that was projected to accomplish a USAF orbital reconnaissance mission. (NAA drawing)

19-foot by four-foot diameter capsule that remained attached to its third stage booster some 80 feet long, when it was inserted into low-earth orbit - it included the first earth-passenger, the *Quadrupednaut* mutt *Laika*.

Shocked and alarmed, Western military and government intelligence people understood that Russia possessed a powerful booster (the R-7 ICBM modified), able to insert multi-ton payloads of capsules, manned or robotic reconnaissance satellites, winged spacecraft and nuclear weapons into orbit.

The USAF and industry were conducting spacecraft studies throughout the 1950s that suddenly increased when Sputnik I was launched. The USAF also solicited rapid response proposals for MISS-Man in Space Soonest cum MIS (Man in Space), using piloted semi-spherical and odd-shaped capsules or a hypersonic winged glide-aircraft. North American responded with the advanced modified X-15 even before the glide-test syllabus had been applied to X-15 vehicle No. 1, 66670.

Orital X-15

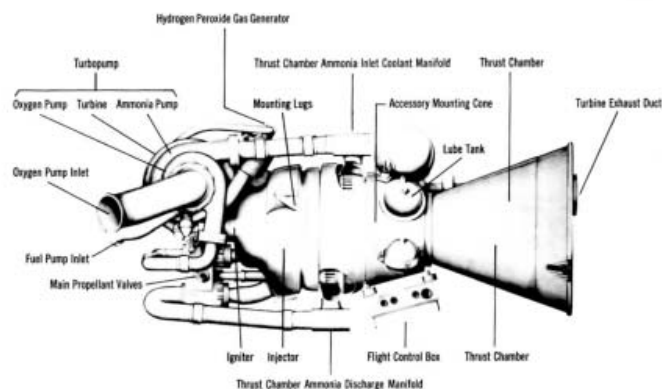
Just 23 days after Sputnik I, North American engineers within the Advanced Weapon System Design offices, completed specifications encompassing a three-step sub-orbital and fully orbital X-15 space-plane program. Step I used the standard generic X-15 airframe (31,250 pounds including a 1,500 pound payload) using the XLR-99-RMI-1 single-chamber engine, designed to burn high specific-impulse fluorine-hydrogen fuel.

NAA engineers projected XLR-99-RMI thrust levels at 60,000 pounds (sea-level) and 75,000 pounds at very high altitudes. This generic X-15 would be constructed of mixed-metals including high-temperature Rene-41 and to strengthen the rear fuselage, while carrying a 1,500 pound payload - its

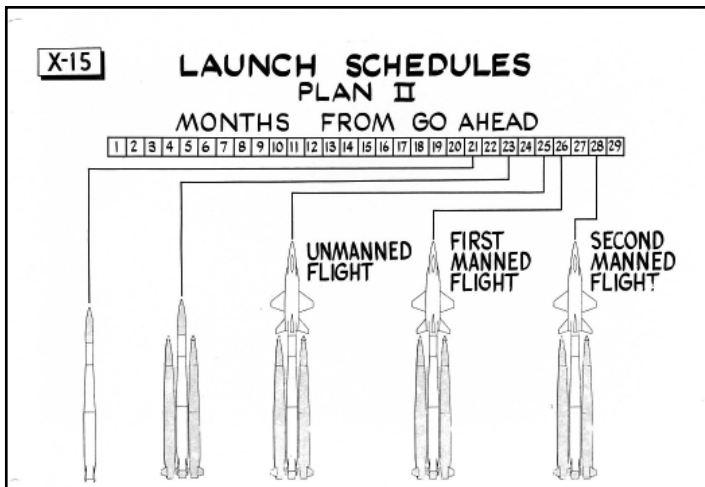
special mounts allowed pinnacle mounting¹⁷ atop a single G-26 Navaho booster generating 240,000 pounds thrust. Had NAA received a contract, initial delivery was projected for the third quarter of 1959.¹⁸

The booster would thrust the aircraft to 10,850 fps, to fly 1,115 miles on a northeast to southeast flight path down the Atlantic Missile Range (Cape Canaveral). It is noted that North American Rocketdyne engineers reengineered and refined a standard V-2 rocket engine into the XLR43-NA-1 series engines for their WS-104A Navaho project's G-26 booster that were further refined for a projected G-38 booster.¹⁹

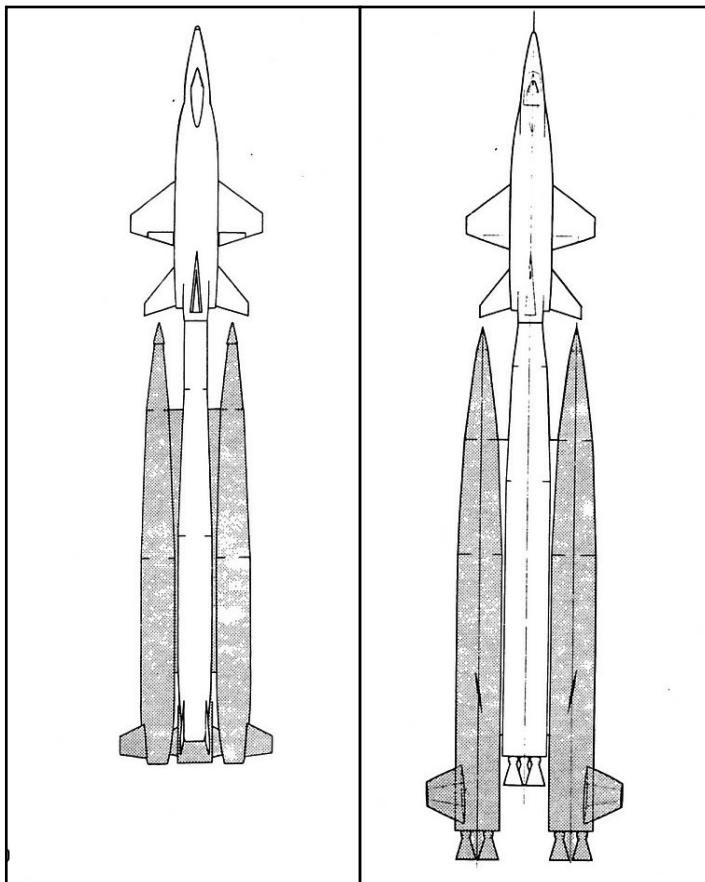
Step II presented a modified X-15A (original X-15 dimensions powered by the XLR-99-RMI-1) but weighing



The chosen powerplant for sub-orbital and fully orbital X-15 proposals was the Thiokol XLR-99-RM-1 liquid fuel rocket engine that would burn fluorine and liquid hydrogen, thus generating higher thrust levels above that of liquid oxygen and kerosene or alcohol. (Thiokol drawing)

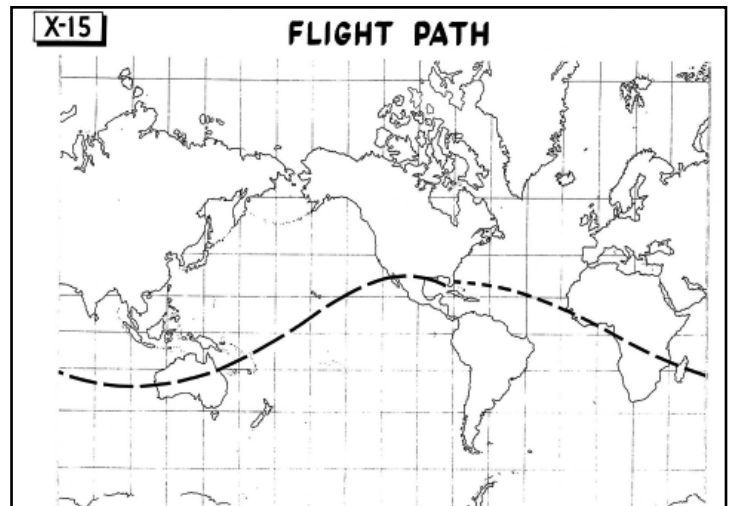


Sub-orbital X-15 contract schedule was superimposed upon the late 1957 (creation of the Orbital X-15 series), and 1959 period, when the initial X-15 spacecraft would complete its air-drop test syllabus prior to actual launch atop the G-26 and G-38 boosters. (NAA drawing)

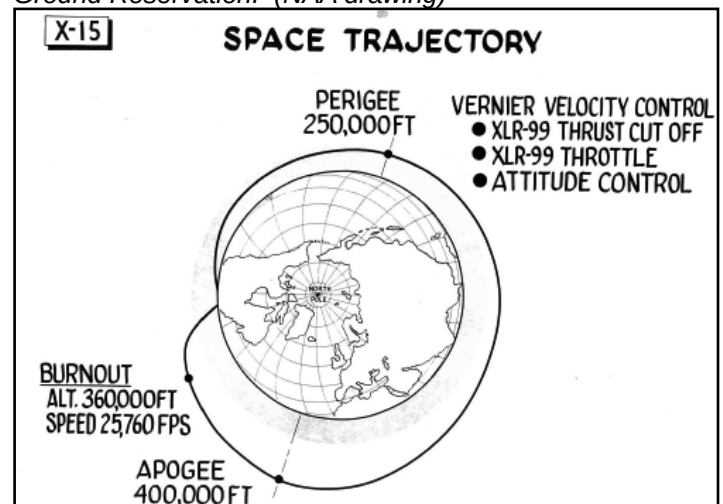


ABOVE LEFT: NAA drawings displaying the proposed generic sub-orbital X-15 in a pinnacle mount position atop the NAA G-26 Navaho booster. The concentrated weight of the heavier orbit-bound X-15s would demand costly and lengthy modifications to the booster's airframe. (NAA drawing)

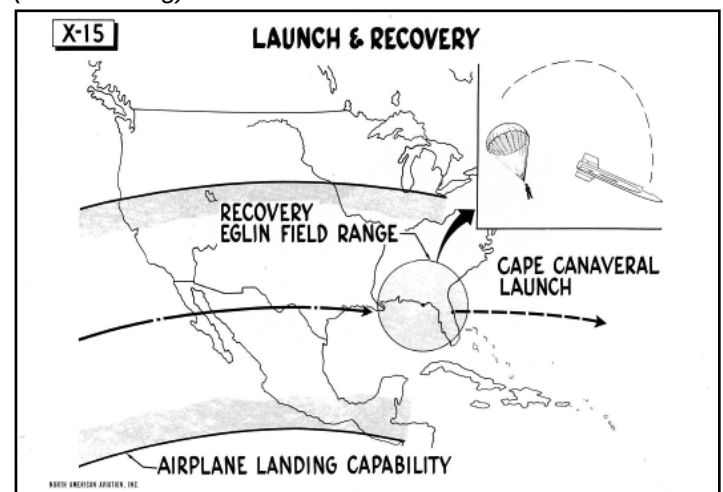
ABOVE RIGHT: The Orbital X-15B pinnacle mounted atop the tri-parallel NAA Navaho booster. G-38's engines were tested but the G-38 booster itself was not constructed. Navaho booster-engine technology was applied throughout the USAF ICBM program and satellite projects. (NAA drawing)



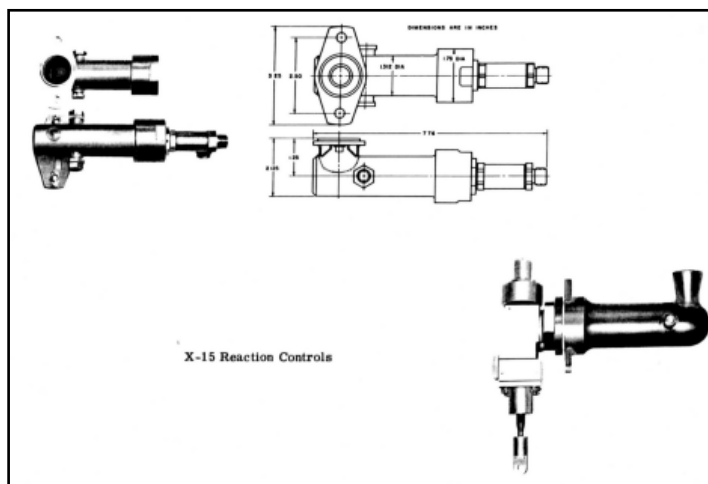
Flight path and footprint of the Orbital X-15 from Cape Canaveral and pre-programmed to land at the Eglin Proving Ground Reservation. (NAA drawing)



Map of the Orbital X-15B that would be amenable to apply photo-reconnaissance equipment over denied territory, i.e., Russia, its shield-satellite nations, and China. (NAA drawing)



Proposed recovery drawing suggests that the astronaut pilot would egress the X-15 and parachute land with the Eglin Proving Ground Reservation, leaving the aircraft a total-loss asset that hopefully would crash in an uninhabited area. (NAA drawing)



Bell Aircraft built reaction-control motors for generic X-15 aircraft; they would operate just as well in orbit on the Sub-Orbital and fully Orbital X-15A and X-15B vehicles. Had NAA engineers needed higher thrust levels, Bell would have built them as they did for Mercury and other space projects. (Ira G. Ross Aerospace Museum collection)

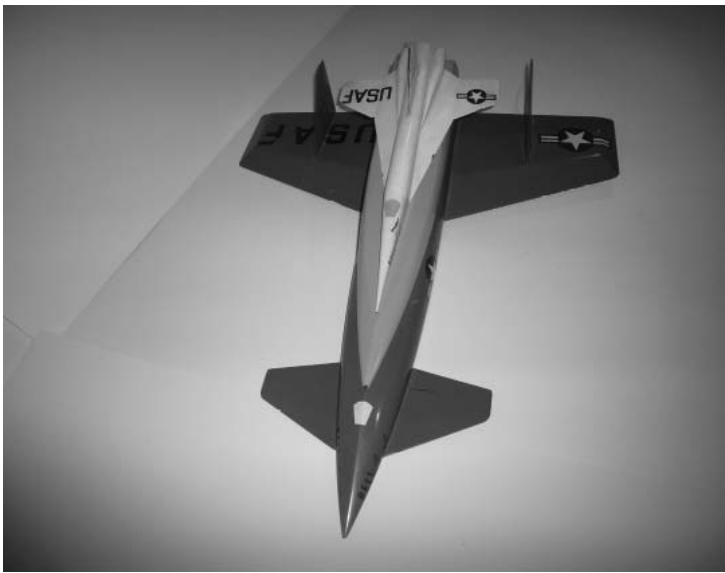
34,850 pounds gross, roughly twice the weight of the initial Dyna Soar orbital glider proposals. X-15A with advanced structural metals would hopefully survive a modest and unproven thermal re-entry heat range peaking at 1,600 degrees estimated. The X-15A's rear fuselage would also be strengthened for pinnacle mounting atop the center booster of the proposed and upgraded tri-parallel G-38 Navaho booster.²⁰ Step II X-15s were offered in two variants - a research package or advanced photo reconnaissance camera suite. The specifications promised speeds of 16,570 fps with a projected downrange capability of 1,741 nautical miles - this to be achieved by early 1960.²¹

NAA engineers calculated that either the original G-26 booster or G-38 airframes composed of aluminum metals should withstand oven-baking temperatures of approximately 520 degrees during one launch cycle of the orbital X-15 series. However, there were other boosters generating higher thrust levels that, while still undeveloped, were undergoing consideration by NAA engineers.

Maj. James C. Spark's 1968 publication *Winged Rocketry*, includes an intriguing Thiokol Corp. artist drawing depicting a big-finned Saturn booster lifting an X-15 research aircraft into orbit. There was also a quad-booster system consisting of three Martin Titan boosters with a fourth-center Titan, upon which is pinnacle mounted an X-15, but none of the two boosters were fully developed, man-rated or available to the orbital X-15 program had it been approved.

The Step III design was the super advanced one-man X-15B (engineers also drew up a two-man X-15B)²² for low-earth orbital military missions, planned for R-464L (also RS 620A) Dyna Soar II and III boost-gliders - promised delivery was 34 months if approved. The single-seat X-15B at 40,200 pounds gross would be powered by a modified Rocketdyne S-4 rocket engine burning liquid fluorine-hydrogen, providing a very high specific impulse rating (higher thrust per pound of fuels burned). The X-15B weighed over twice that of projected Dyna Soar gliders at 12,000 to 15,000 pounds gross; NAA engineers were precariously banking on their projected tri-parallel G-38 booster to insert a very heavy X-15B into orbit at 25,000 fps. NAA projected delivery of the X-15B and G-38 booster 34 months after the go-ahead.

Each slender center booster, either G-26 or G-38, required expensive modifications to heavily strengthen the upper body so it could withstand a pinnacle mounted generic X-15 or the increasingly heavier X-15A and X-15B aircraft. The North American Rocketdyne Division tested the Navaho G-26 and G-38 booster engines at their engine test facility in the Santa Susana Mountains. But none of the XLR43-NA-1 engines let alone the G-26 and G-38 boosters for the advanced X-15 expedited plans was subjected to a required man-rating program.²³ Man-rating protocols for boosters launching piloted vehicles into space demanded they be engineered for



Still surviving over 60 years later, is the Bell in-house constructed model of their MX-2276 BoMi or Bomber Missile. Its gestation period of 10 years required, even demanded, input from a hypersonic research aircraft in order to birth as hardware and fly. (Tim O'Keefe photo)

8. Marks M. Eugene. "Aeronautics and Astronautics," 1915-1960." NASA, 1961.
9. NASA Facts, FS-2003-07-0083 DRFC.
10. Boyne, Walter J., *Beyond the Horizons*, pp.265-268.
11. Bell Interoffice Memorandum, March 3, 1951, and March 7, 1951, describing an Intercontinental Ballistic Missile Proposal to the USAF.
12. NACA letter from Hugh L. Dryden to Larry Bell, October 31, 1951. He offered Bell Aircraft Corp. copies of the four-volume engineering data reports to Roy J. Sandstrom, Vice President of Engineering.
13. NASA Facts, FS-2003-07-0085 DFRC First Generation X-1.
14. IBM News Release, April 14, 1955, concerning Bell Aircraft acquisition of an initial IBM 650. Bell engineers quickly applied it to crunch research data derived from their X-series research aircraft, the AGM-63 Rascal, and several highly classified boost-glider projects such as BoMI, R-459L "Brass Bell," and other projects.
15. Marks, M. Eugene. "Aeronautics and Astronautics," 1915-1960." NASA, 1961.
16. Marks, Eugene M, NASA Historian; "Aeronautics and Astronautics," 1915-1960.
17. James Gibson, author of a quality book concerning the Navaho Project wrote a "look-back" article on Navaho for the North American Aviation Retirees Bulletin, Summer 2007. Mr. Gibson states in his article that all drawings of the G-38 booster with the X-15 were always mounted pick-a-back style or side mounted. This author has never seen or obtained drawings depicting the G-38-X-15 mounted pick-a-back. The drawings accompanying this article originated within the NAA Engineering Department and their Weapon System Advanced Design offices, and were not modified or doctored to depict the X-15 in the pinnacle mounted position. This layout displays X-15 and booster in the pinnacle mounted position for the G-26 and G-38 X-15 proposals in NAA Document Report No. NA-58-195. The author merely separated the X-15 and G-26 and G-38 drawing itself from the large black text taking up the rest of the page, just to display the G-26-X-15 and proposed G-38-X-15A & X-15 B configurations alone. Therefore, no "myth" is being perpetrated here by misrepresented or modified drawings for the sake of altering history in this article. It must be said that in the confusion and chaos of the early Sputnik era that various corporations reacted to a somewhat shocked Air Force to create "crash" get-a-man-into-orbit quick, proposal whereby fantasy overcame common sense, and many projects were literally delivered by the multiple dozens to the USAF ARDC, AMC and ASD. NAA is no exception in this matter and no denigration is intended. Many proposals were simply unacceptable and not viable or workable while others, such as the heavy modification of the yet to be glide-tested let alone, powered X-15 and modified G-26 or G-38 boosters to launch an X-15 required huge amounts of time and money to man-rate and extensively modify with no guarantee of quick success.
18. NAA Report No. NA-58-195. The orbital X-15 proposal was signed off on November 27, 1957, promising delivery 21 months later had they received a contract.
19. NAA Engineering Department Report NA-57-1435. Technical Summary-Advanced X-15 Research Vehicle Report, H.A. Evans, Manager, Weapon System Advance Design, November 27, 1957.
20. Ibid.
21. Ibid.
22. Temple, Parker, L., "X-15B: Pursuit of Early Orbital Human Spaceflight, *Air Power History*, Spring 2008, Vol. 55, No. 1.
23. Wheelock, Vince, NAA Retirees Bulletin, Fall 2008. Rocketdyne, the Early Years.
24. Unnumbered letter (Project Office Identifier is MDZSXB) to the USAF Plant Representative at Boeing Airplane Co. from the Assistant Chief, Dyna Soar WSPO (Weapons System Project Office), Calvin B. Hargis, Jr., Office of the Deputy for Advanced Systems Directorate of Systems Management describing the process of "Man-Rating" a rocket booster used for the purposes of launching into sub or full orbit, a manned space vehicle.