GREAT EXPECTATIONS:
North American Aviation's Exotic Advanced X-15 Concepts
Part II

by Dave Stern

North American artist drawing of the X-15A-3 HTV prominently displaying its severe 70-degree wing sweep and diamond-shaped wing-tip fins. (NAA drawing from the author's collection)

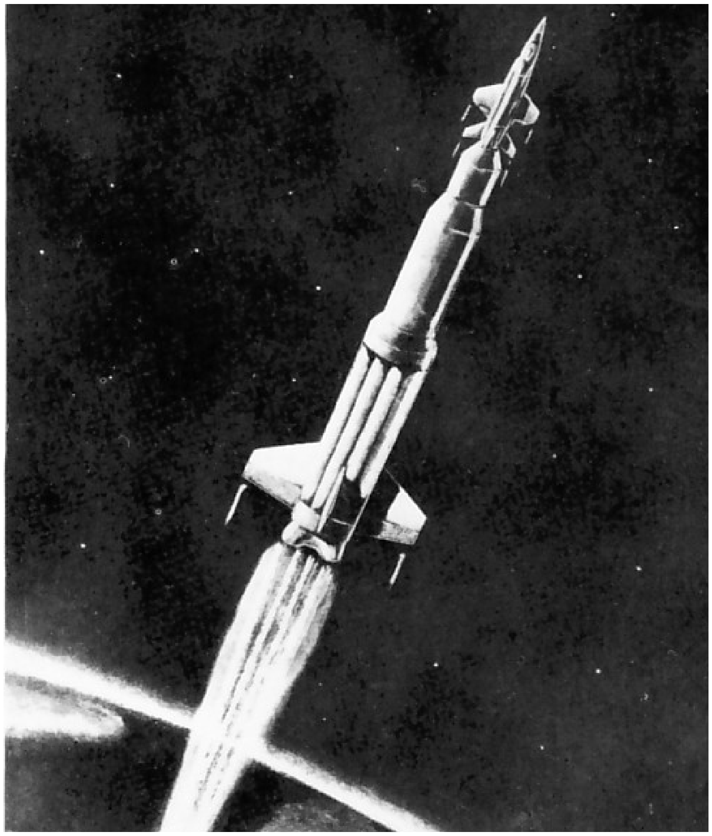
North American engineers comprising the Weapon System Advanced Design Department attempted to improve upon the basic intra-atmospheric X-15 layout, hoping to quickly provide the USAF with a vehicle capable of operating in low-earth orbit, even offering a stretched airframe to accept a military reconnaissance suite. Updating and improving the airframes with high-heat sustaining metals would hopefully transform a generic X-15 into the Orbital X-15A and B variants able to sustain the high thermal temperatures of reentry.

A refrigeration system was proposed to cool the cockpit and equipment bay although, it goes without saying, that the astronaut-pilot wore a full-pressure suit. The B model would operate with updated electronics and oxygen equipment for extended flight durations. Since Murphy's Laws operate in the vacuum of space and within the earth's atmosphere, not one, but two auxiliary power units would provide independent electrical and hydraulic power. The alternating current system would generate 4 kva/115-200 volt, 400 cps, three-phase power, while the direct current voltage would be generated by 100-ampere silicon diode rectifiers. Hydraulic power would be provided by 3,000 psi variable-displacement hydraulic pumps operating irreversible flight control features.

Further design changes in the X-15B were a five percent-thick wing with a 2.5 aspect ratio, flaps, but no ailerons and all-moving horizontal stabilizers. The lower vertical surface could be jettisoned by the pilot immediately prior to landing.[1] Internal structures modified with still unproven ceramic materials were designed to withstand short duration temperatures peaking at 3,500 degrees F in stagnation areas. Rene-41 would replace aluminum and titanium applied throughout the generic X-15's primary internal structure, yet retain its high-strength high-temperature steel alloys already installed; the airframe would endure 1,600 degree F temperatures, if the whole vehicle was externally coated with a special black finish.

NAA engineers also considered the application of the advanced metals Haines-Stellite or Hastealloy R235 and the heat-sink materials Beryllium Oxide, Zirconium Silicate, Titanium Carbide and Zirconium Boride.[2] Advanced X-15, X-15A and X-15B would be equipped with generic X-15's sidestick controller system and retained Bell Aircraft's miniature reaction control motors generating 43 and 113 pounds of thrust; Bell Aircraft could have provided updated variants giving the pilot control of the aircraft's pitch, roll and yaw attitudes during an orbit. The vehicles would carry 300 channel sensing and recording systems, cartographic equipment or intelligence and motion picture reconnaissance packages. A suggested reconnaissance suite consisted of high-resolution equipment - a K-40 aerial camera, T-11 Tri-metrogon cameras, one standard motion picture camera and one high-speed motion picture camera.[3]

To exit the orbital path and return to earth the pilot would fire two interior-mounted solid-rocket motors situated at the aircraft's C.G. (Center of Gravity) point, to maneuver the



This Thiokol artist drawing depicts their proposed orbital X-15 heavy booster. NAA engineers in the Weapon System Advanced Design Office perhaps understood that using their Navaho G-26 and G-38 boosters would be inadequate to launch the X-15A and B models into low-earth orbit. (Thiokol drawing from the author's collection)

X-15B into an elliptical orbit then enter the re-entry footpath leading to Edwards AFB or Eglin AFB. Pilot egress systems were optimized for the mission it would accomplish in orbit and consisted of a rocket-catapulted ejection seat equipped with a shock-wave generator, stabilization fins, head-limb restraints and an auto-timer separation and parachute deployment system.[4]

The egress system drawing suggests that the pilot must abandon the X-15B to crash, perhaps due to far heavier empty weights and higher landing speeds since the X-15A and B proposals display neither increased wing span (22 feet), chord-wise extensions, nor modified spinal stringers to withstand heavier landing loads that, if severe, might fracture the vehicle's back.

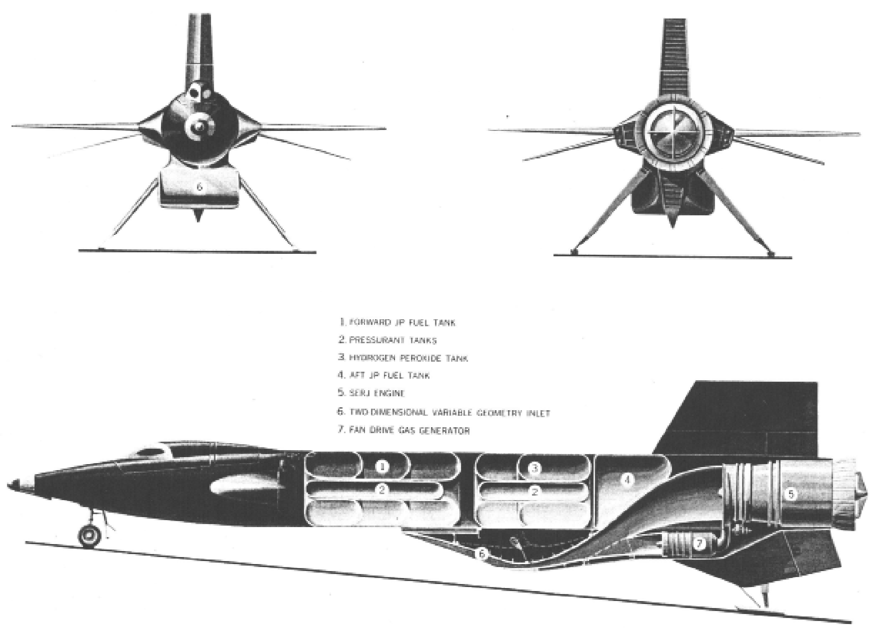
Transforming the generic hypersonic intra-atmospheric and briefly exo-atmospheric X-15 into the orbital X-15A and B model spaceplanes was a quick-response engineering exercise for the USAF to launch a military astronaut into space before the Russians. Funds for the project were unavailable and many engineering issues applicable to the orbital X-15 series remained unknown factors.

Meanwhile, thousands of hours of NACA-NASA, USAF Flight Development Laboratory (FDL), industry and university wind tunnel tests formulated the basic design criteria for winged orbital airplanes (many 1950s winged spacecraft or boost-glider projects were referred to by their engineer-creators as just that...an airplane). The boost-glider possessed a flat bottom fuselage, thick blunt well rounded leading edge delta wings swept to 70 degrees or more, a blunt nose and reliable thermal reentry protection. An alternate upcoming choice included the bulbous boat-tailed and baguette shaped lifting-body configurations exhibiting the glide characteristics of a large square brick.

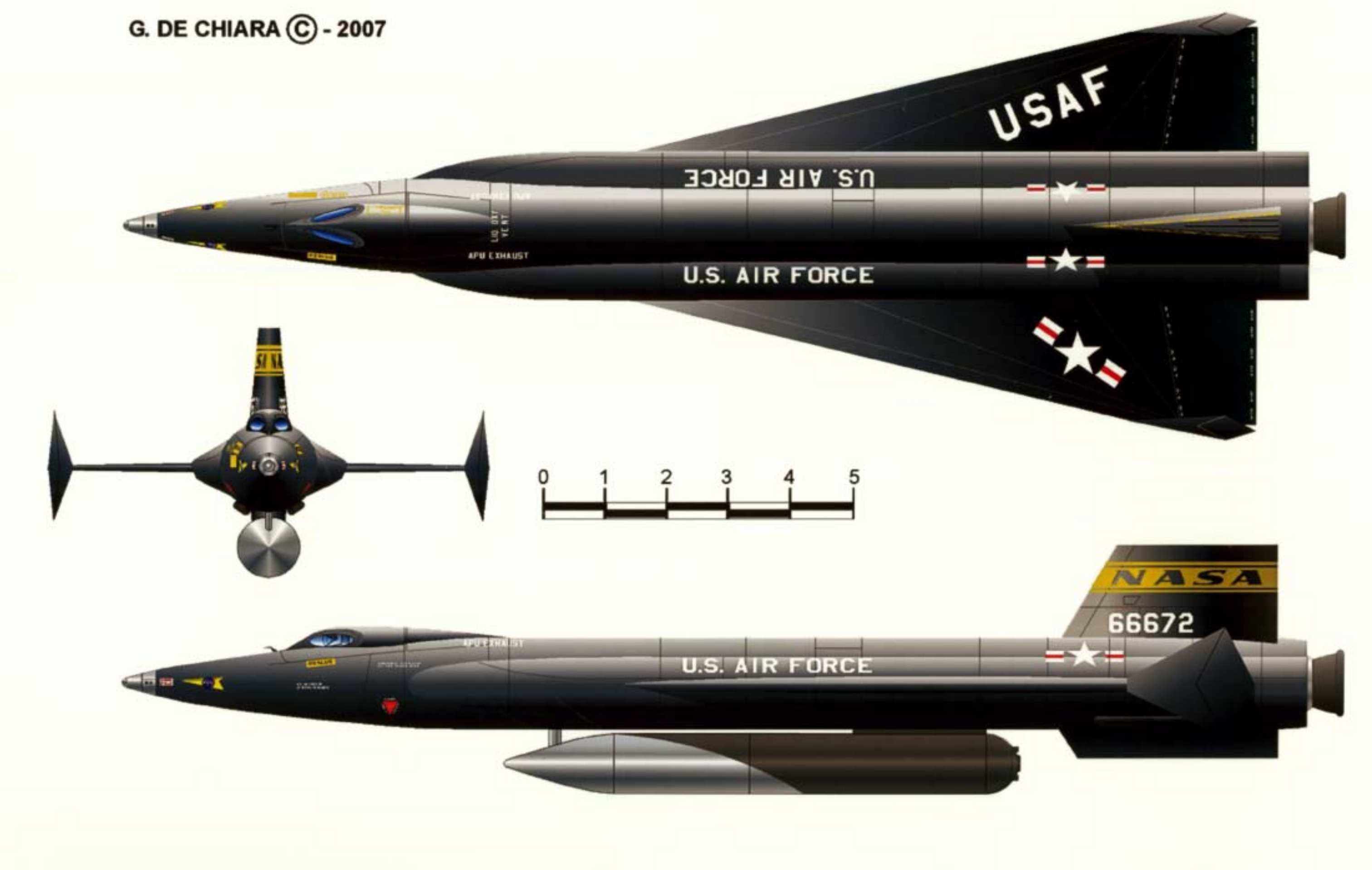
The Air Force ARDC and Air Material Command examined the North American Orbital X-15 proposals, but simply filed them away with other now-historically important space projects that never reached the hardware stage.

During the late 1950s to mid-1960s there existed scientists and engineers identified throughout the U.S. industrial community, as radical and free thinking-engineers tagged "the Wild Birds."[5] Derisively known as crackpots, many gained employment throughout the aerospace industry, advancing rational thought to the limits of their individual capacity. Martin-Denver's Dr. Dandridge Cole working in its quite secret Force XXIV and later General Electric, mentally departed the rational reservation boundaries, by proposing advanced and quite startling human biological modifications for space travel - some are actually the stuff of science fiction-horror genre. Realistically speaking, many of his creations were beyond the reach of contemporary 1950s and 1960s technology.[6] It is of interest to note that even Douglas' famous crack engineer Edward Heineman was also categorized as a "Wild Bird."

Since North American was also participating in USAF space projects beyond the Orbital X-15 proposals they too, hired a "wild bird" in Dr. Toby Freedman. One of Dr. Freed-

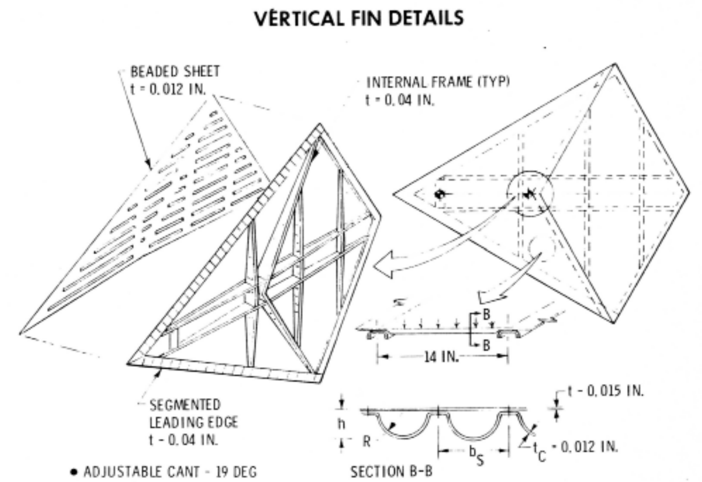


One of many unfunded projects requiring a modified X-15 was Marquardt's SERJ turbo-ramjet engine undergoing development at Marquardt's test facility. (Drawing from Scott-Lothar-Upship.com via the author)



This quality 3-view drawing presents the X-15A-3 with the large belly mounted fuel tank allowing extended duration hypersonic flight to speeds of 8,064 fps above the 6,750 fps burning internal fuels. (Drawing courtesy of Igor Afanasyev, Russian aerosapce history author.

One of two handsome wind tunnel models built at North American Aviation to test the X-15A-3 within the sonic, supersonic and hypersonic speed regimes. Holes in the canopy, side fuselage and tip of the vertical fin are possible mount points for the model to assume various pitch and yaw attitudes during tunnel tests. (NAA photo from the Boeing archives)

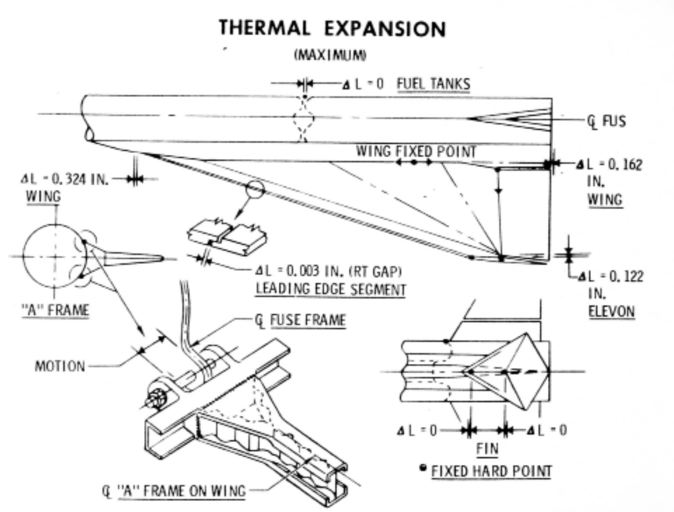


Engineers worried that using X-15 upper-lower wedge-shaped vertical surfaces might be inadequate for directional stability at hypersonic speeds. Engineers then removed the early upswept winglet style tips and revised the design by applying two fixed-position diamond-shaped wing-tip fins. (NAA drawing)

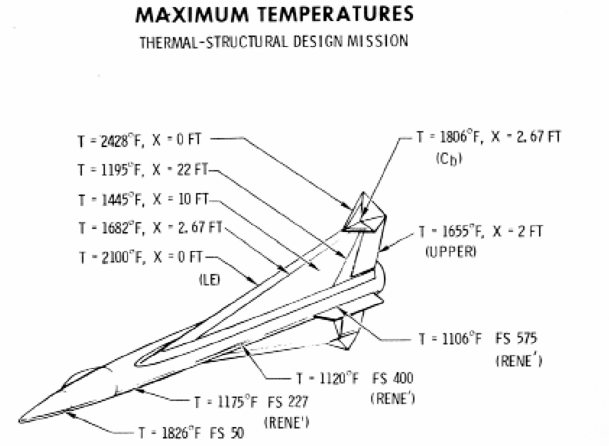
man's advanced studies involved methods of developing a super astronaut known as Optiman, a human being specifically developed to operate various spacecraft in earth-orbit or deep space, and occupy orbital and deep-space bombardment platforms.

No details concerning the Optiman study are known to have entered the public domain.[7] Since Orbital X-15 variants would perform military missions in space, Freedman's Optiman studies were applicable to the project.

In the X-15 North American engineers possessed a hypersonic airframe amenable to modifications as a test-bed for advanced air-breathing engines and other test projects that, while proposed, were cancelled for lack of funds. Some lesser-known proposals included testing segments of the Bell Aircraft developed and patented double-wall cooling and insulation system, planned for its MX-2276 BoMi boost-glider, their advanced boost-glider studies and Dyna Soar I glider proposals. The USAF acknowledged its capabilities and



Details of the X-15 HTV's wing and the expansion joints were included from the generic X-15. (NAA drawing)



North American engineers created this thermal gradient to approximate their estimates of the maximum temperatures to be endured by the delta-wing X-15 HTV during hypersonic flight. (NAA drawing)

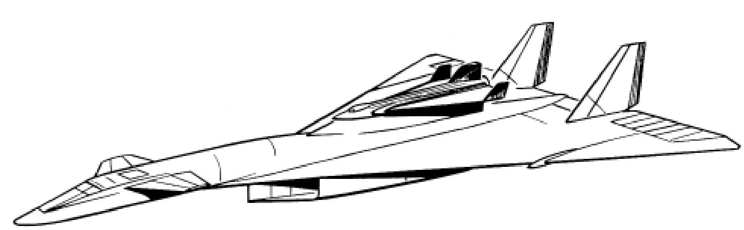
funded continuous development and testing well into the late 1960s, long after the Dyna Soar project was cancelled, such was their faith in Bell's system.

Bell's cooling system protected an intra-atmospheric or exo-atmospheric hypersonic airframe constructed of aluminum with exotic radiant heat metal exo-skins, an inner insulation layer, and a circulating coolant of water-alcohol. It absorbed the heat and shielded the cockpit and vital systems from the intense thermal gradients of sustained hypersonic flight through the atmosphere and when reentering the atmosphere.

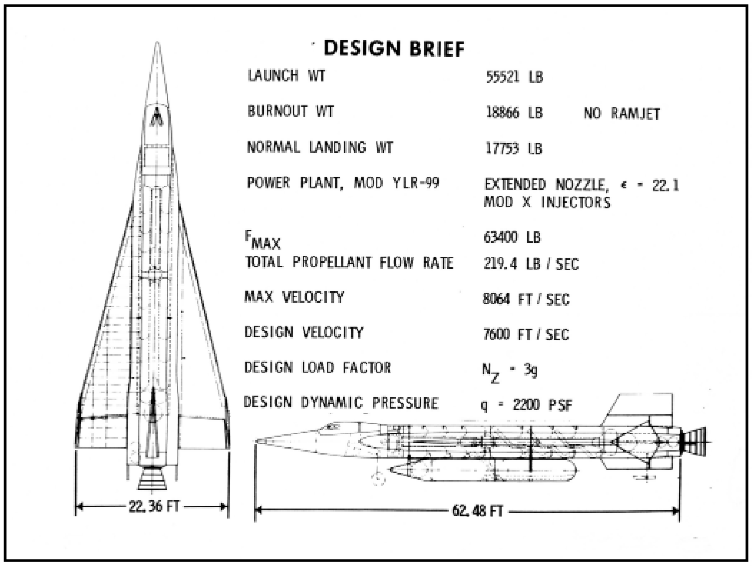
Bell constructed double-wall panels were actually flight-tested as wing sections on the prototype Convair B-58 Hustler during its supersonic flight syllabus, without interfering with its operational certification for SAC. Panels were even tested in low and high speed wind tunnels and in test rigs ringed with heat lamps, so the next logical step was testing it on one of the generic X-15 aircraft.

Bell engineers proposed building a double-wall cooling-insulation unit as the nose-section of an X-15 that included constructing a small number of lower rear detachable tail surfaces also using the cooling system, but the offer was neither accepted nor funded. Bell, the USAF and NASA thus missed a true test of this system's ability to cool a hypersonic vehicle.[8]

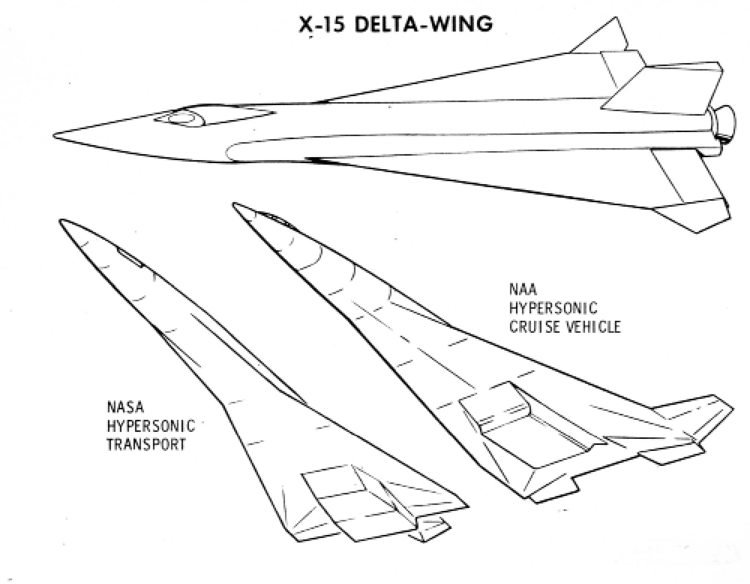
Marquardt Aircraft Co. engineers were unique among American manufacturers for innovative advancements in



North American engineers suggested the use of their XB-70 as a launch platform for the X-15A-3, providing increased speeds and altitudes. This early drawing displays the earlier upswept wing tip version of the X-15A-3 before engineers reconfigured it with diamond-shaped tip-fins. (NAA drawing)



Design brief performance specifications are given for the highly modified X-15A-3 HTV proposal. (NAA drawing from the author's collection)



Most engineers in the industry concluded that the severely swept delta-wing was the appropriate wing design for various hypersonic projects. The X-15 HTV's extreme wing sweep was the chosen planform for enduring sustained hypersonic flight near or just above the thinner reaches of our atmosphere while withstanding the resultant thermal gradients. The X-15A-3's delta wing planform is seen on the two illustrations: NASA Hypersonic Transport, and the military-oriented NAA hypersonic cruise aircraft as a reconnaissance platform. (NAA drawing)

high-speed air breathing engine technology, specifically the humble ramjet motor. Their engineers developed (1955-1965) the MA-165 liquid hydrogen ramjet engine and proposed mounting it beneath the lower rear fuselage of a structurally updated X-15, thrusting it to speeds between Mach 3 and Mach 8.

As the X-15 program approached its cutoff date, on March 17, 1967, North American Aviation's Los Angeles Division released details of an advanced X-15 research project. Mr. H.A. Evans, the X-15 program director, publicly revealed that four years of research yielded plans for an advanced delta-wing configured X-15 to confirm new structural designs for hypersonic vehicles. Directly responsible for the X-15 HTV (Hypersonic Test Vehicle) project were Mr. A. Tweedle (Senior Engineer), L.M. Gaines (Senior Engineer Aerodynamics), and Mr. E.W. Johnston (Technical Manager), working in the Los Angeles Division of North American Rockwell Corporation.

Since advanced ramjet motors and liquid hydrogen powered turbo-ramjet engines were already under development, the X-15 HTV was considered a logical and progressive vehicle to test such advanced technology and push manned hypersonic flight beyond that attained by the generic X-15 series.[9] The primary foci were major structural problems associated with hypersonic flight (sustained or otherwise) centering upon the nose, crew and cockpit fuselage, passenger and cargo areas, liquid hydrogen tanks, air-inlet and propulsion compartments, wing structure and surface heat shielding, tail structures and control surfaces. The X-15 HTV airplane would test the basics of hypersonic aerodynamics in areas of lift, drag, lift-to-drag ratios, heat effects on basic aerodynamic shapes, corner-flow conditions, elevon control effectiveness, etc.

All were critical to the stability of a vehicle flying within the speed ranges of Mach 4-6 and Mach 6-8, briefly or at sustained hypersonic speeds.[10] NAA engineers proposed the following modifications to an existing X-15 airframe that extended the fuselage with a plug extension of 120 inches to 62 feet 8 inches. Generic X-15 wings would be replaced with a delta wing exhibiting a severe planform sweep of 76 degrees, six degrees beyond that of the Dyna Soar glider wing designs. The radical sweep of 70 to 76 degrees was the generally agreeable wing sweep of choice, and applicable to future intra-atmospheric and exo-atmospheric hypersonic boost-gliders, transports, sustained altitude and speed reconnaissance-bombardment and perhaps single-stage-to-orbit vehicles.[11]

The HTV's wing span remained similar to a generic X-15 to easily fit beneath the wing and engine pods of the B-52 Mom-ship. The HTV's delta wing area equaled 603 square feet with 22.36 feet compared to generic X-15's 22.3 foot span and 200 square foot area. Engineers designed removable alternate leading edge wing segments installed as 1.5 inch long sections with .003 (three thousands) inch gaps for thermal expansion during flight. The X-15 HTV drawings included a large centerline drop tank extending the YLR-99 (also XLR-99) engine firing duration, a repositioned and strengthened nose landing gear and rear fuselage plus the skid-gear. The extended forward fuselage section was a 10 degree cone supporting a fixed ball shaped nose, and early into the design the aircraft displayed upswept wing tips.[12]

Projected gross weight was 55,521 pounds at launch, 18,886 pounds at burnout, and 17,773 pounds during landing. NAA engineers estimated that the YLR-99 would generate 63,700 pounds of thrust to achieve a design velocity of 7,000 fps and a maximum velocity of 8,064 fps, using an extended engine nozzle. At maximum speed the X-15 HTV was designed to endure 95 seconds of hypersonic flight using the extra fuel from the drop tank.

Engineers requested that the NAA model department construct two X-15 HTV models; one low-speed 1/15 scale model and a 1/50 scale high-speed wing tunnel model to reveal aerodynamic and thermal loads. The former model was reportedly tested up to approximately Mach 2 while the high-speed model endured simulated wind tunnel speeds between Mach 5 and Mach 7. Both models accumulated 300 hours of wind tunnel testing.[13]

The size of the critical upswept wing tips elicited a reappraisal of the design where stability levels were concerned - the engineers replaced them with a set of delta shaped wing-tip plates nearly identical to the planform of the WWII German Zitterrochen missile, data that NAA engineers assessed in 1946 for application to the early designs of their MX-770 cruise-missile project.[14] Temperature considerations for the actual X-15 HTV were determined by the wind tunnel model tests, where, as one retired Boeing Wind Tunnel model craftsman stated, "the air don't care, but a correct vehicle design does indeed, matter."[15]

NAA engineers determined that lower fuselage temperatures would reach 1,826 degrees F, elevon temperatures at 1,655 degrees F, wing-tip plates enduring the highest temperatures at 2,400 degrees F, and wing lower surface temperatures peaking at 2,100 degrees F on the leading edges and 1,200 degrees F at the wing's mid-span.[16]

The temperature criteria listed above determined the engineering department's preliminary selection of exotic metals for X-15 HTV to survive hypersonic flight. The wing-box assembly would be constructed of Rene 41 with a TD nickel leading edge - this same metal TD nickel also forming the elevons, tip plate fins and their leading edges. Certain fuselage components such as the side fairing skins would consist of Rene 41, while the internal fairing A-frames would be HS 1.51 metal castings.

Wing skins were proposed as .018 inch thick with corrugations or beaded sub-skin panels of .015 inch thickness, all of Rene 41 metal.[17] The delta wing X-15 HTV's mission was focused upon obtaining research data in a real-time atmospheric environment that included the following data points: the fuselage was rigged with 100 pressure orifices and 700 thermocouples, while the right-hand wing contained 25 thermocouples and 100 pressure orifices, all generating analog readings.

The left-hand wing housed 500 thermocouples, 50 strain gages and four skin friction gages, while the vertical surfaces and elevons contained 80 thermocouples, 50 pressure orifices, 20 strain gages and two skin friction gages.[18] These data were collected and transmitted as analog telemetry later analyzed and reduced to useful engineering data by means of the IBM 709 series 7094 "mainframe" computer system.

It possessed a 32,768 word core memory, or 150 kilobytes of memory (generating admiring wows in its time). The IBM 7094 accomplished 50,000 to 100,000 floating-point operations per second and its 36-bit word length was ideal for scientific calculations requiring precise lengthy digits to render accurate data from research aircraft test flights at North American Rockwell.[19]

It is both unfortunate and a shame that a war in Southeast Asia, tight funding and the very expensive high-stakes race to the moon overshadowed this quite logical extension of the X-series of research aircraft; obviously the aircraft would have greatly extended our knowledge of hypersonic flight and design.

Endnotes

1 NAA Engineering Dept. Report NA-57-1435, Technical Summary, Advanced X-15 Research Vehicle, November 27, 1957.
2 Ibid.
3 Ibid.
4 Ibid.
5 Alexander, Tom. "The Wild Birds find a Corporate Roost," Fortune, August 6, 1964.
6 Ibid.
7 Ibid.
8 Bell Aerosystems Report D7105-953001, "Preliminary Design Study of Applications of Double-Wall Structures to the X-15," September 1960.
9 News Release, North American Aviation Inc, Los Angeles Division, GHHO31067, March 17, 1967.
10 North American Aviation (no number of date) Report. "The Concept of the Delta Wing X-15 by A. Tweedle, L.M. Gaines and E.W. Johnston."
11 NAA Report NA-66-1164, specifications and drawings for the Delta Wing X-15.
12 Ibid.
13 North American Aviation Report 66-336 drawings and specifications for Delta Wing X-15.
14 NAA Engineering Dept. Progress Report No. 8, NA-46-1083, November 1946-Project MX-770.
15 Interviews with retired Boeing Co. wind tunnel builder friend, Mr. John Swartzwelder, stated that fellow model builders and wind tunnel technicians used the term "the air don't care," in describing the airflow despite various positions and attitudes of models relative to tunnel air-flow. Half models with vertical fin, horizontal stabilizer, and one wing, were often attached against a tunnel wall and tested in this configuration; obviously the airflow over and around the model mattered where the correct design of the model's configuration and lifting surfaces were concerned should a full-size soon-to-be constructed. The design of the aircraft would then be thoroughly tested under actual flight conditions, either verifying or negating wind-tunnel test data.
16 Ibid.
17 Ibid.
18 Ibid.
19 NAA (no number or data), "The Concept of the Delta Wing X-15, by A. Tweedle, L.M. Gaines and E.W. Johnston."

IBM Fact Sheet; the IBM 7090 series Data Processing System, October 4, 1960.