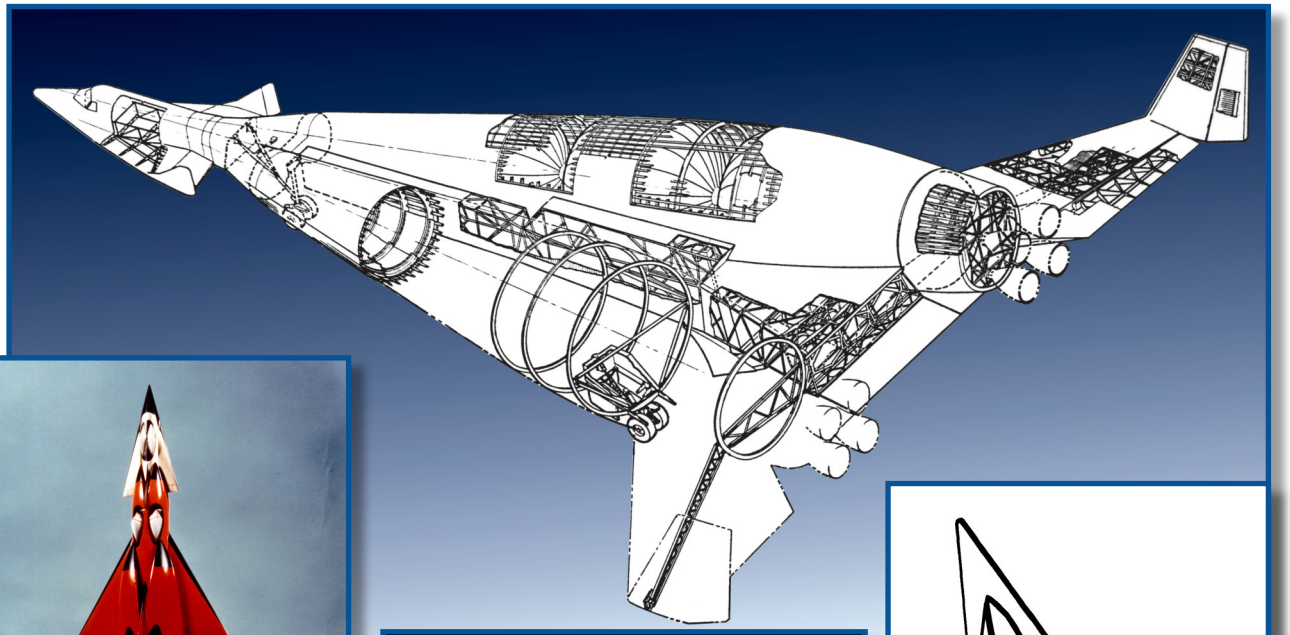
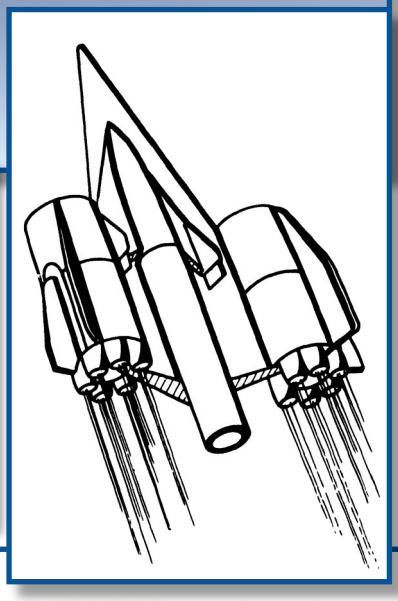
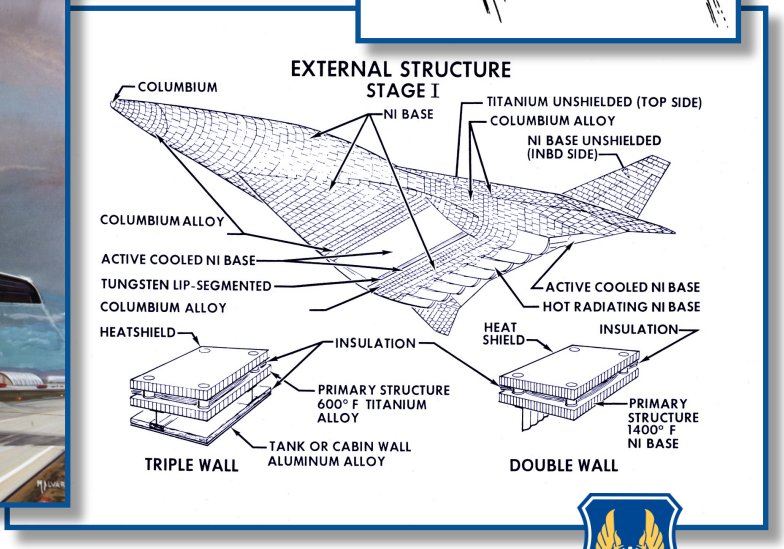
A Look Back...

RECOVERABLE BOOSTER PROPOSALS

A Future That Never Was...







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RECOVERABLE LAUNCH BOOSTERS: A FUTURE THAT NEVER WAS..

The idea of making flight into space as routine as atmospheric flight has been around since the 1930's when Eugen Sänger first published detailed information about his ideas for a suborbital, winged vehicle, capable of delivering a payload halfway around the world using a skip-glide technique Sänger referred to as dynamic soaring. Though Sänger's '*Silverbird*' would never be built, his concepts for winged flight into space became the subject of significant research well into the 21st century.

As early as 1942, the United States became aware of Sänger's work, when the (National Advisory Committee for Aeronautics (NACA) translated a copy of his 1934 study. Combined with the technological knowledge gained on rocket propulsion from the German scientists brought to the U.S. under Operation Paperclip during the final days of World War II, flight into space was beginning to become more of a reality than fantasy. Five months after studies presented at the First Symposium on Space Flight held in New York City in October 1951, Colliers Magazine published articles based on these studies titled "Man Will Conquer Space Soon." Yet, it was the team of Walt Disney, Wernher von Braun and Willey Ley who first brought spaceflight to the American public with production of *Man in Space,* an hour-long television feature. An estimated 42 million viewers tuned in to watch the premier in October 1954.

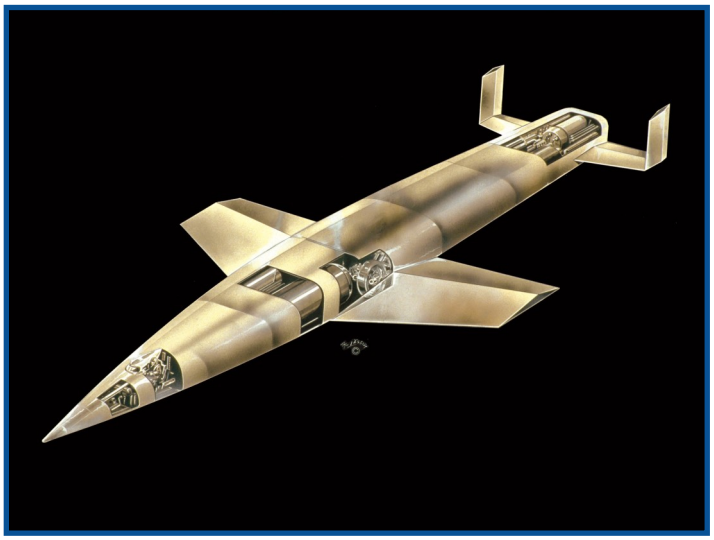
In the U.S., the Goodyear Aircraft Company produced some of the earliest conceptual work on winged flight into space. Their Manned Earth-satellite Terminal Evolving from earth-to-Orbit ferry Rocket (METEOR) design research dates to early 1954. Over the next two decades, conceptual studies from nearly all major aerospace contractors, such as; Bell Aircraft, Boeing, North American Aviation, Republic Aircraft, Convair and the Martin Company became increasingly prevalent. Most projects funded by the Air Force under various Systems Requirements studies were given strange acronyms such as; BoMi, RoBo, HIRES, POBATO, ACES or simply referred to as Aerospaceplane.

Many of the designs pushed the boundaries of reality and theory; proposing the use of materials that had yet to be invented, with propulsion systems that were purely theoretical at the time. On the drawing board were, liquid-fueled rocket engines, powered by; hydrogen and oxygen, and even nuclear-fuel. Single, dual and tri-cycle engines that combined the use of turbojet, ramjet and rocket propulsion into a single engine package, propelled these unique shapes into space. Vertical takeoff, horizontal takeoff including vertical and horizontal landing concepts were explored for their pros and cons; yet fully recoverable systems became the focus of many studies.

Much of this research went into the design for the Space Transportation System, a compromised design using both reusable and expendable components. Though flown for 30 years, the shuttle never truly provided the economical or routine access to space that it originally envisioned. Significant effort was put into the National Aerospace Plane (NASP) project throughout the 1980's and 90's but was ultimately deemed uneconomical and too technologically advanced for production; the program terminated in 1993.

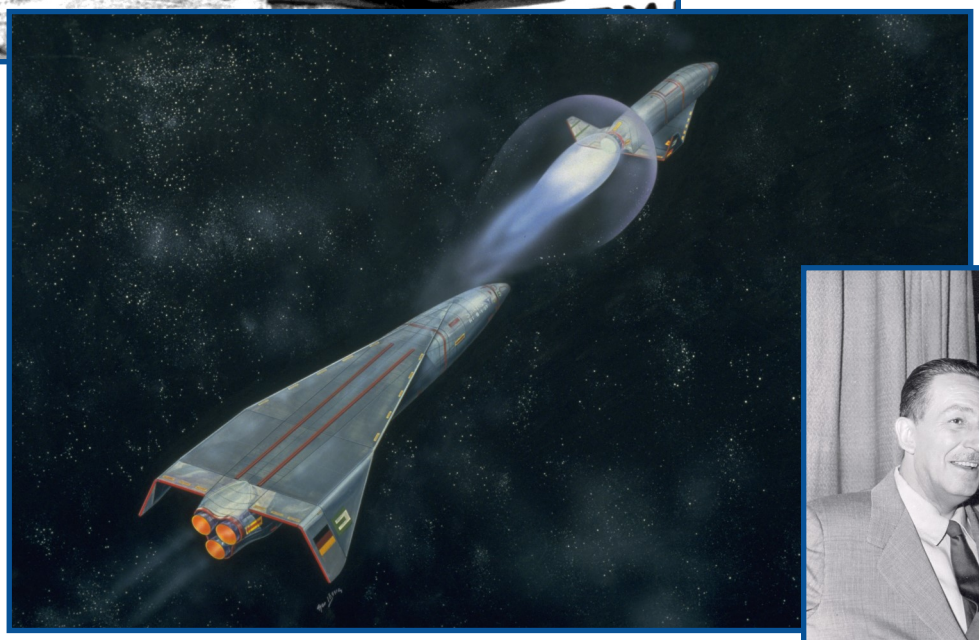
Though not the advanced spaceplane engineers had originally envisioned, SpaceX achieved an economical, partially-reusable booster and capsule system in 2015 (the second stage booster is expendable). Single stage to orbit, fully-reusable winged vehicles, remain the Holy Grail of aerospace; but as technology advances, the visions of the past may yet become the vehicles of the future.

Most of what you will find on the following pages came from the archives of the Air Force Materiel Command History Office, a research facility located at Wright-Patterson AFB, Ohio. Our research revealed a variety of gems, many a simple mention or illustration in an obscure report, while others came from archived materials supplied by the manufacturer or personal historical archives. We hope you enjoy this glimpse into what could have been.

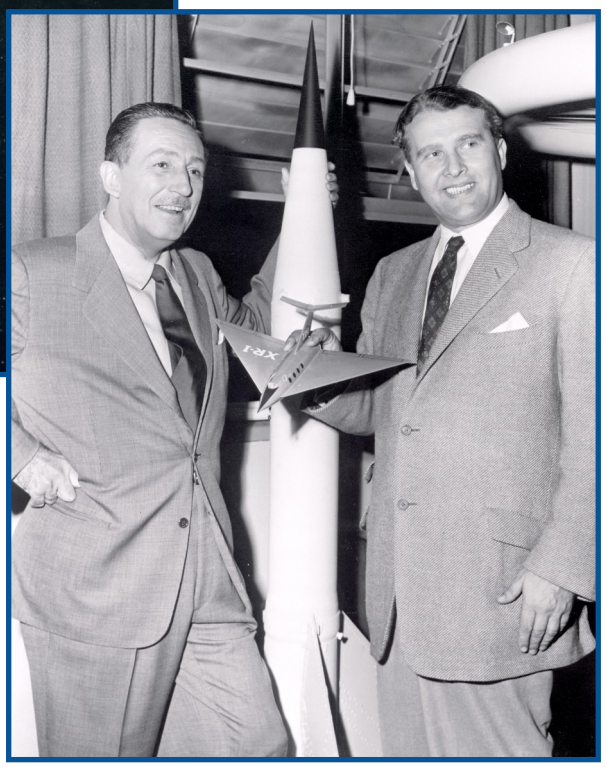


Left: Eugen Albert Sänger (1905-1964) conceptualized one of the first reusable spaceplanes, called *Silverbird*, in the early 1930's.

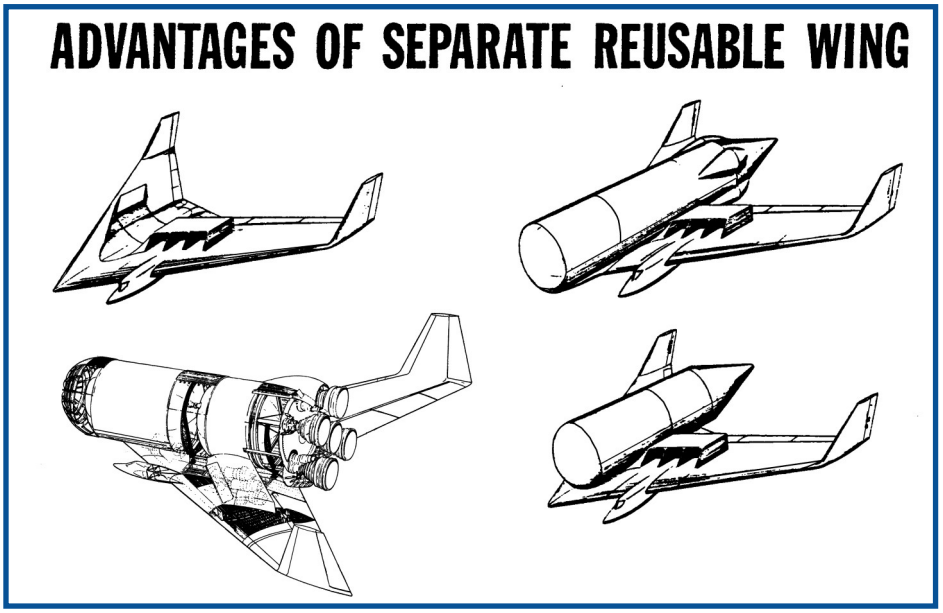
Above: Sänger continued to refine his design for the *Silverbird* throughout the 1930's. *Silverbird* used a skip-glide technique Sänger called dynamic soaring, to deliver a payload halfway around the world.

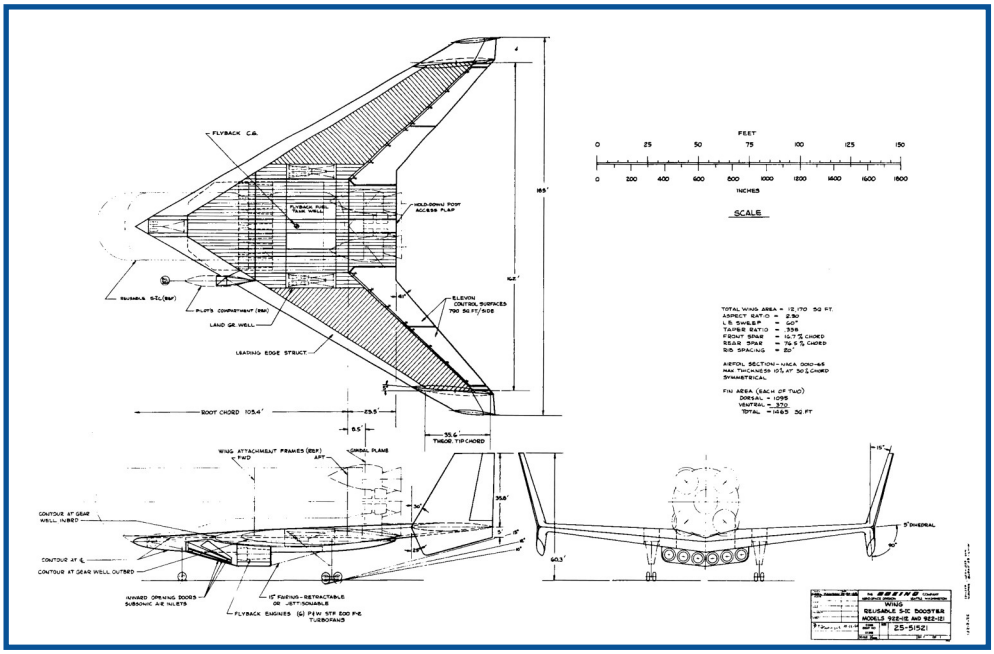


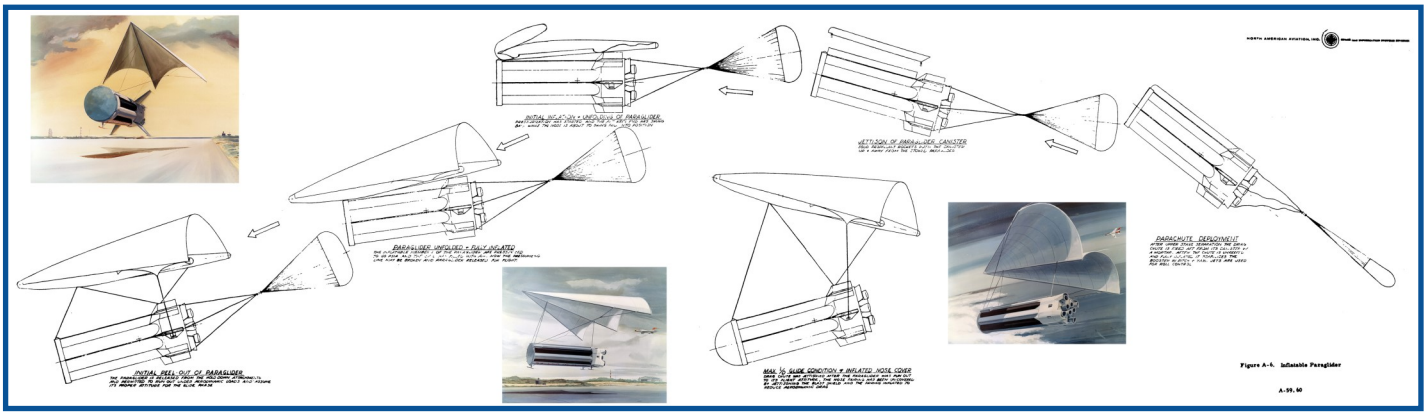
Above: 21 years after his death, Messerschmitt-Bölkow-Blohm (MBB) renewed studies of the Sänger design. Dubbed Sänger II, this two-stage-to-orbit design was ultimately cancelled as being too costly.



Bottom: Bringing the dream of spaceflight into an estimated 42 million homes, Walt Disney (left) and Wernher von Braun collaborated on the program "Man In Space" which debuted in October 1954.

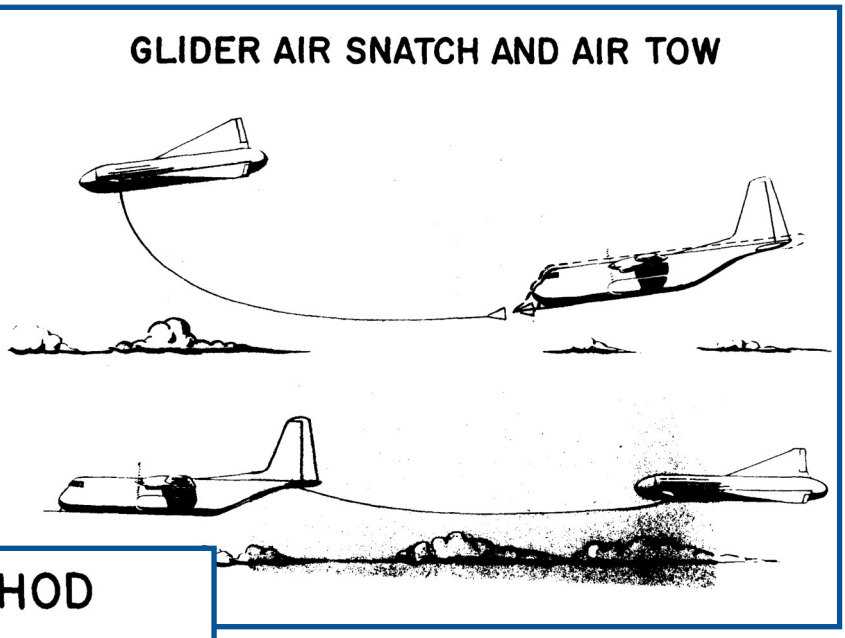


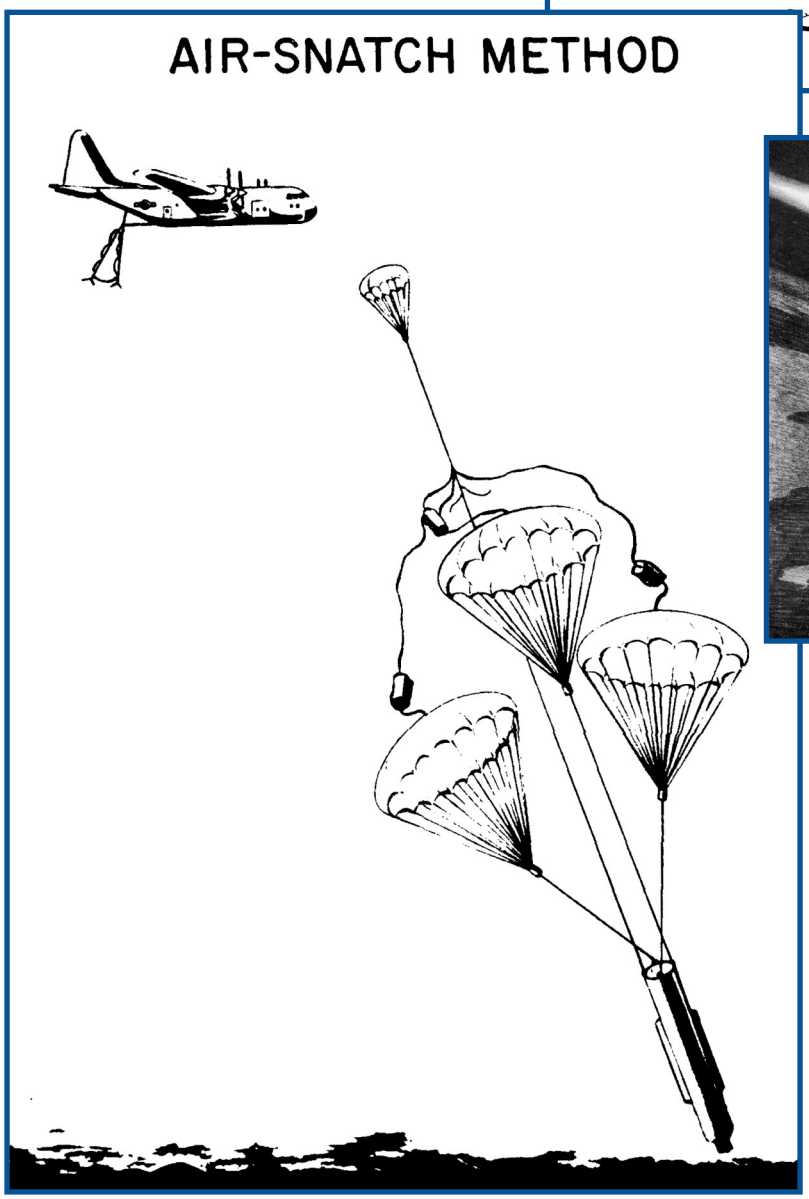


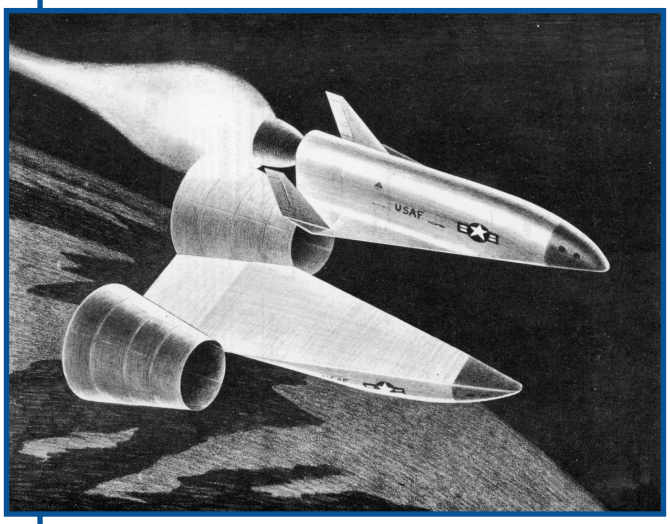


All: Significant research effort was put into making the Apollo Saturn boosters recoverable. The specialized, removable carrier aircraft designed by Boeing in 1963, could act as a first stage for the Saturn vehicle stack or utilized as a transport for outsized cargo. Paraglider recovery of a Saturn booster was also studied. Utilizing a Rogallo Wing parasail and retractable skids, the booster would glide down to a smooth recovery and refurbished for another mission.

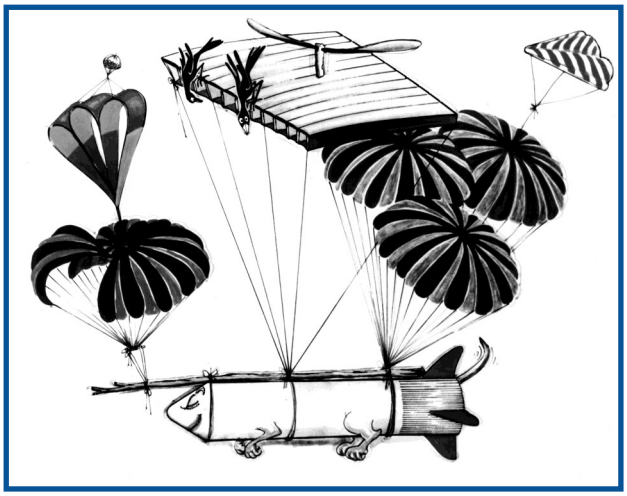
Right and Below: Some early proposals for reusable booster, air recovery by C-130. At right the unmanned glider releases a tow line during decent that was captured by the C-130 tow plane for a controlled landing. Below the C-130 captures the parachute of the descending booster much like the technique used for the Discoverer satellite reconnaissance film pods.



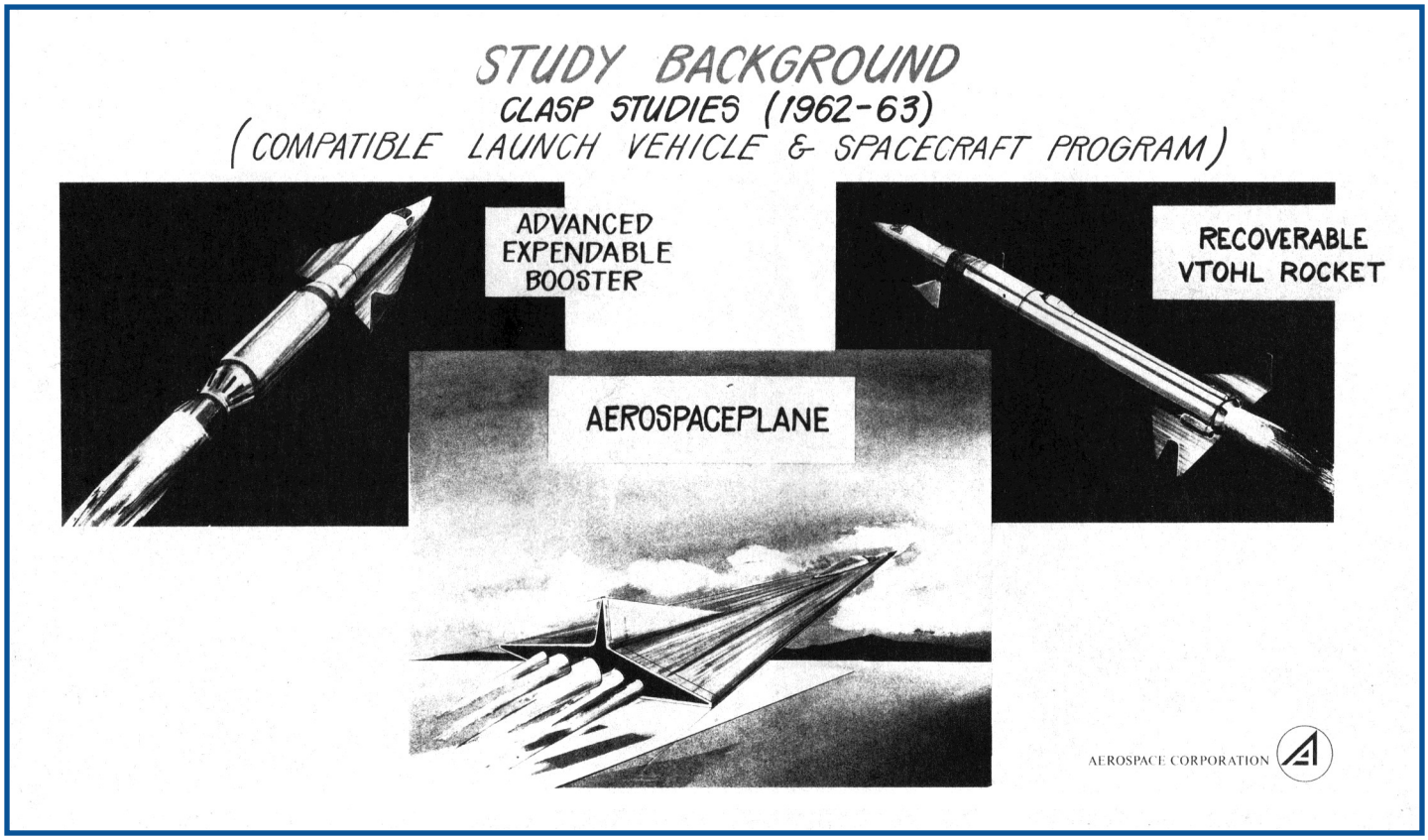


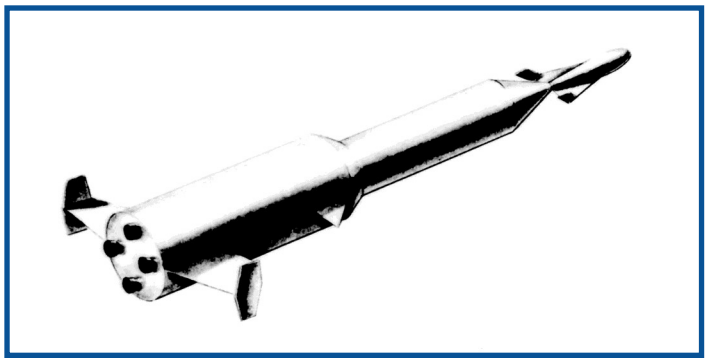


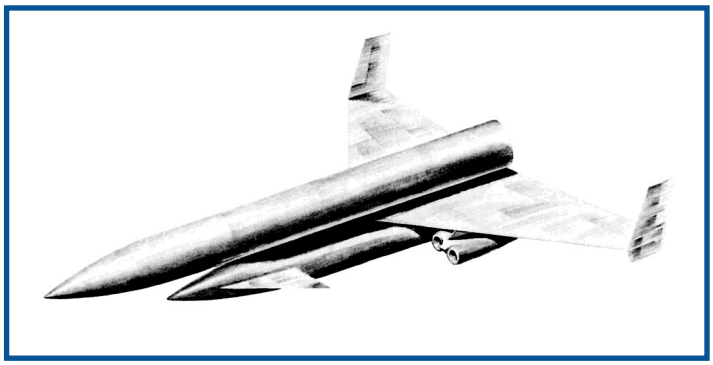
Above: One of Martin Company's Astrorocket proposals used an air-augmented rocket design known as a rocket engine nozzle ejector (RENE) to increase thrust of the booster vehicle.

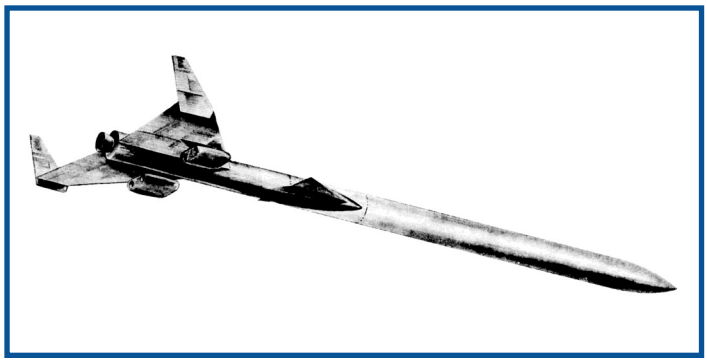


Right: One cartoonist found a bit of humor in all of the proposed designs for booster recovery and simply added all of them into the design of the "Recovery Pig"

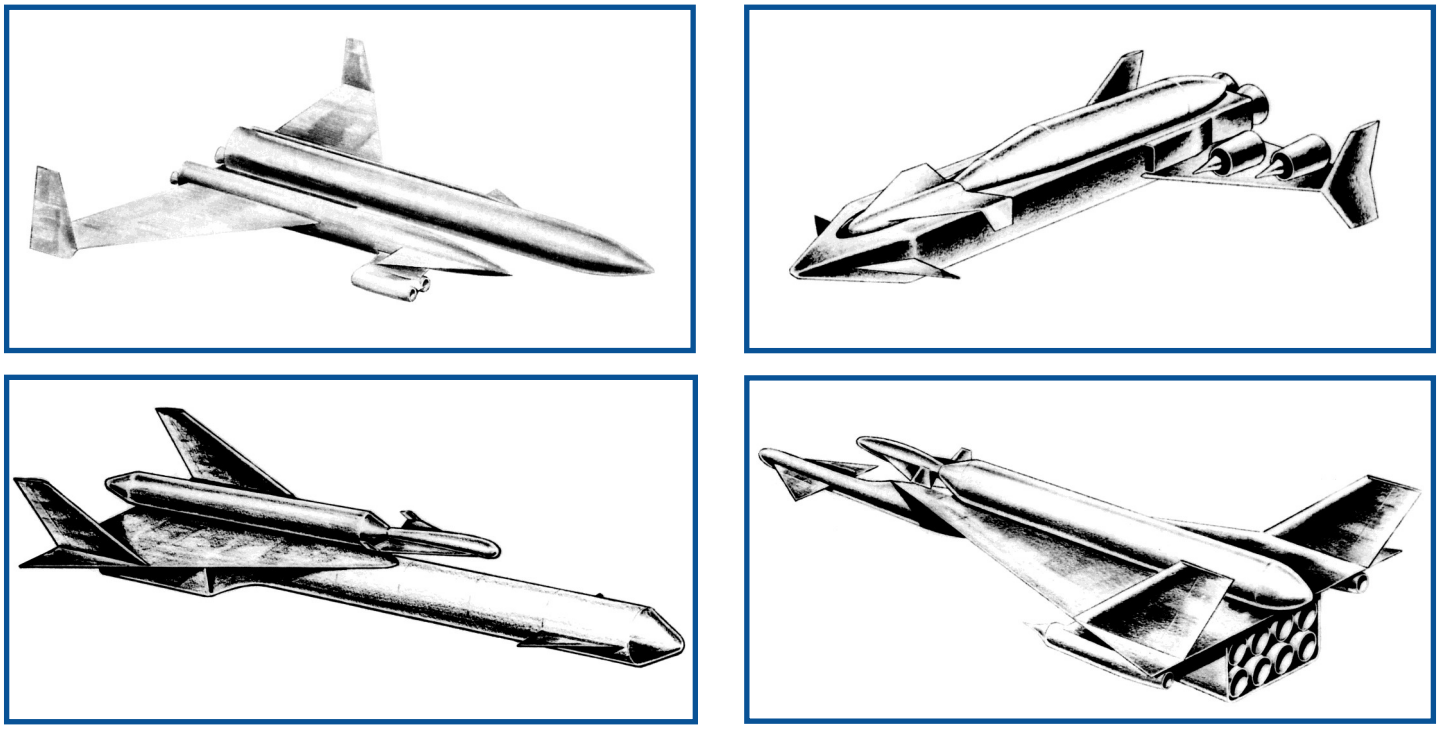




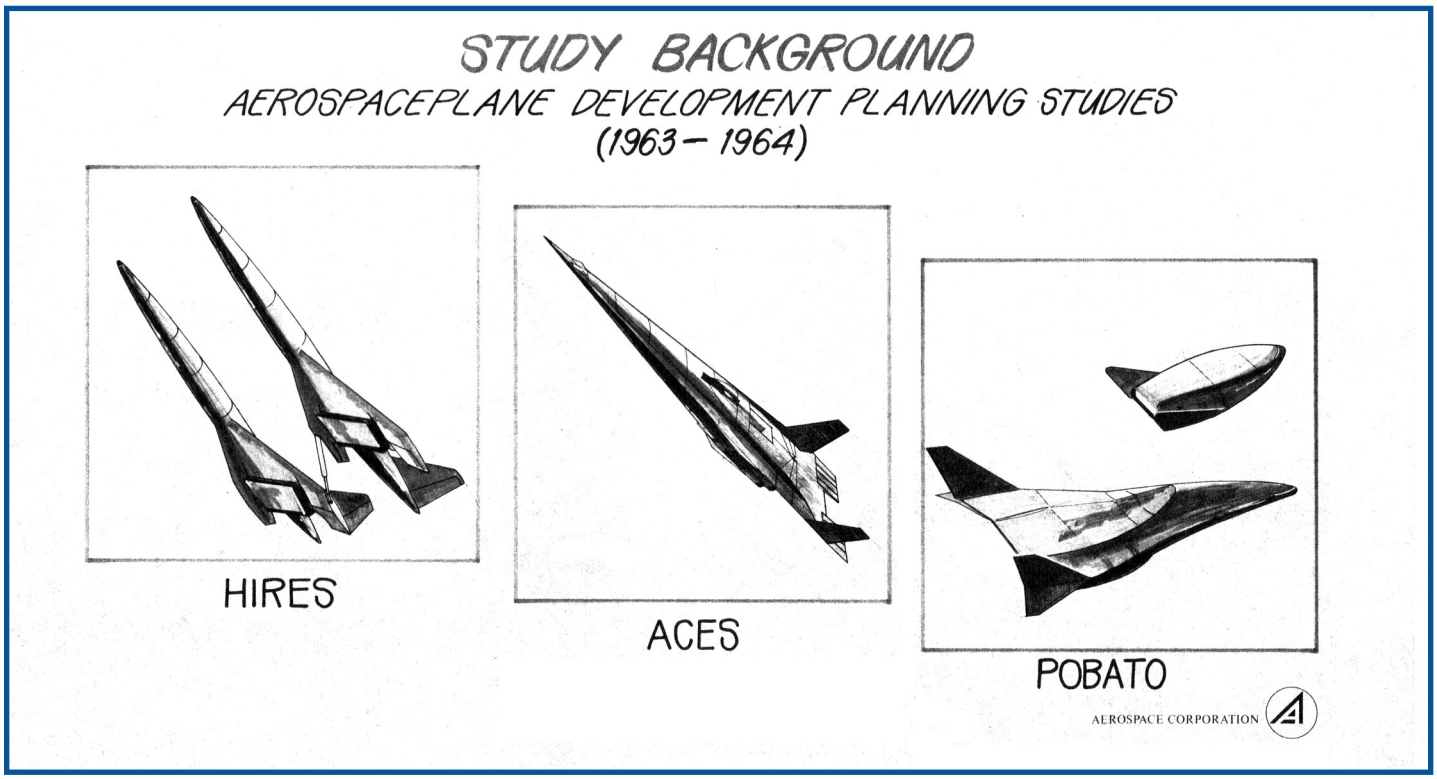




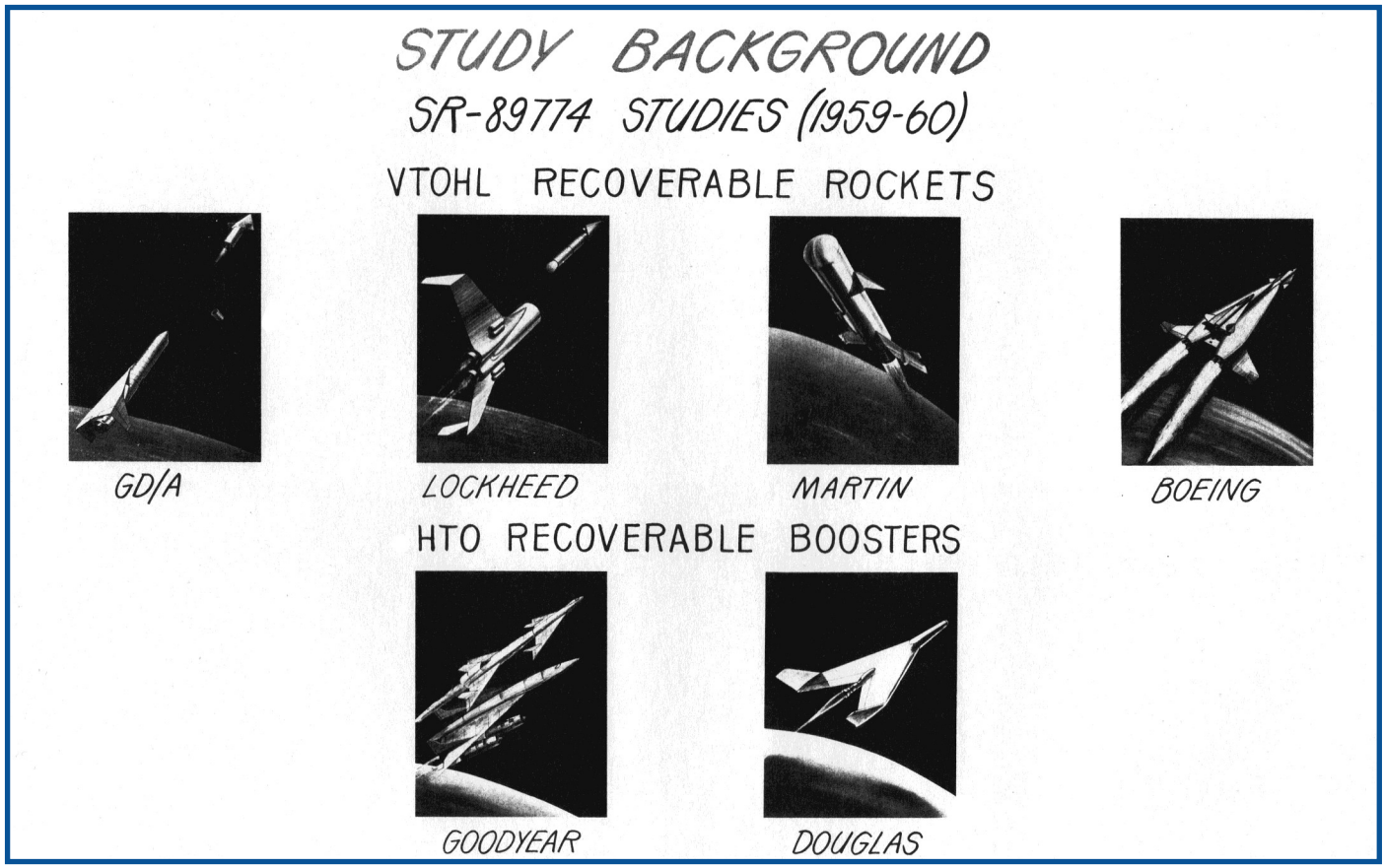
All: Defining the best approach to space access began with a series of research projects into various categories such as expendable rockets, Aerospaceplane designs and recoverable boosters. Recoverable booster baseline designs were subcategorized even further (clockwise from top left): Vertical Takeoff/Horizontal Landing (VTOHL); VTOHL-Single Fuselage-Parallel Staging; VTOHL-Single Fuselage-Tandem Staging; VTOHL-Twin Fuselage-Semi-Tandem Staging; *continued on next page*.

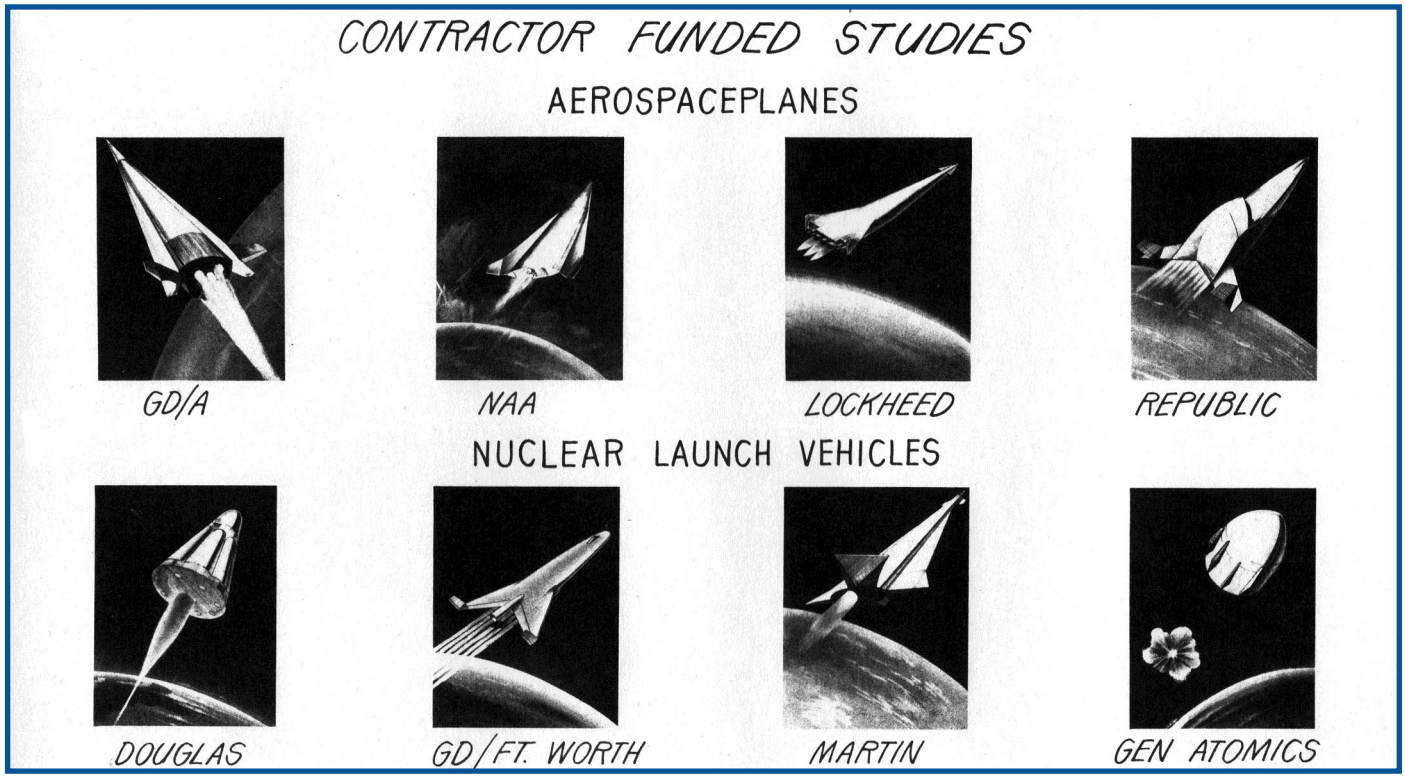


Above: *Continued from page 6*–clockwise from top left; VTOHL-Twin Fuselage-Parallel Staging; VTOHL-Three Stage-Hyperjet; Horizontal Takeoff and Landing (HTOL)-Three Stage-Turbo-ramjet; HTOL-Three Stage-Turbo-ramjet-JP-6 fuel (used specifically in the General Electric J93 engine).

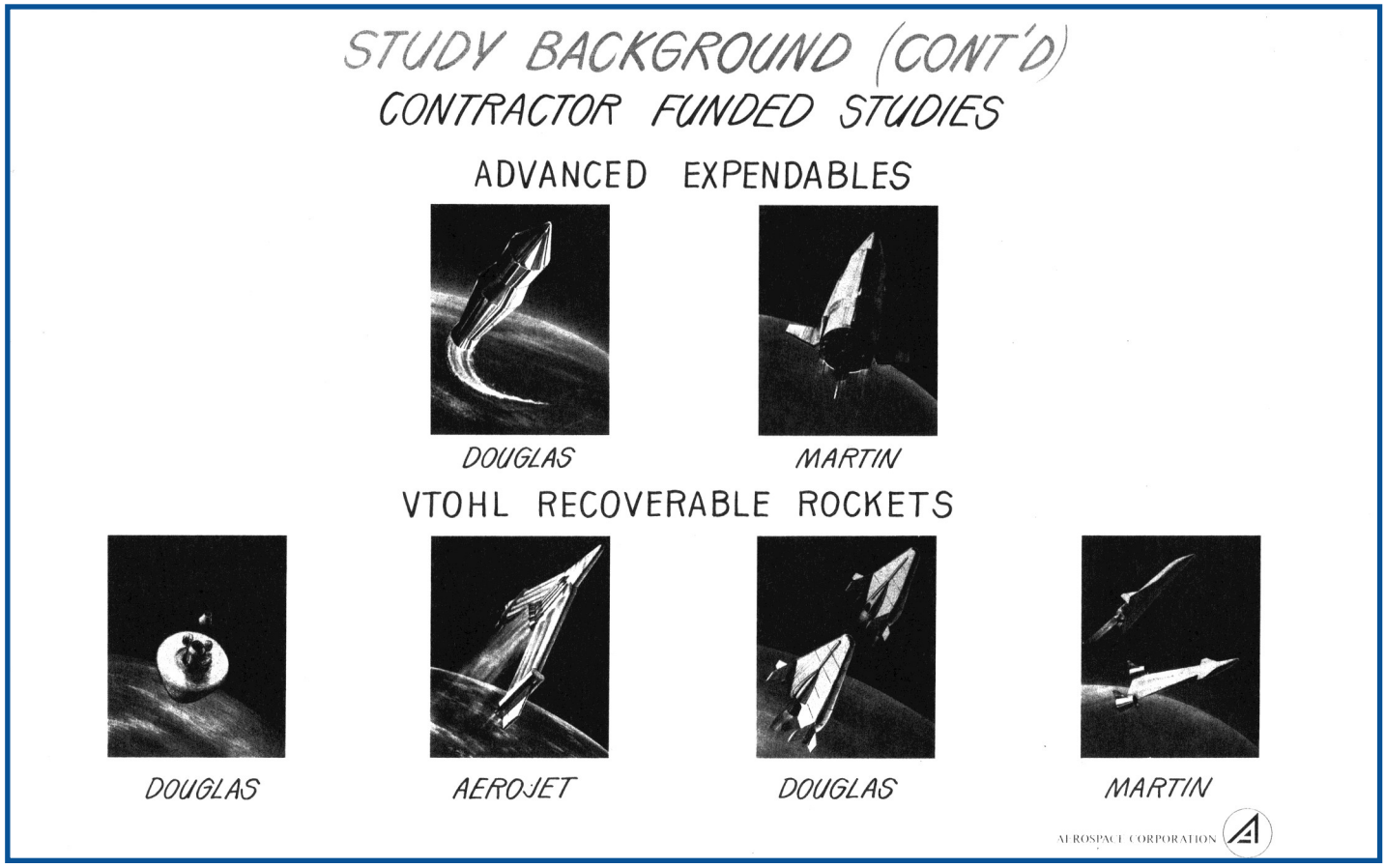


Above: Results from initial Aerospaceplane studies conducted by the Research and Technology Division, Air Force Systems Command, provided insight into the comparison of three different design concepts funded by the Air Force; Douglas Aircraft- Hypersonic In-flight Refueling Studies (HIRES); General Dynamics Astronautics- Air Collection and Enrichment System (ACES) and North American Aviation- Propellants On Board At Take Off (POBATO).

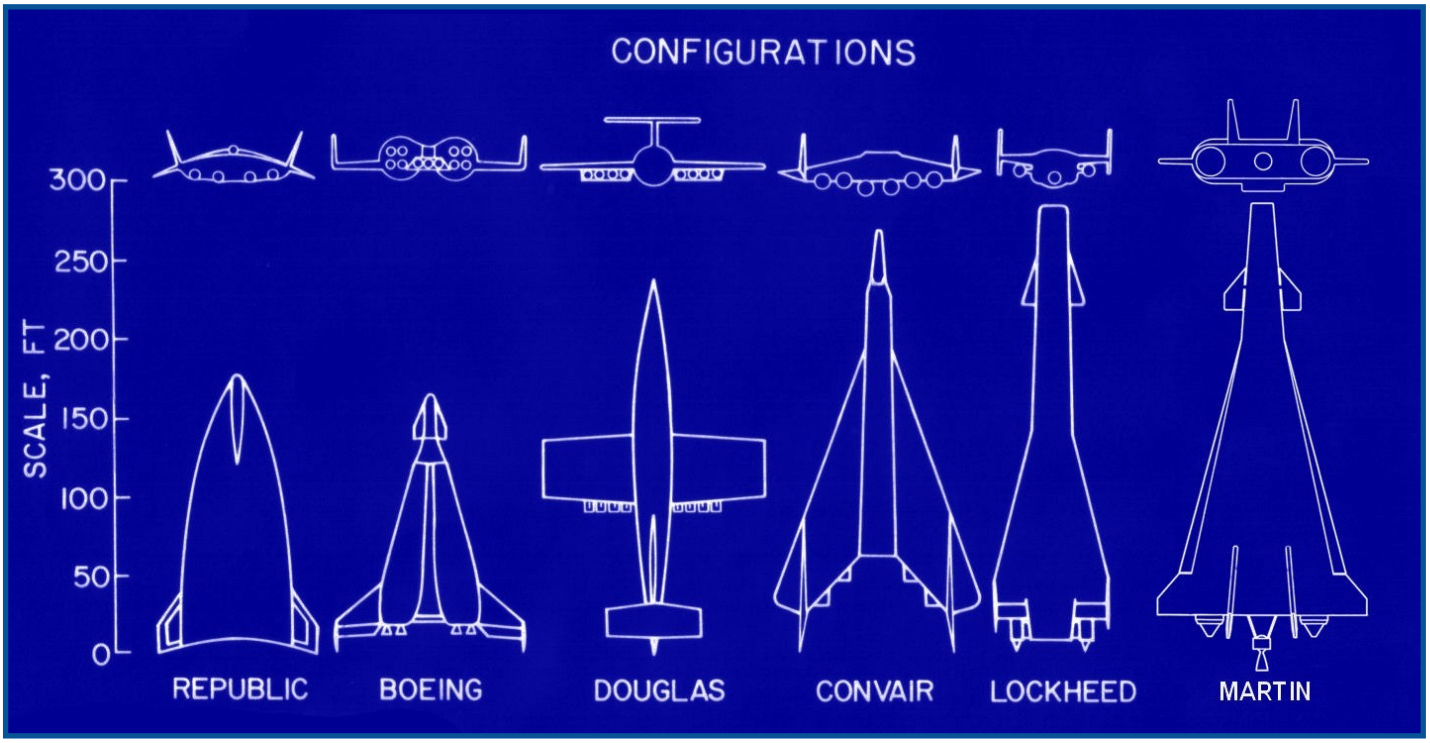




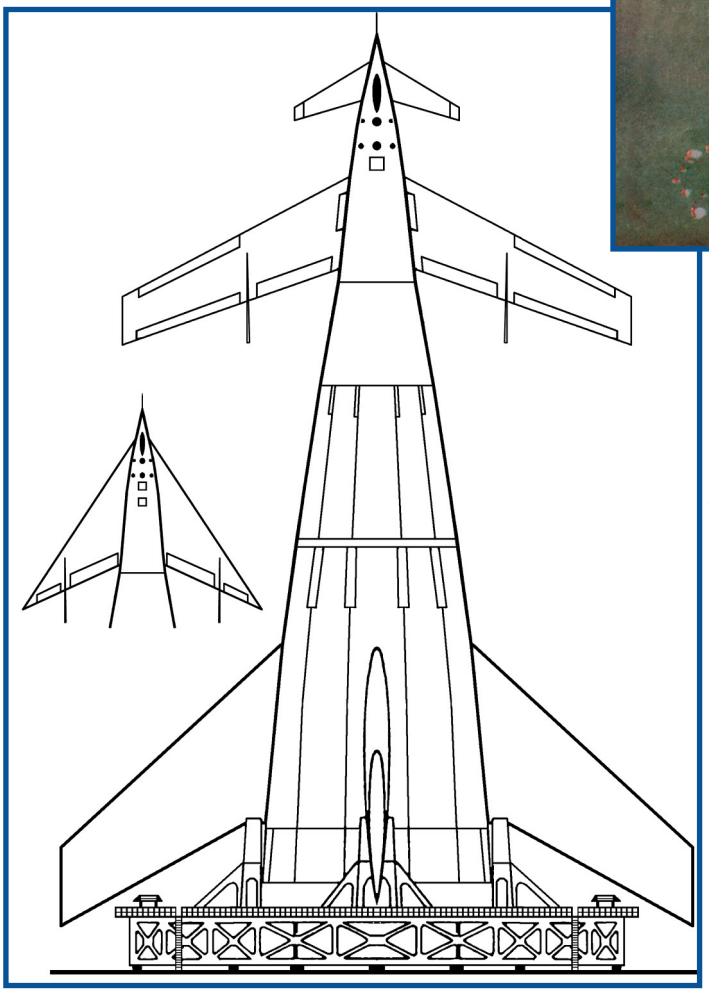
Page 8 and 9 Top: Between 1959 and 1961 no less than 17 contractor studies were submitted under Air Force Systems Requirement 89774 of which 10 received further funding. The first phase covered all types of recoverable boosters while the second phase placed emphasis on Vertical Takeoff/Horizontal Landing (VTOHL) and Horizontal Takeoff and Horizontal Landing (HTOL) vehicles. Results were found to favor VTOHL, but the economic gains over conventional expendable boosters appeared to be modest.



Below: Nice graphic showing the size comparison and different designs from 6 of the 10 funded design studies. The vehicles range from the conventional Douglas Aircraft layout to the more ambitious designs from Republic Aircraft and Boeing to the downright futurist-looking entries from Convair, Lockheed and Martin. Some companies created studies for both VTOHL and HTOHL vehicles. In the end, expendable boosters remained the mainstay of access to space for the rest of the 20th century.



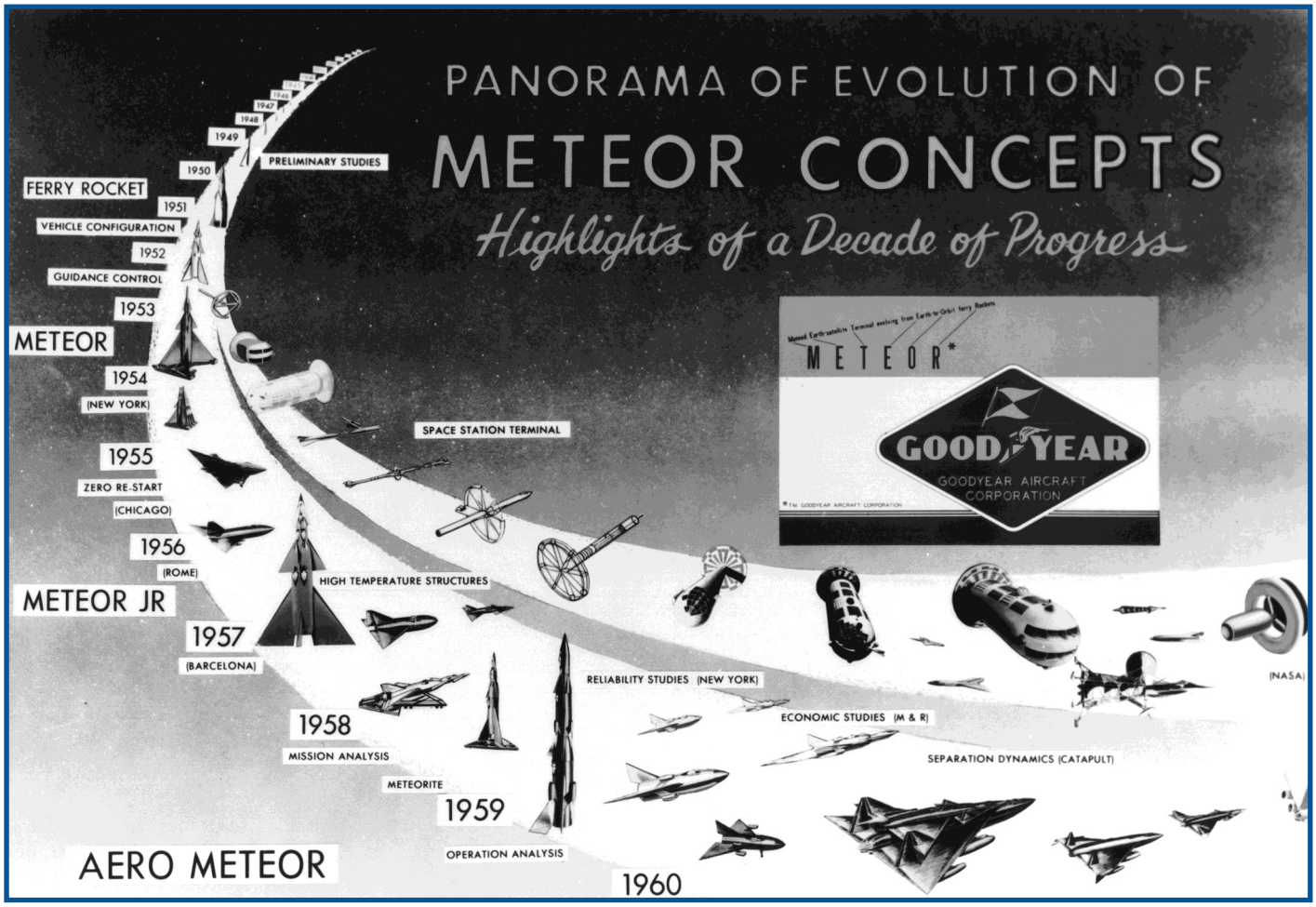
VERTICAL TAKEOFF

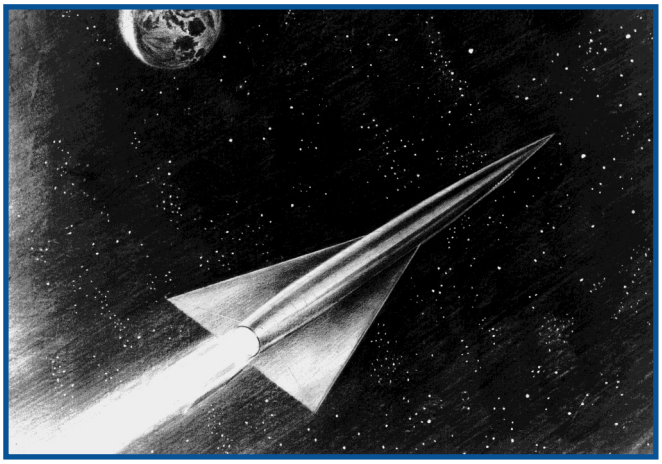


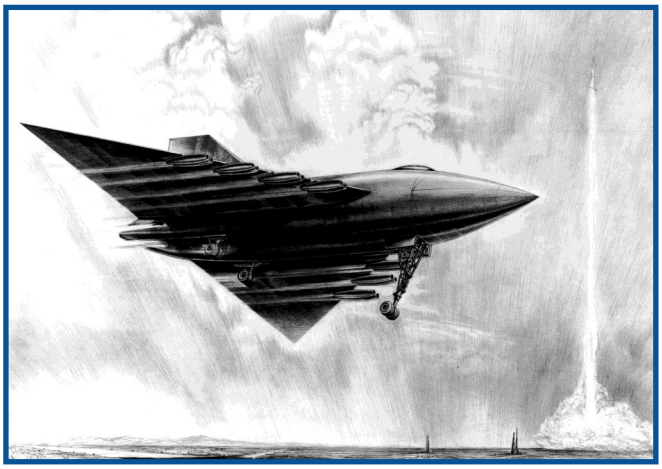
Top Left: Throughout the 1950's, renowned space artist Chelsey Bonestell created spectacular visions of the future including this 1950 piece that looks remarkably similar to the German A-4B, a winged version of the V-2 rocket.

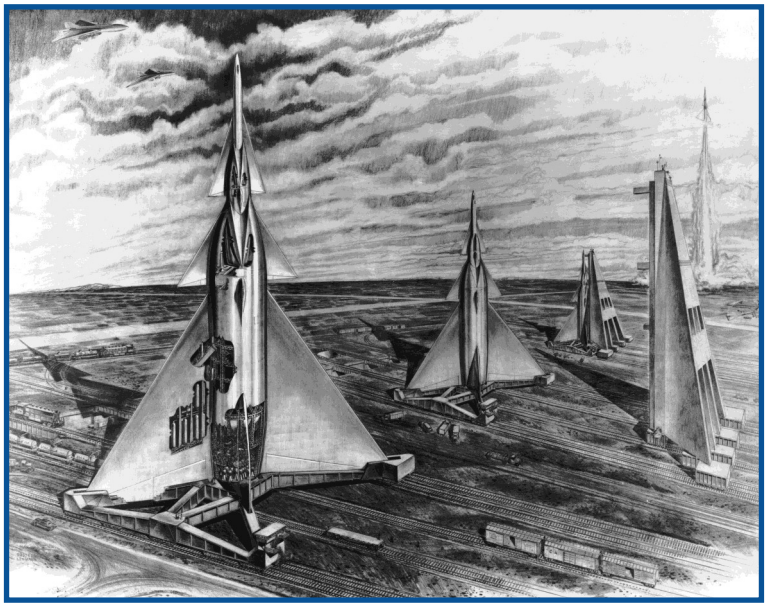
Above: Using cover artwork from Chelsey Bonestell, the March 1952 edition of Colliers magazine contained articles on manned space flight written by such notables as Willey Ley and Wernher von Braun.

Left: The proposed von Braun ferry rocket of 1951 was similar in size to the Apollo program Saturn V with similar capabilities yet weighed twice as much due to the crude manufacturing capabilities of the day.

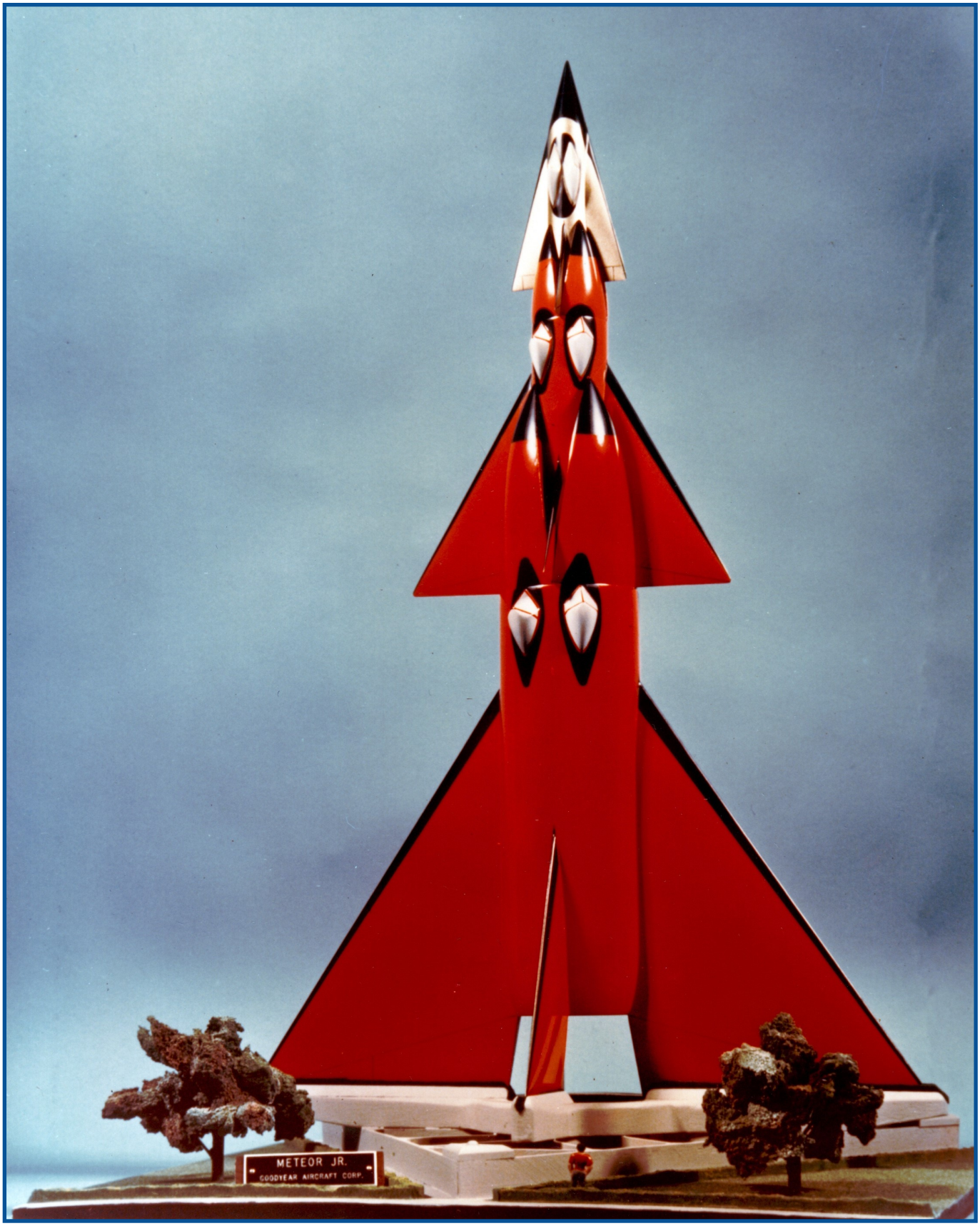




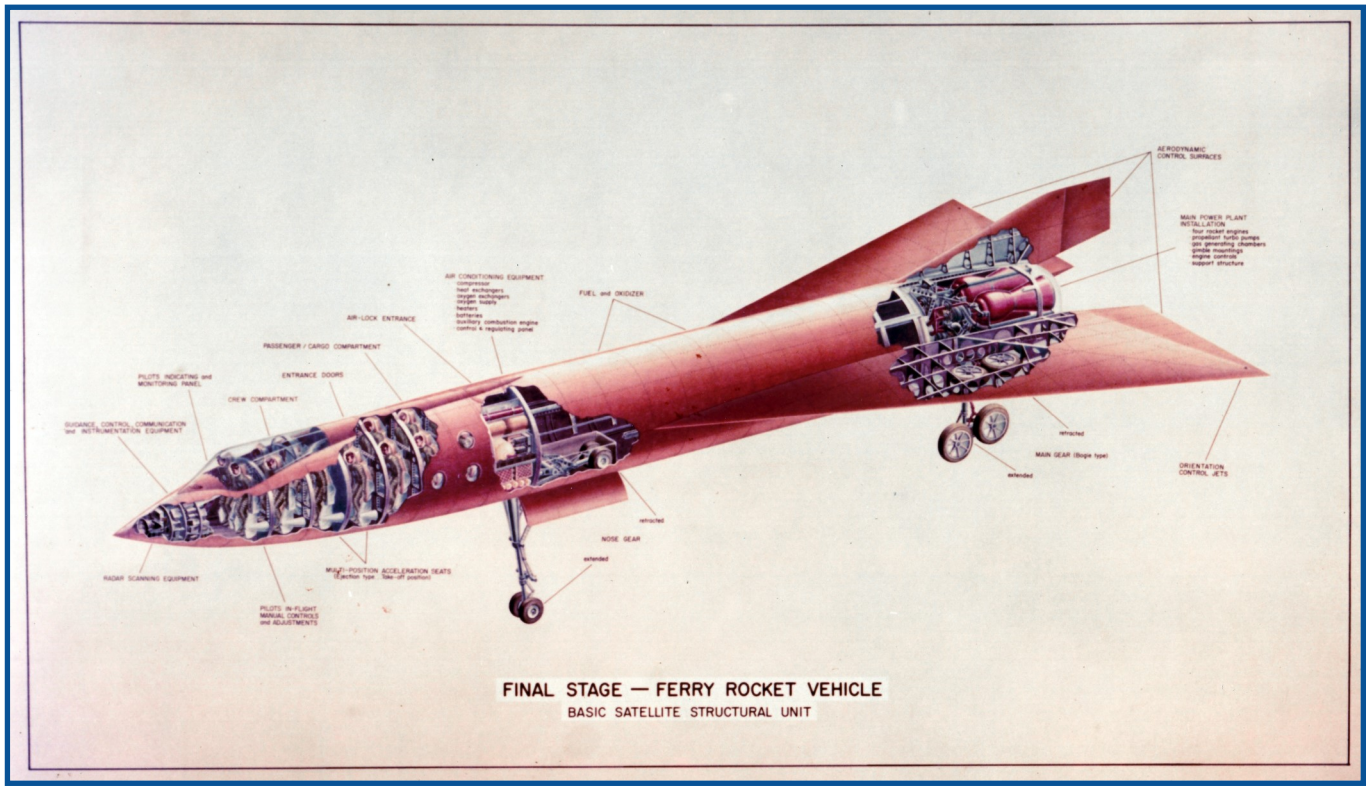




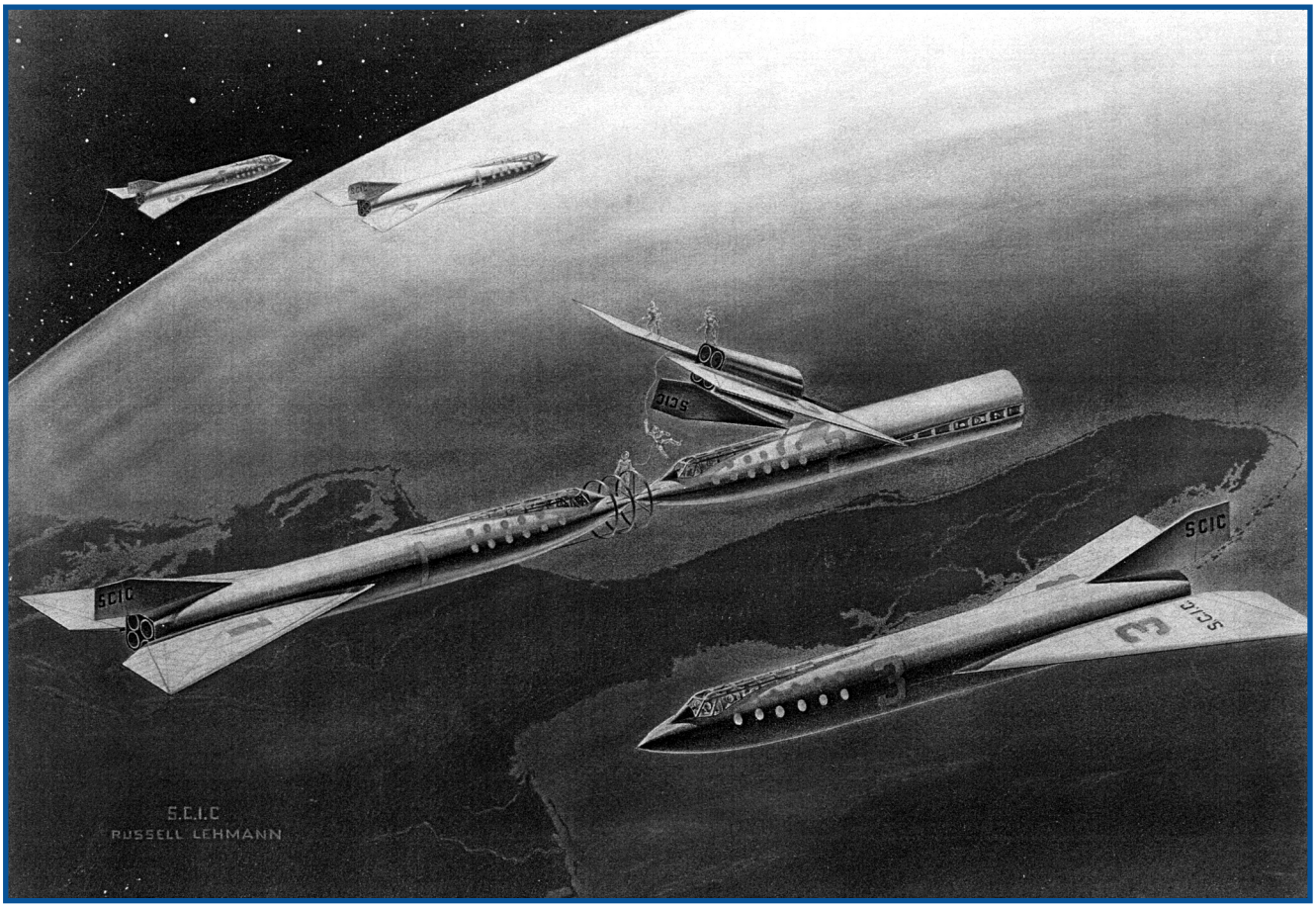
All: Goodyear Aircraft Corporation took an early interest in manned space flight with their METEOR project. METEOR, an acronym for Manned Earth-satellite Terminal evolving from Earth-to-Orbit ferry Rockets, conceived by Goodyear engineer Darrell Romick in 1954, eventually evolved into a series of designs under the METEOR Jr and Aero-METEOR projects.

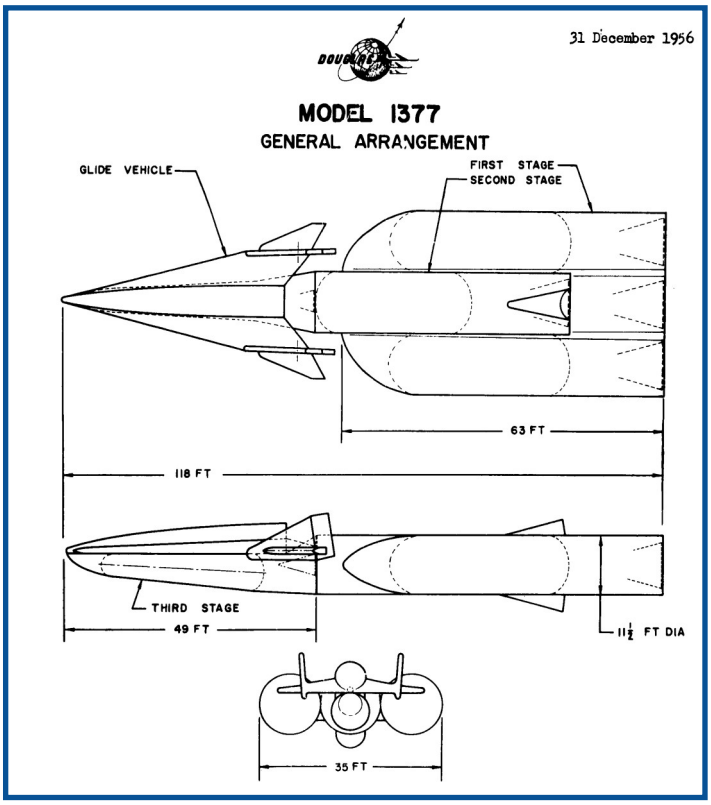


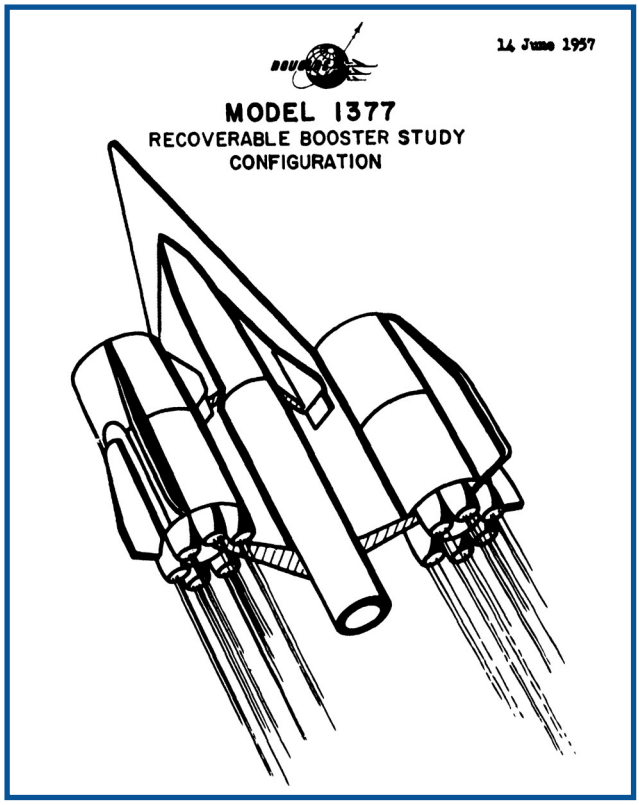
Above: Engineers at Goodyear, convinced that recoverable boosters were the way to get to space, continued with their studies. METEOR Jr. was conceived in 1957 as a scaled-down version of the original METEOR concept. Despite their efforts, nothing came of METEOR and this bright red model of METEOR Jr is one of the only pieces that survive today, on display at the Udvar-Hazy Center of the National Air and Space Museum.



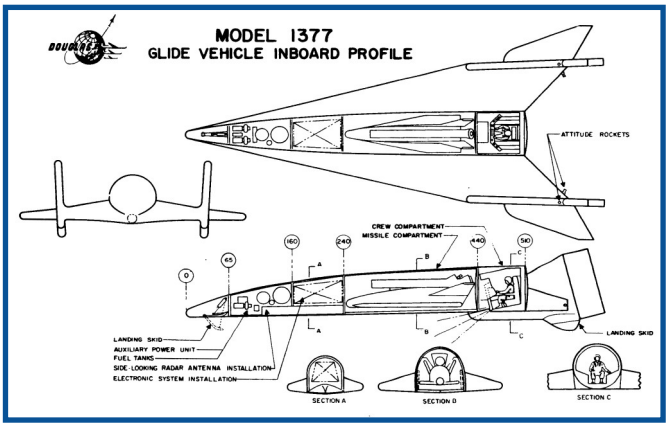
All: The ferry rocket of METEOR Jr. contained space for up to 14 passengers and crew, each placed in multi-position acceleration seats capable of ejection in case of emergency. The Air Force and NASA each funded studies at Goodyear based on the METEOR concepts, but never advanced beyond these studies. As shown below, the vehicles could be used individually or docked together as required by mission parameters.

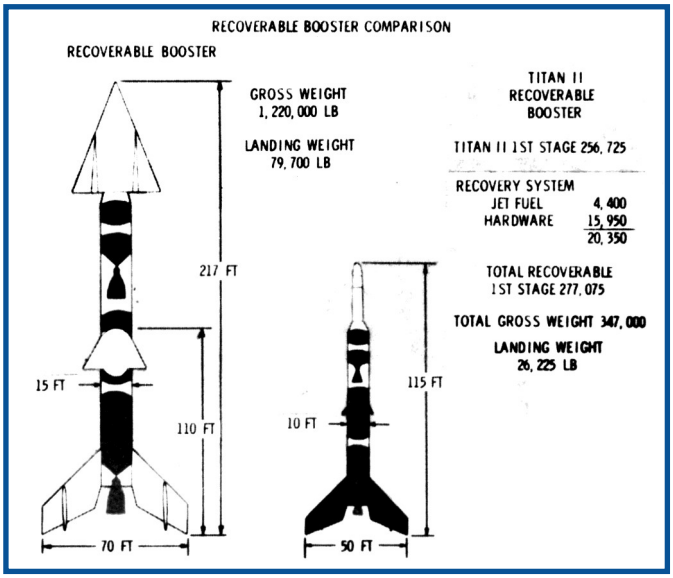


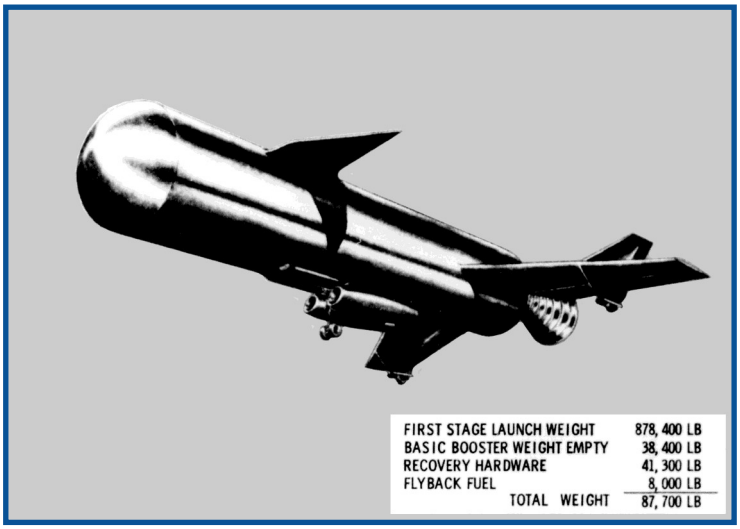




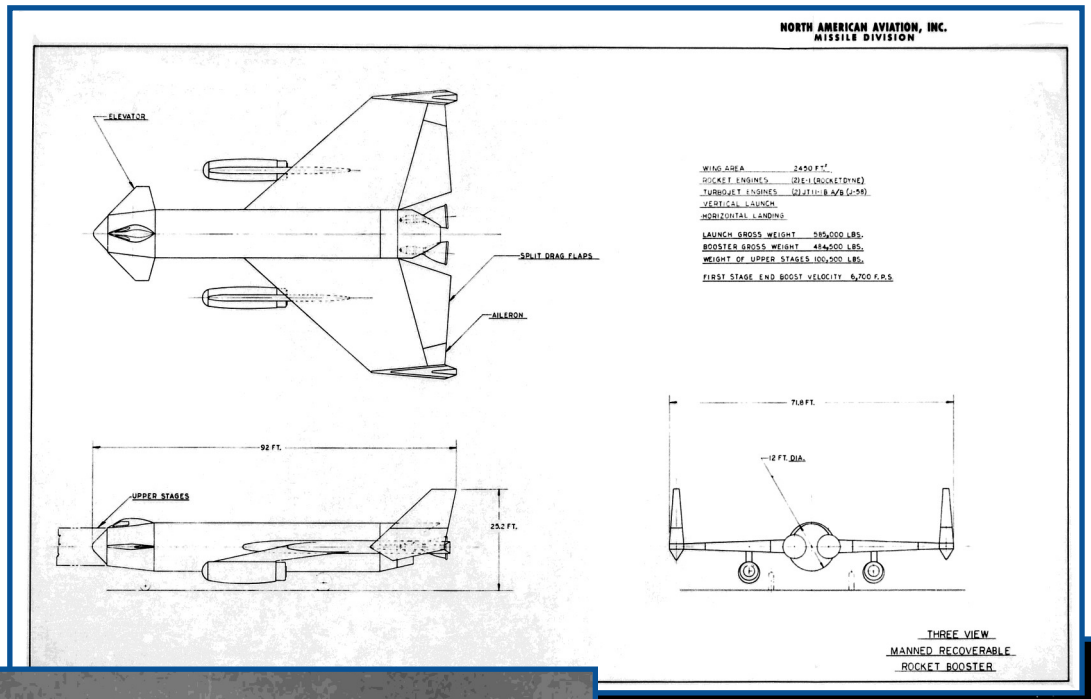
Above and Right: The Douglas Model 1377 began as a 6 month study under project RoBo (Rocket Bomber) with an expendable first and second stage and only the glider being reusable. By June of the following year it evolved into having a reusable, air-breathing first stage. The glider's design used Inconel X as the primary structure and is unique in having the pilot in the rear of the vehicle.

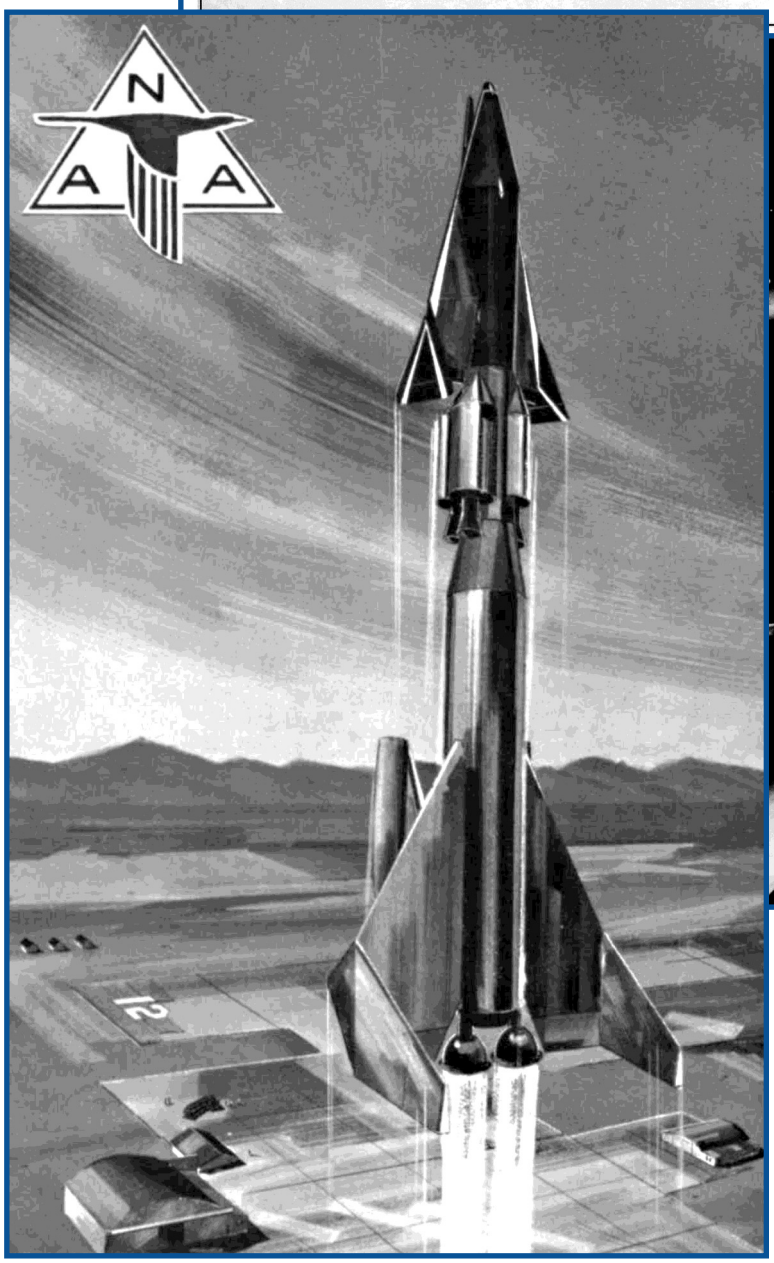






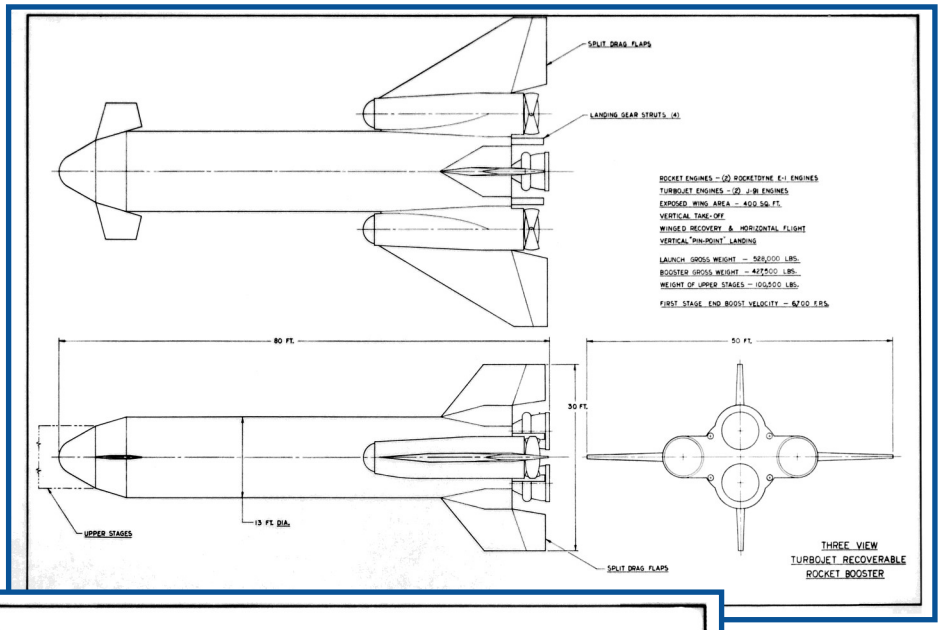
Above: Early designs from the Martin Company in 1961 took a basic approach to recovering the booster by simply adding fixed wings and a pair of airbreathing engines to the first stage. The same design process proposed similar modifications to the Titan II rocket to make it recoverable.

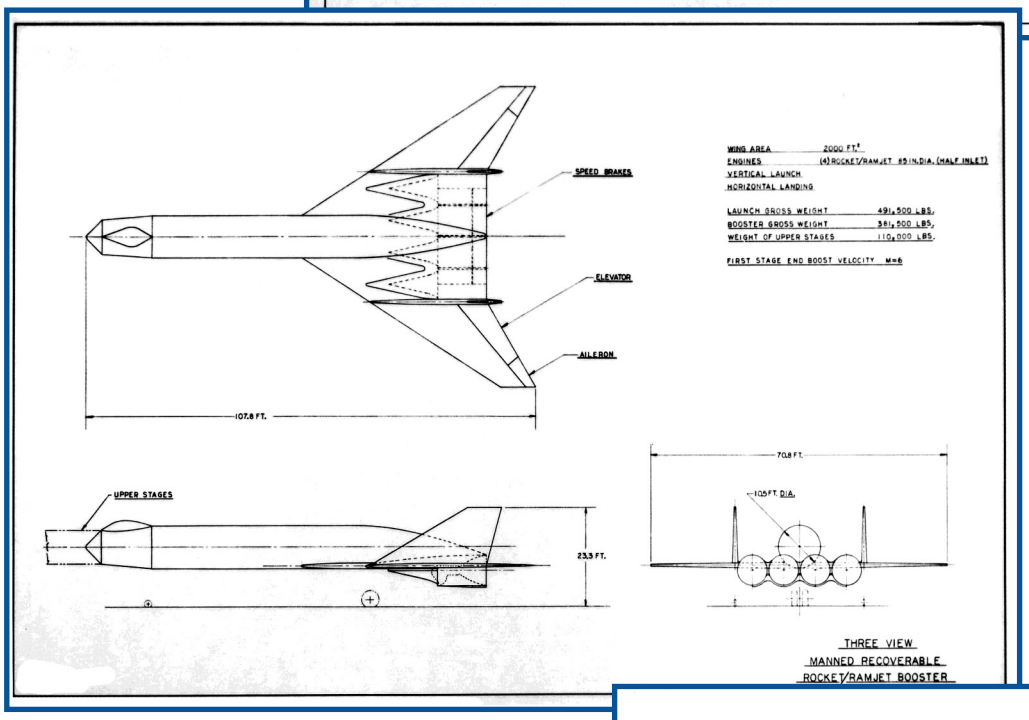




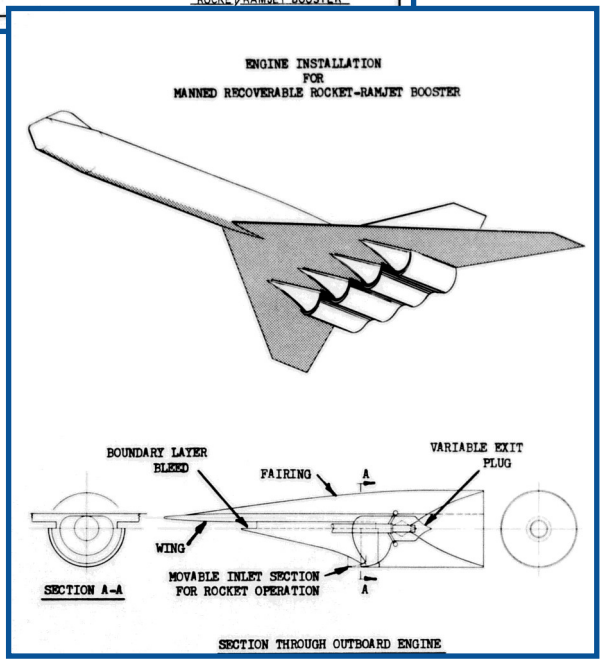
All: This North American Aviation (NAA) recoverable booster design began as a proposed booster for Boeing's Dyna-Soar. Boeing subcontracted NAA for a series of studies on a recoverable booster. The Rocketdyne F-1-powered design was also proposed as a crewed vehicle with the addition of a crew compartment and canards on the forward structure.

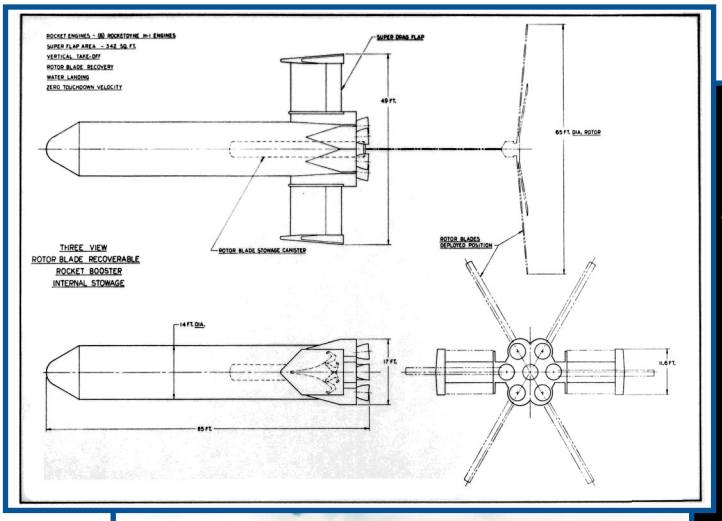
Right: This North American proposal from 1959 utilized two Rocketdyne F-1 rocket engines for the vertical boost phase and twin, six-foot-diameter, nuclear -powered, Pratt & Whitney J91 engines for horizontal flight and vertical "pin-point" landing.

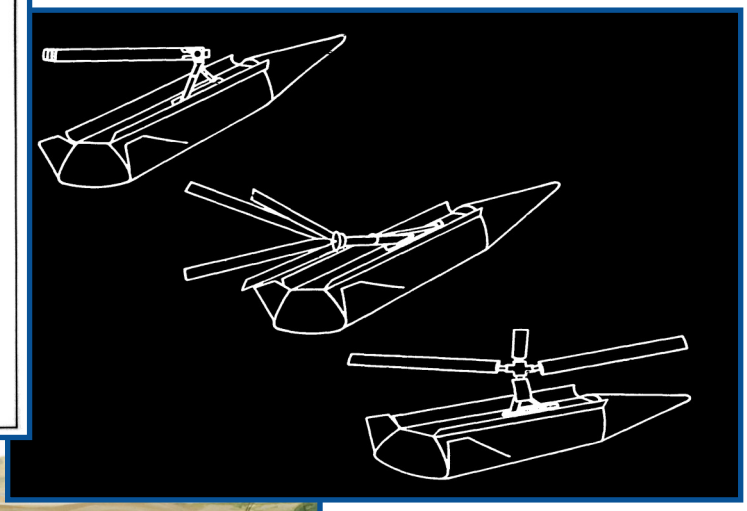


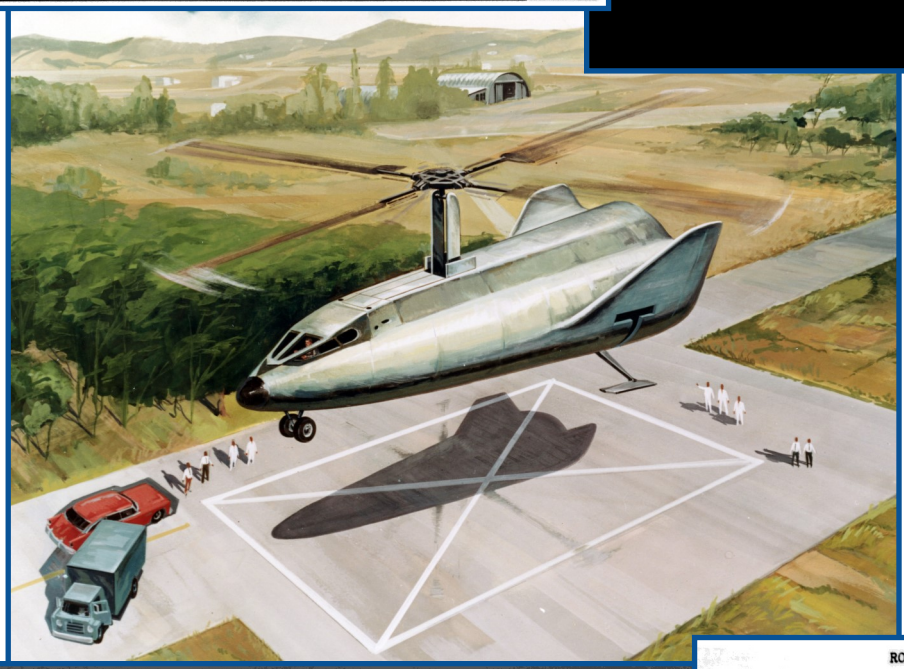


Above and Right: Another North American design from 1959 proposed using 4 rocket/ ramjet engines, an early variation of what became known as combined-cycle engines. With a launch gross weight of 491,500, this craft is designed for a vertical launch and horizontal landing mission profile.

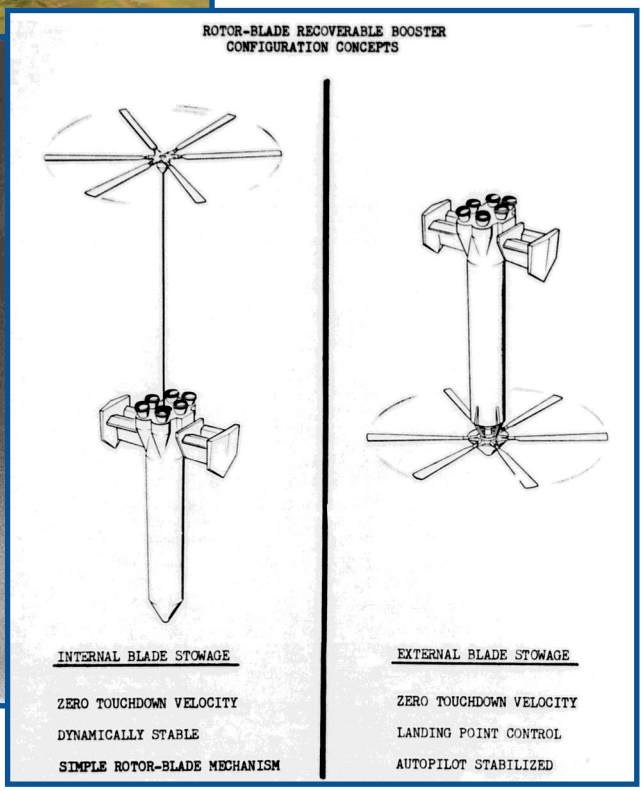


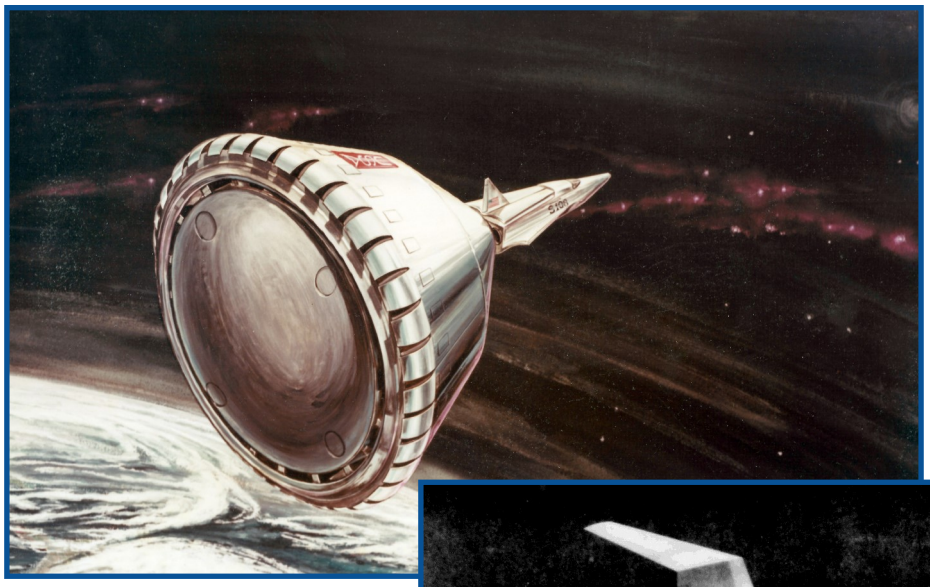




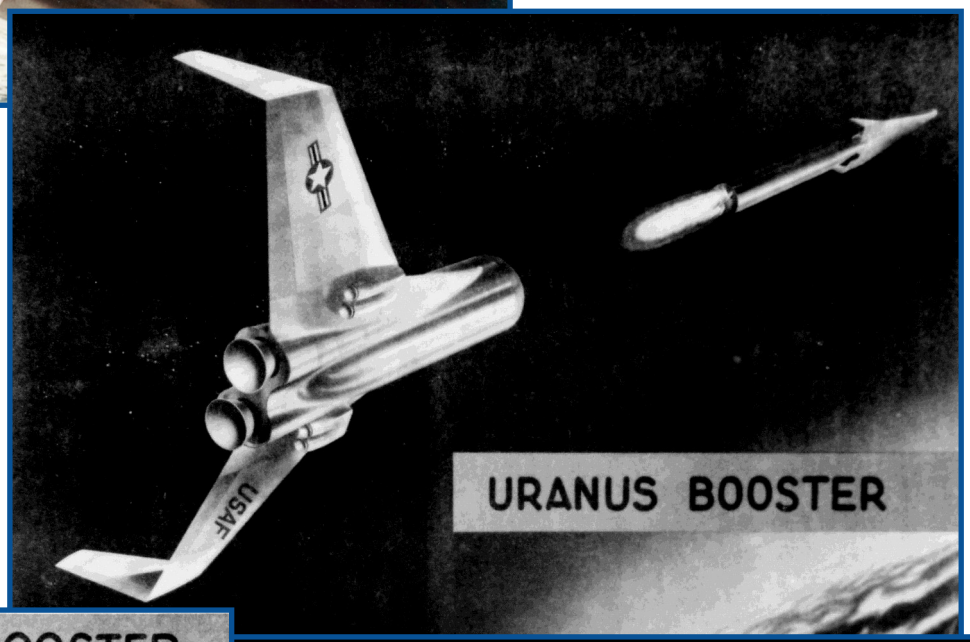


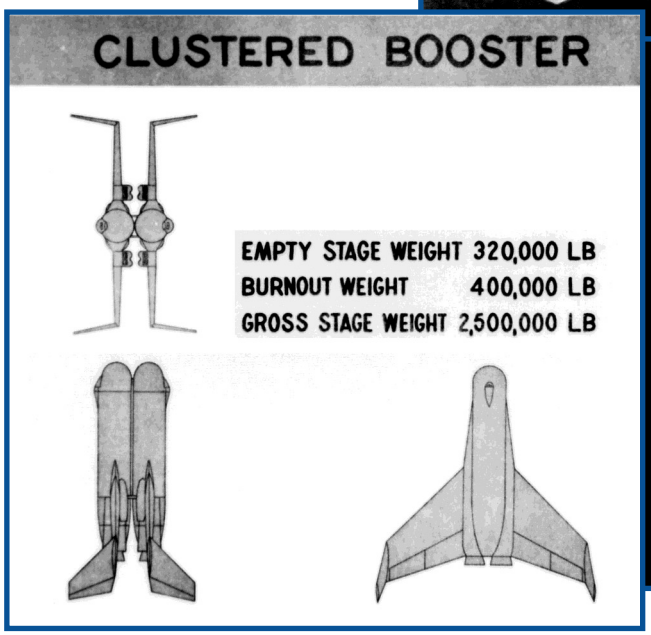
All: Some fanciful proposals utilized rotary wings for recovery. Proposals varied between designs, with some craft having the rotary wings stored internally while others stored against the exterior of the fuselage. This concept would be reborn in the late 1990's for the Roton Rotary Rocket which made only 3 hover flights in 1999 before being cancelled.

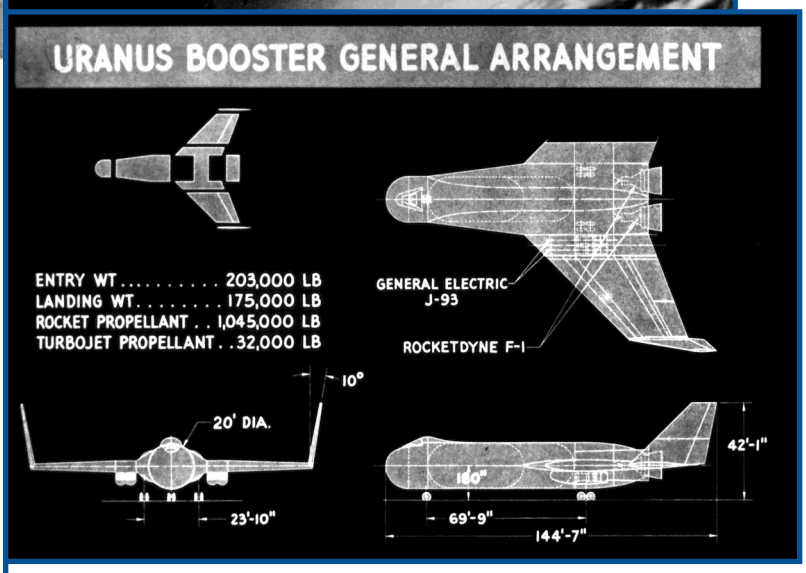




Left: The Chrysler SERV (Single-stage Earth-orbital Reusable Vehicle) proposed utilizing a twelve module LH2/LOX aerospike engine around the rim of the base, covered by movable shields. Two RL-10 rocket engines provided de-orbit thrust for this vertical takeoff and landing design. Note the lifting body spaceplane, MURP (Manned Upper-stage Reusable Payload), on top of SERV.

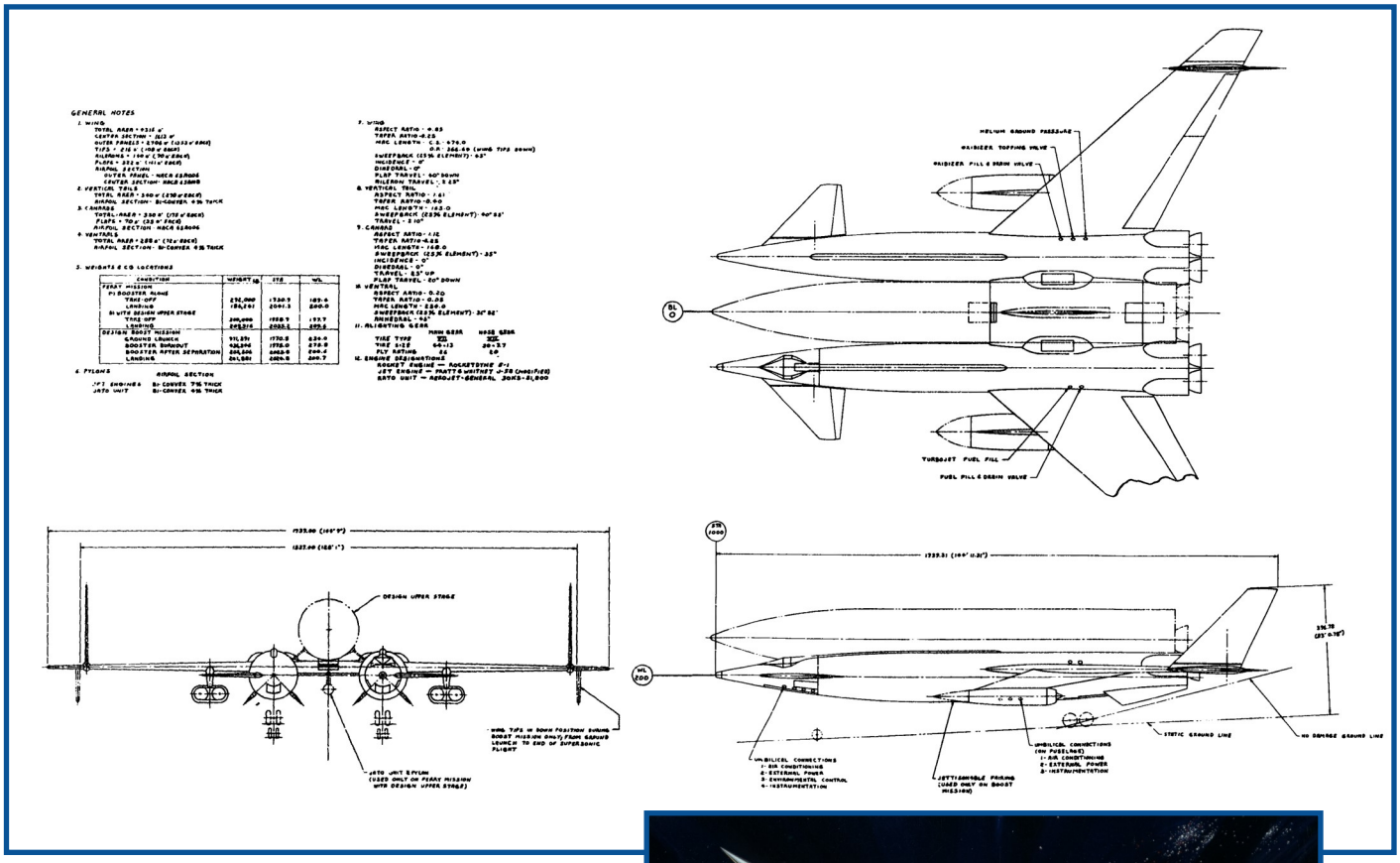






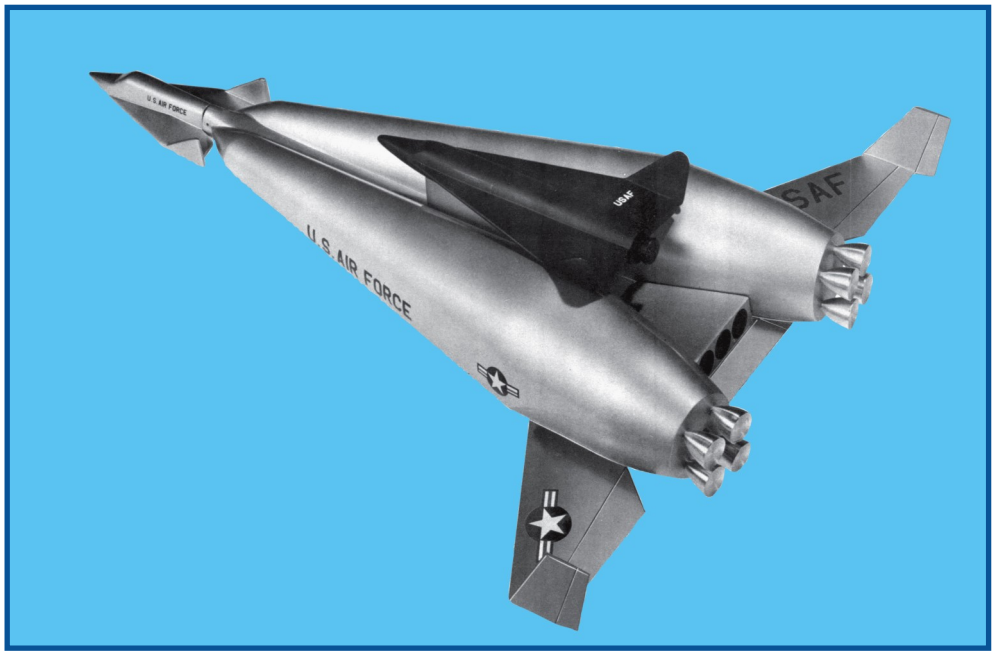
Three above: In 1961, Lockheed Sunnyvale proposed the universal recoverable booster system known as Uranus. With an empty weight of 160,000, the Uranus booster weighed less than a Boeing B-52 Stratofortress. Lockheed designed the vertically launched, horizontal landing vehicle around the use of 2 Rocketdyne F-1 rocket engines, but also provided alternatives using the less-capable E-1, plus 4 General Electric J93 air-breathing engines for horizontal flight and landing.

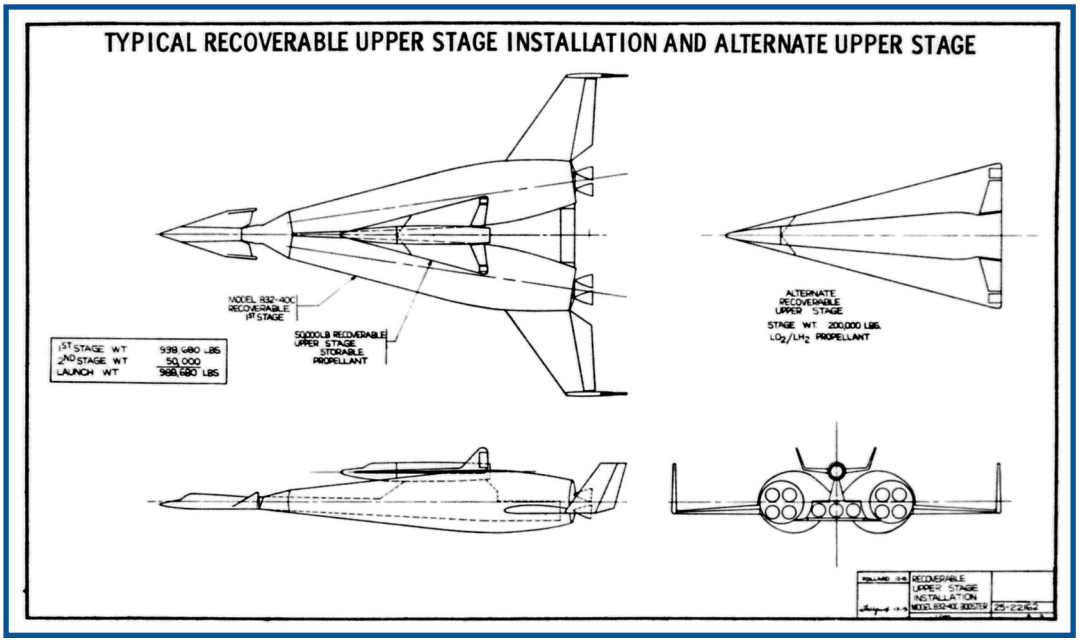
Right and Below: The Missile & Space Systems Department, Hamilton Standard Division, United Aircraft Corporation turned in a very detailed study under SR-89774, known as Project 7969. This VTOHL concept proposed launching a variety of payloads with the capability of landing on a 10,000 foot runway. With 2 Rocketdyne E-1 rockets per side, the 4 Pratt & Whitney J58 airbreathing engines were covered by jettisonable fairings. Another novel feature were the outboard wingtips that could rotate 90 degrees down for added stability. This craft could also be used for ferry missions, boasting a 2,000 nm range with the use of an Aerojet-General RATO booster for takeoff.

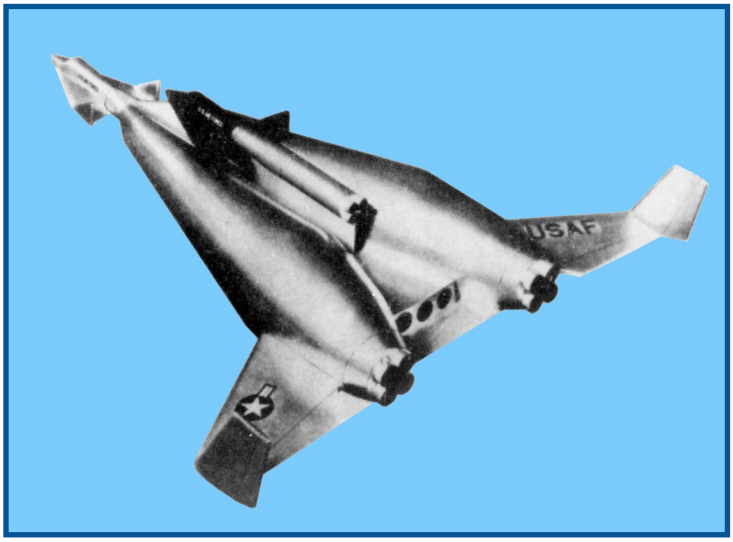


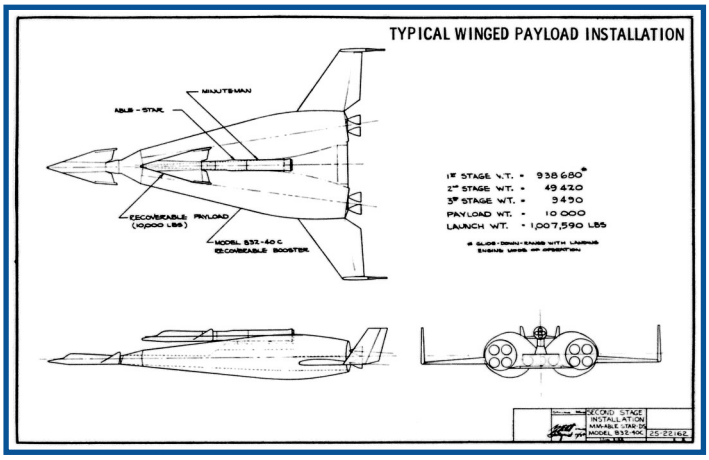
Right: This design from Lockheed made use of a large reusable first stage, an expendable second stage with a winged, orbital recoverable third stage. The concept, known as RAPT (Reusable Aerospace Passenger Transport) was similar in design to many of the early MX-2276 BoMi (Bomber Missile) concepts.

Right: The Boeing double-body, winged booster, known as Model 832-40 made use of a Dyna-Soar glider as the crew module and escape capsule. Powered by twin clusters made up of 4 Rocketdyne J-2B rocket engines for vertical boost and 3 hydrogen-fueled, General Electric MF239C Turbofan engines for horizontal flight and landing. Designed for use with a variety of upper stages including this recoverable, delta-winged vehicle.

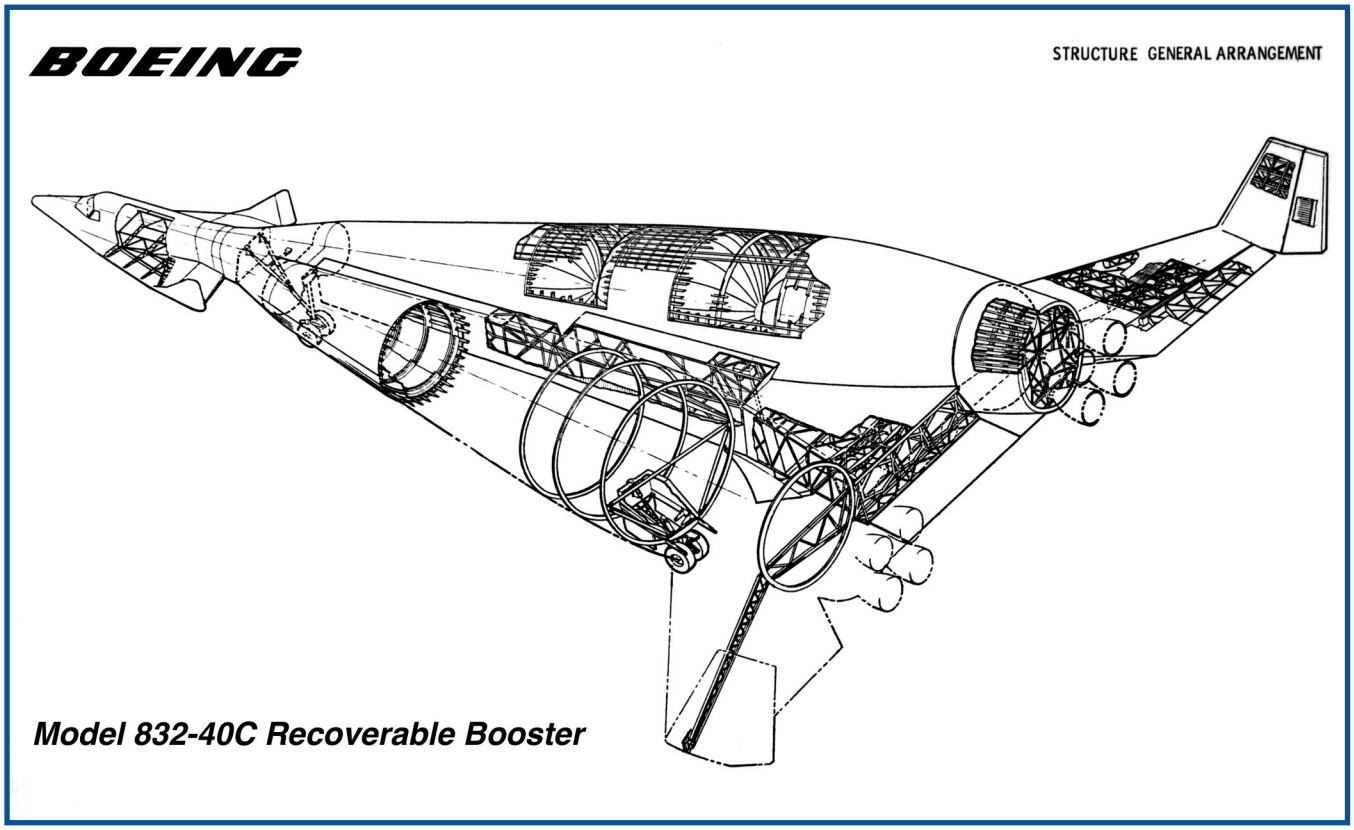




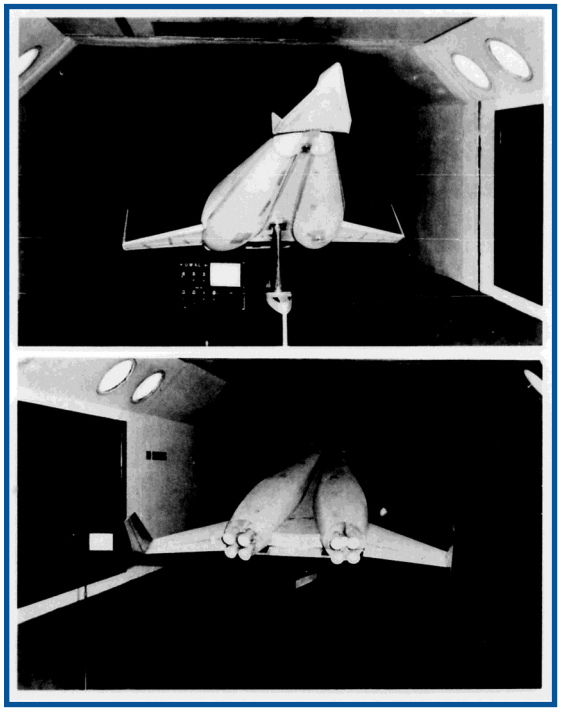


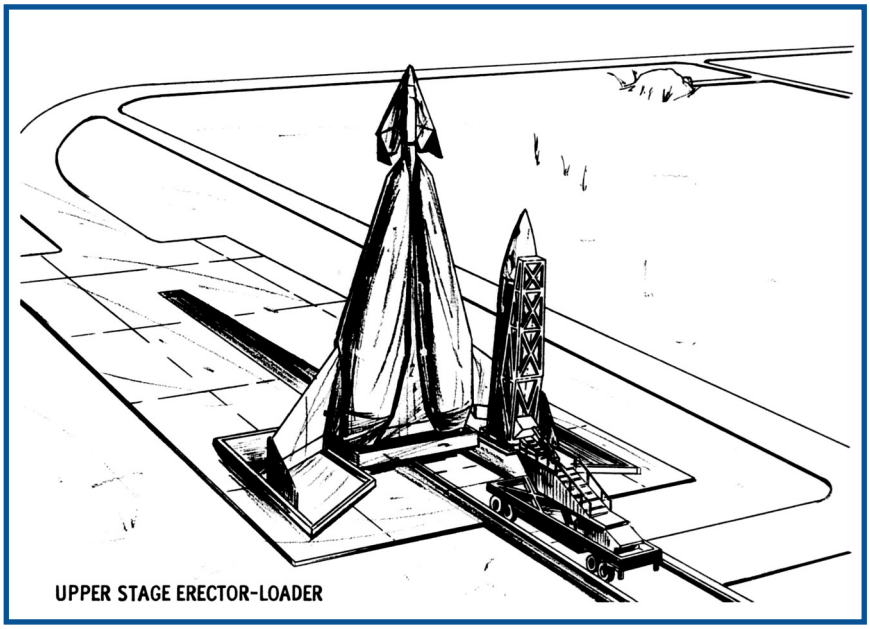


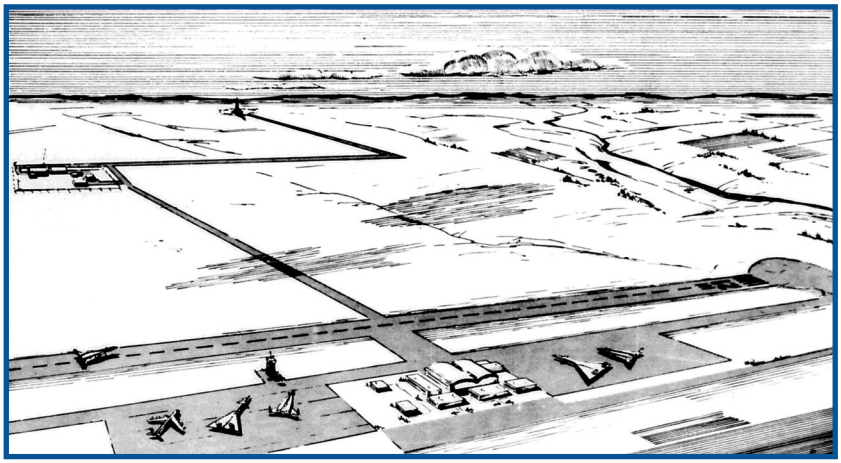
Left and Above: One upper-stage variation included a Dyna-Soar glider launched into orbit using an expendable booster system that include a Minuteman first stage matched with an Thor-Ablestar second stage.



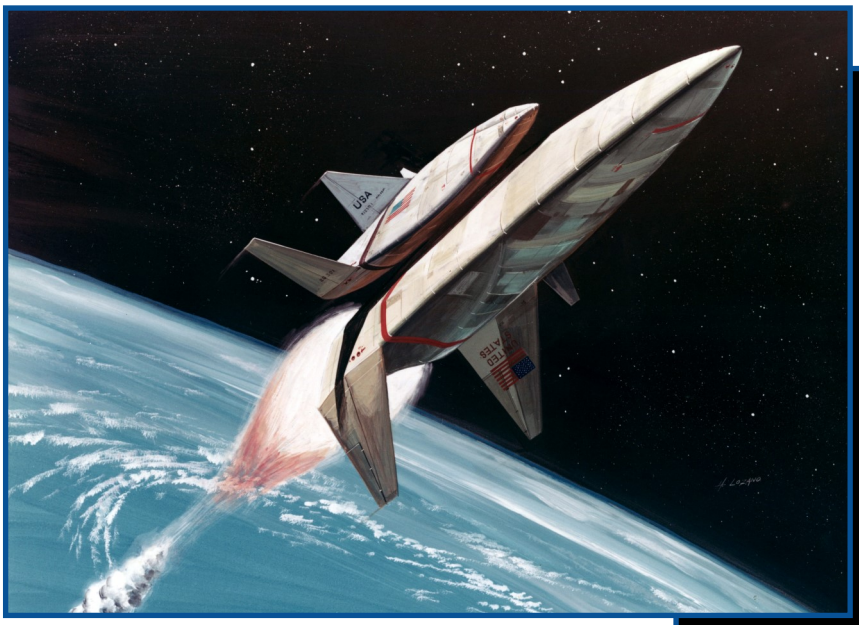
Model 832-40C Recoverable Booster

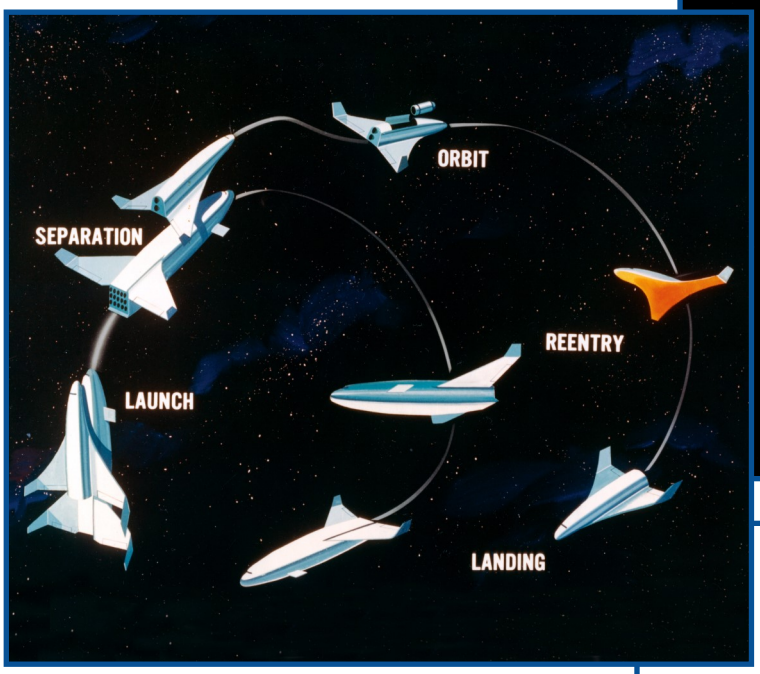


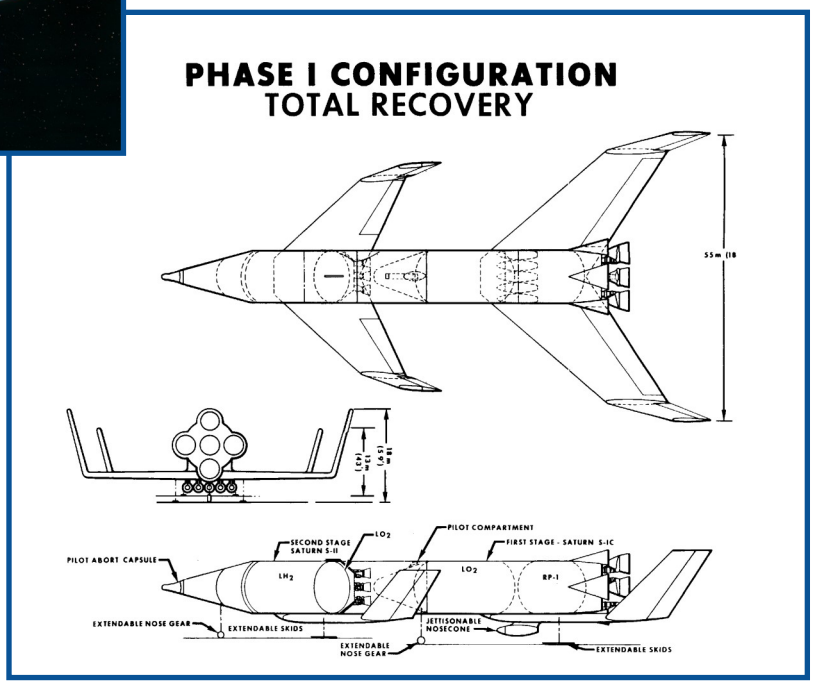




All: Boeing put great effort into the Model 832 design series that included wind tunnel testing of the basic 832-40C design. Artist concepts of upper booster mating on the launch pad and standard layout of the recovery base layout are included in the Boeing-produced studies. Note the B-70 Valkyrie bombers and KC-135 Stratotankers on the ramp with the Model 832.

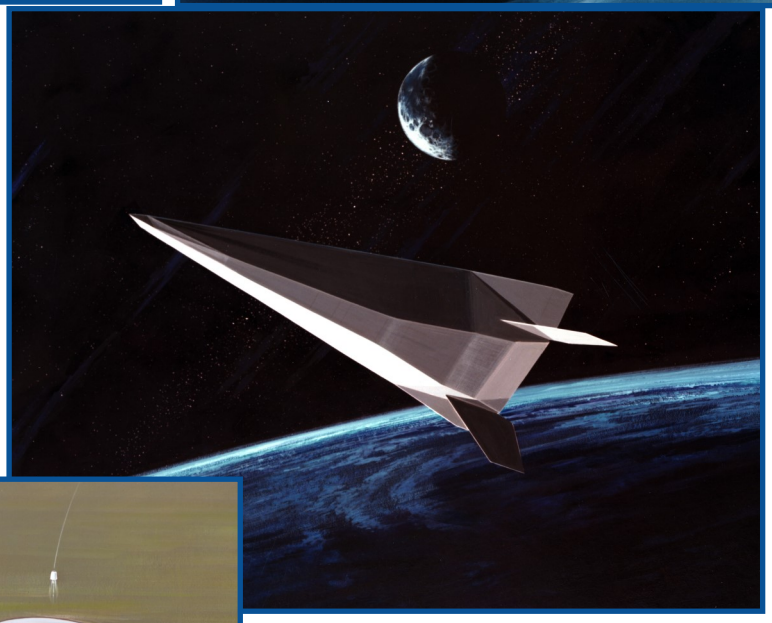






All: A significant number of concepts produced throughout the 1960's were VTOHL, multi-stage designs. Top left is a Boeing concept of a fully reusable system; Top right shows a 3-stage design from NASA Langley using airbreathing engines for horizontal flight; Above artwork shows a basic mission profile for the two-stage-to-orbit, fully recoverable launch system while the two-wing setup at right from North American Aviation boasted a 100-ton fully reusable vehicle using the Saturn S-1C first stage and Saturn S-II second stage, both with extendable skids.

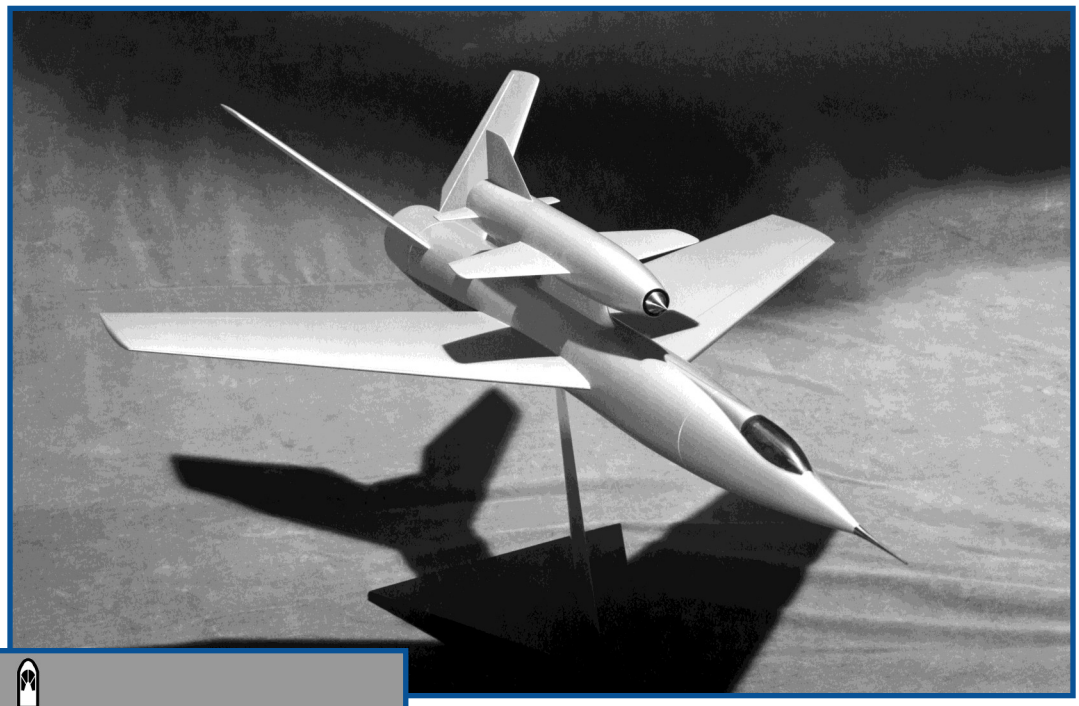
Left and Below: The 1970's brought about a significant amount of refinement to the recoverable booster designs. North American Aviation's concept from a 1970 study on a two-stage to orbit fully-reusable system shows how the orbital vehicle shape had changed from the early BoMi, RoBo and Dyna-Soar designs of the 1960's.

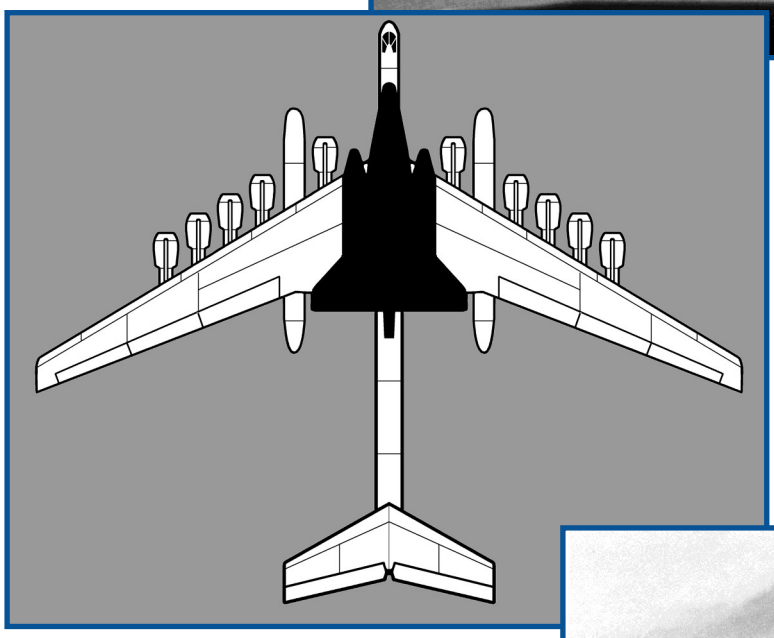


Left and Above: For the 1980's, recoverable systems received a new name, the Transatmospheric Vehicle (TAV). Once again, aerospace contractors created studies related to an Air Force request to investigate a vehicle that could take off from Earth, propel itself into orbit and return for a conventional landing. The concepts shown here are from a McDonnell Douglas study completed in 1984. The TAV base at left shows a simple launch and recovery base with multiple vehicles taking flight at the same time.

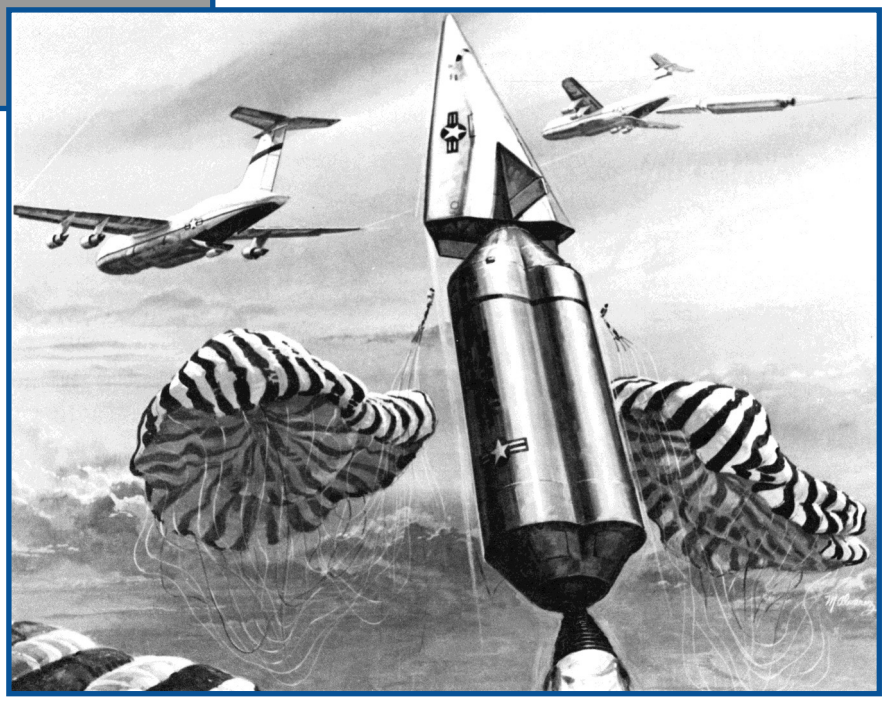
HORIZONTAL TAKEOFF

Right: In 1952, two engineers at the NACA High-Speed Flight Research Station (HSFRS), Hubert M. Drake and L. Robert Carmen released an ambitious proposal which utilized a large carrier aircraft and a smaller craft capable of Hypersonic flight. This 'V' tailed design appears to be based on the Drake-Carmen vehicle although the smaller craft appears to be a ramjet.

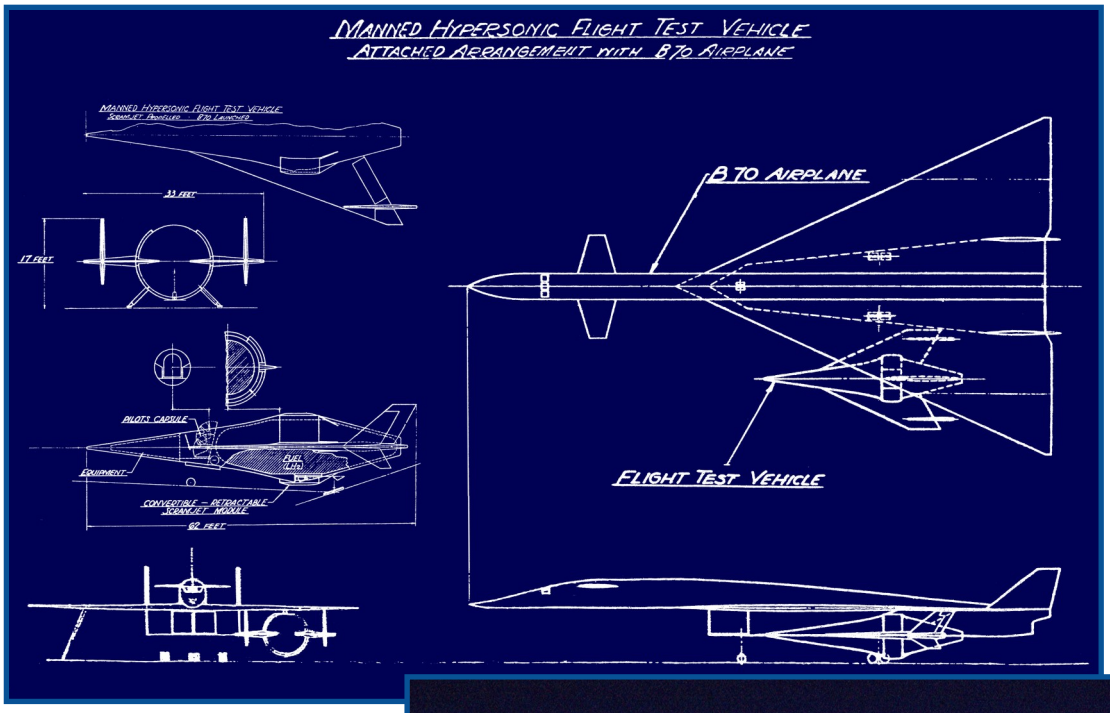


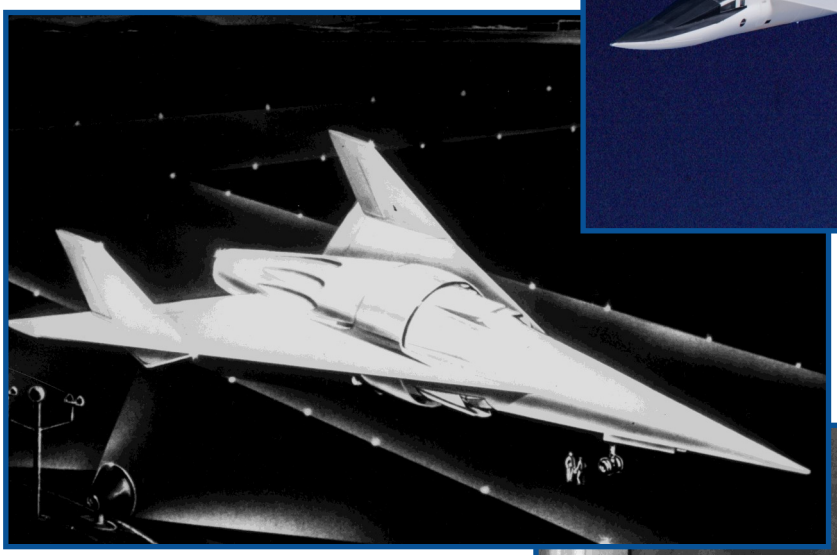


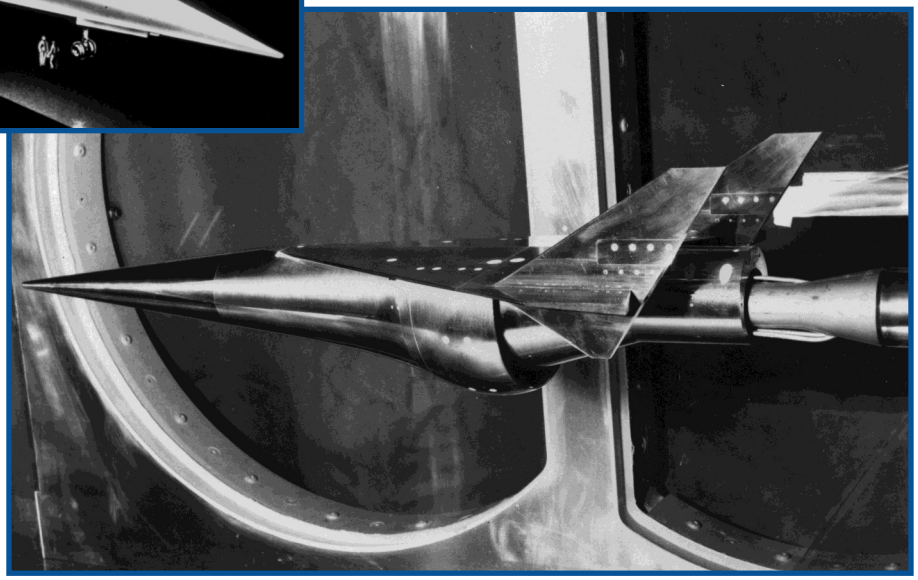
Left: One of many concepts proposed by Robert Salkeld of United Aircraft was this ten-engine monstrosity that carried a small, stage-and-a-half orbital craft. The small craft carried beneath the carrier ship would be boosted into orbit with the use of a liquid-fueled engine fed by external tanks located along the sides of the vehicle.



Right: Rockwell International proposed using the C-5 transport to launch their recoverable launch vehicle. The unit would be extracted from the cargo bay with the use of parachutes which would also angle the vehicle vertically prior to engine ignition.

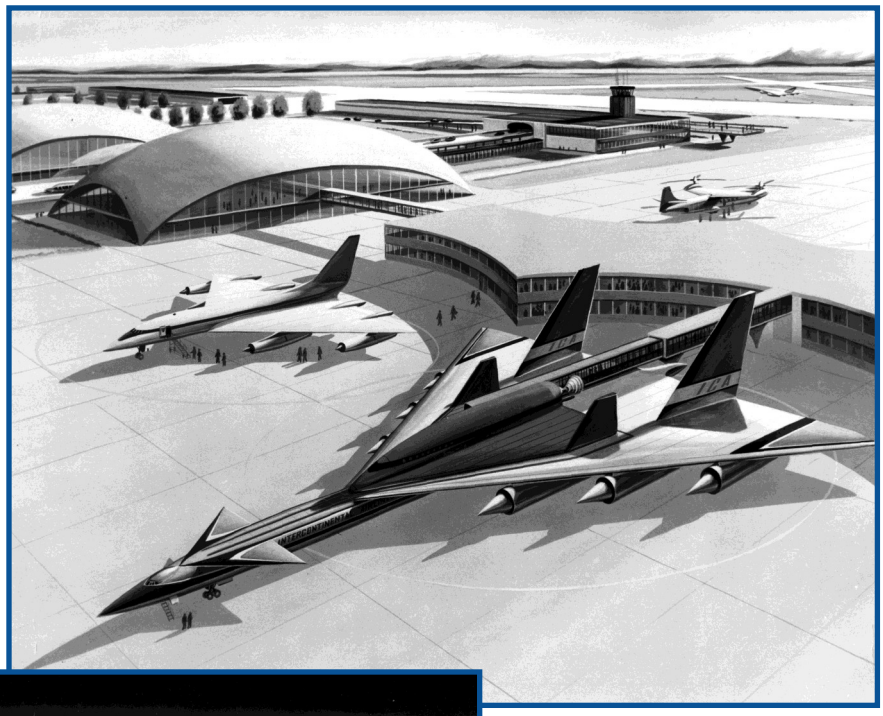


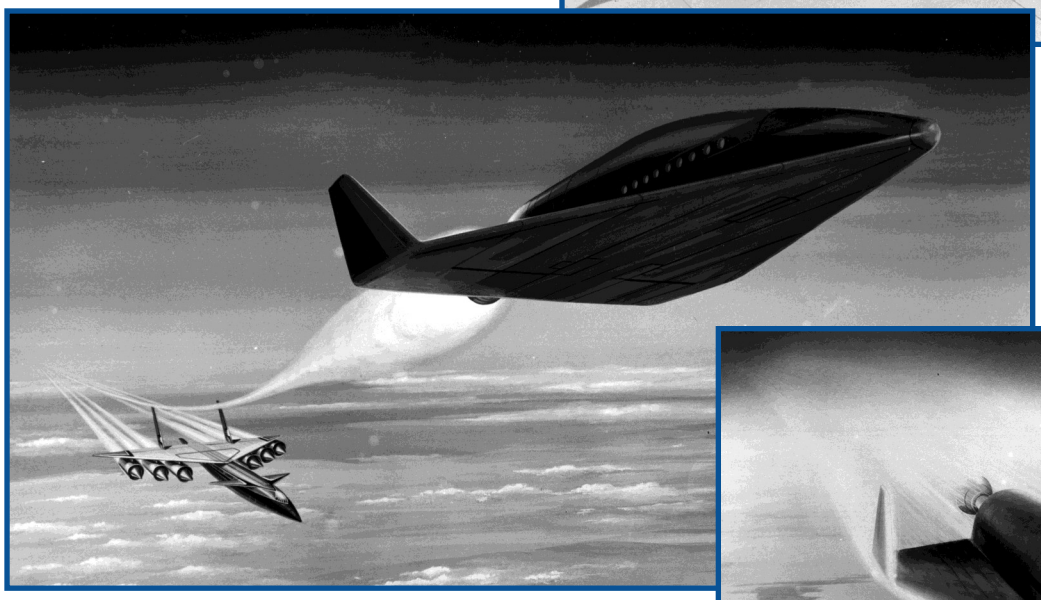


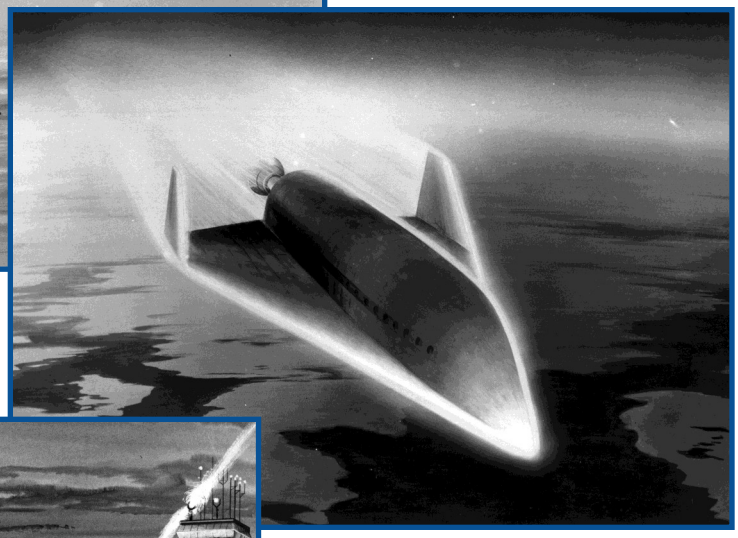


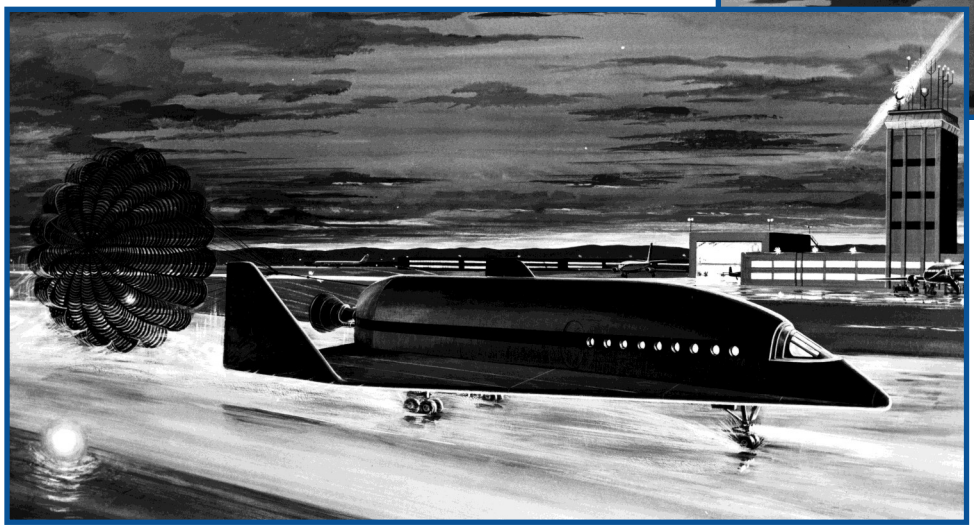
All: Manned hypersonic flight has long been a challenge for the aerospace industry. This proposal from Republic Aircraft made use of airbreathing scramjet engines around the center fuselage and proposed using the B-70 Valkyrie as a high-speed carrier vehicle. Note the design evolution from mid-wing to high-wing in the photos above and at right.

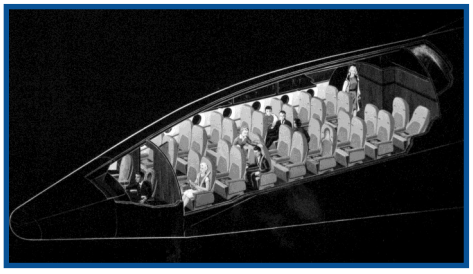
All: In 1960, Bell Aircraft Corporation had their own vision of the future when they proposed a boost-glide transport capable of taking 30 passengers from Los Angeles to Paris in just 1 hour and 4 minutes. By 1980, launched from a turbo-ramjet-powered carrier vehicle, passengers could pay around $750 for a flight at the edge of space in air-conditioned comfort and comfortable seating, including several minutes of weightlessness, and land at their favorite overseas destination in just over an hour. With a development cost close to 1 billion dollars, the design didn't make it much past the concept phase.



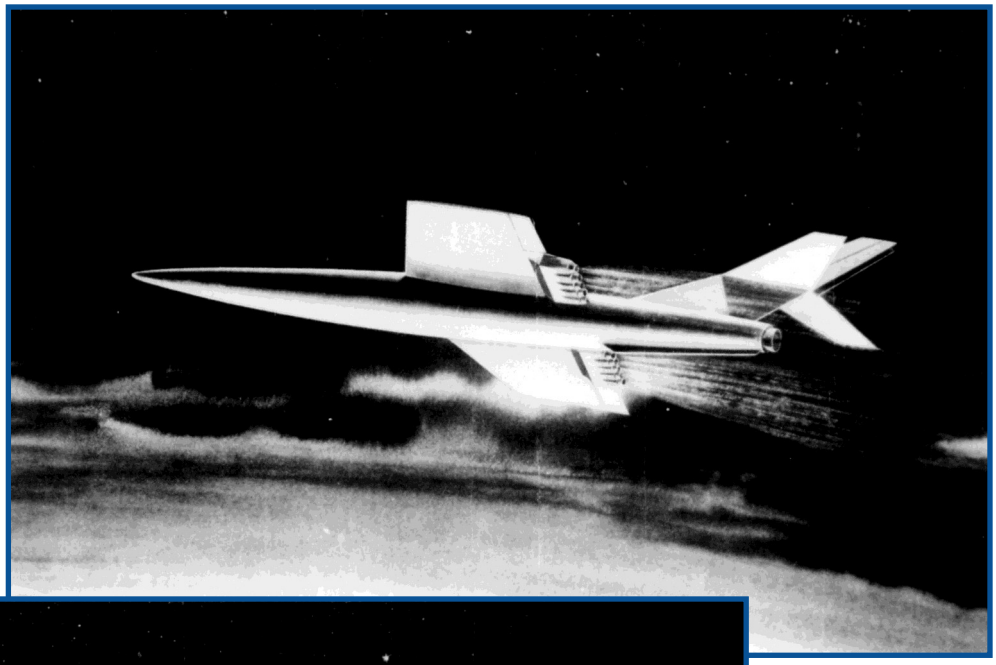


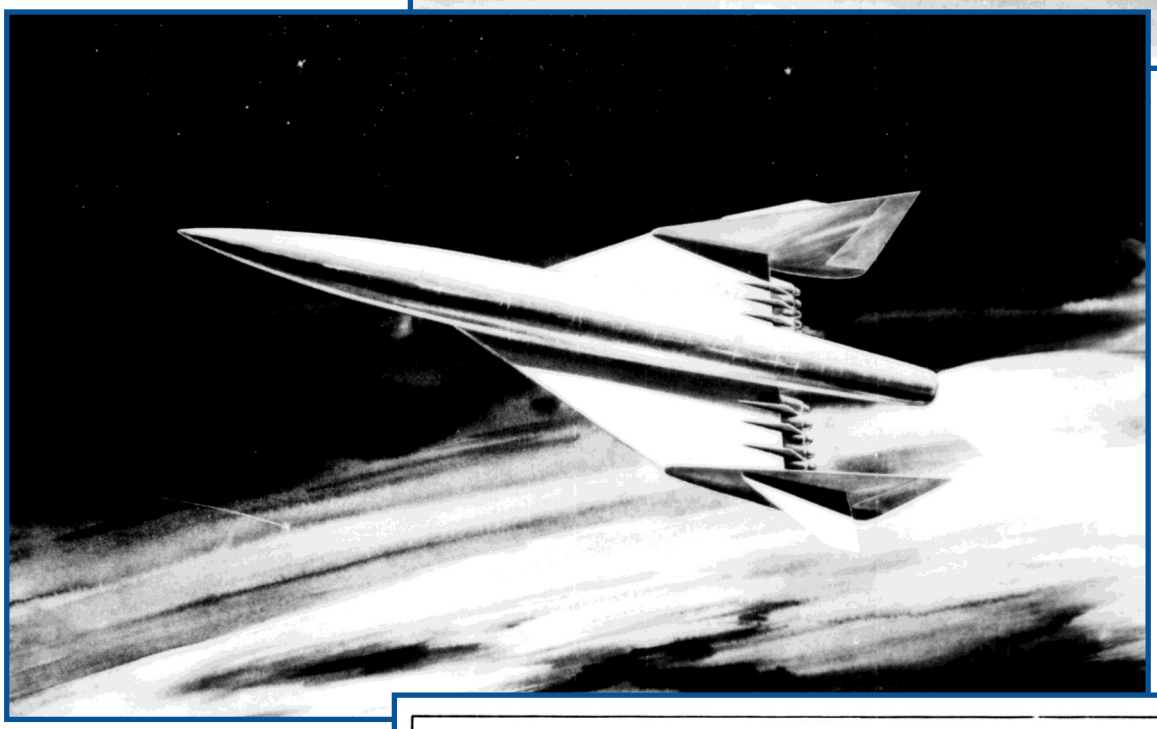




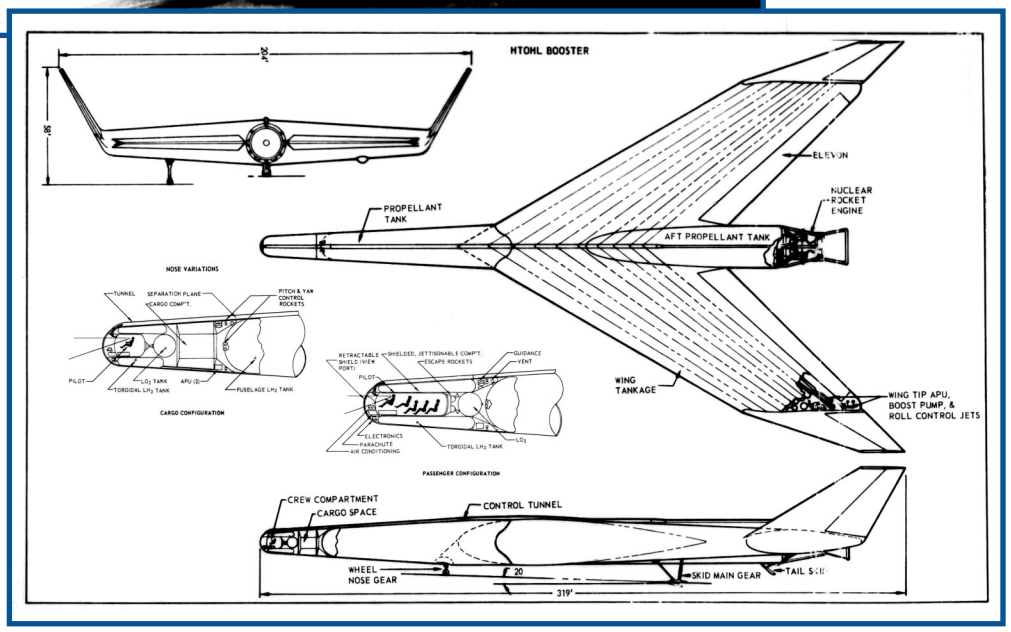


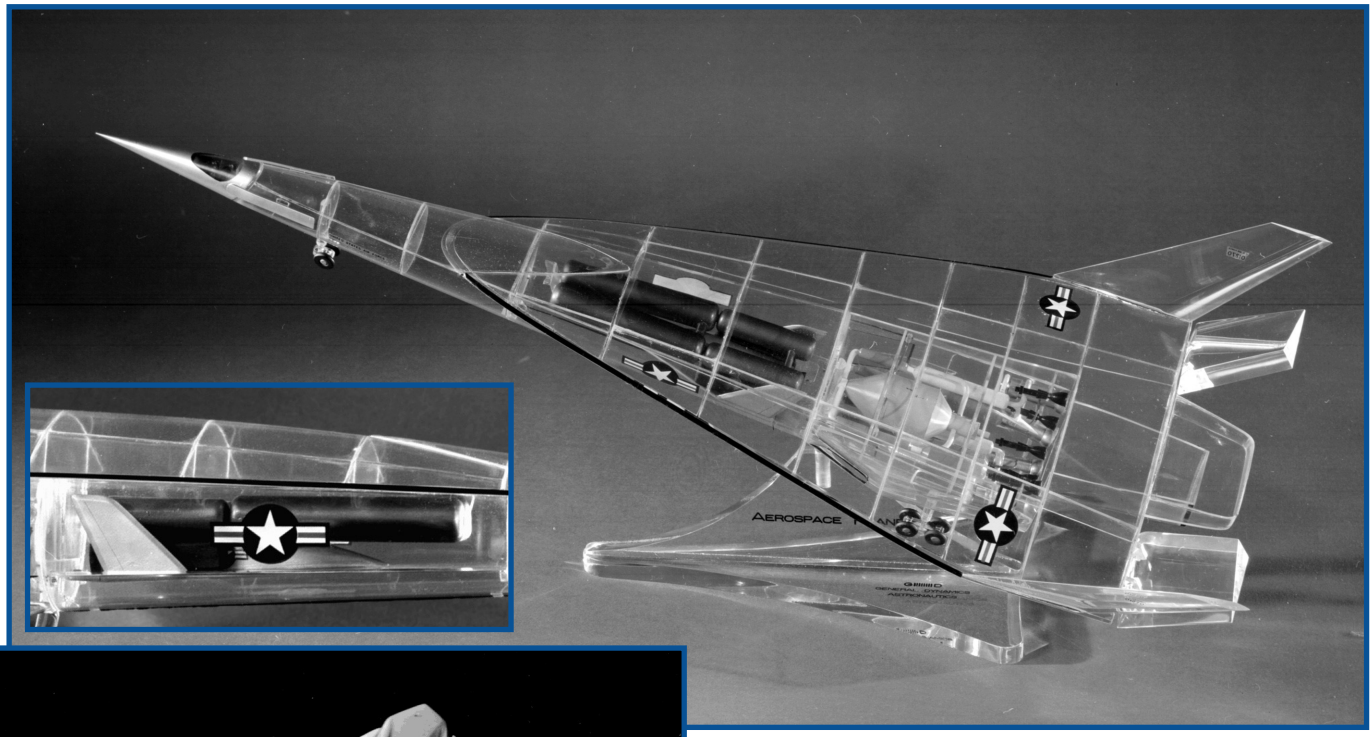
Right and Below: Under Air Force System Requirement (SR) 19786 for an Aerospace-plane, Douglas Aircraft proposed two different hydrogen-fueled single-stage-to-orbit (SSTO) designs. Both projected putting up to a 30,000 pound payload into a 100 to 300 mile earth orbit using a combination of reaction controls and large aerodynamic surfaces.





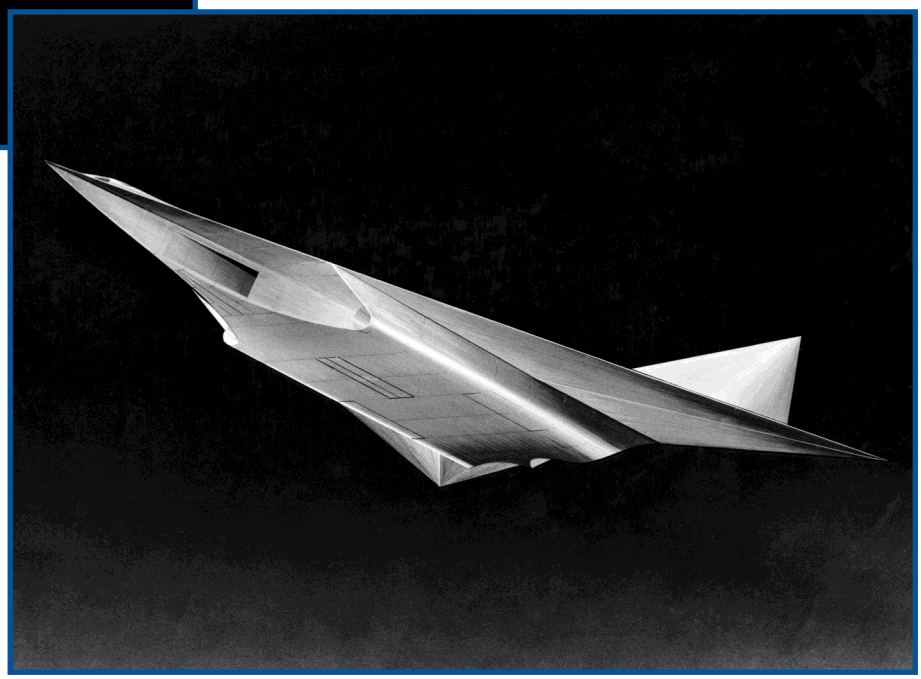
Right: The majority of space in this Douglas Aircraft design under SR-89774, stored propellants for the single nuclear engine capable of 817,000 pounds thrust. The structure of the 165 foot span wing would be made from titanium sandwich skin over a conventional aluminum frame. The small payload area in the front could be arranged to carry passengers or cargo. Note the skids used for main landing gear.



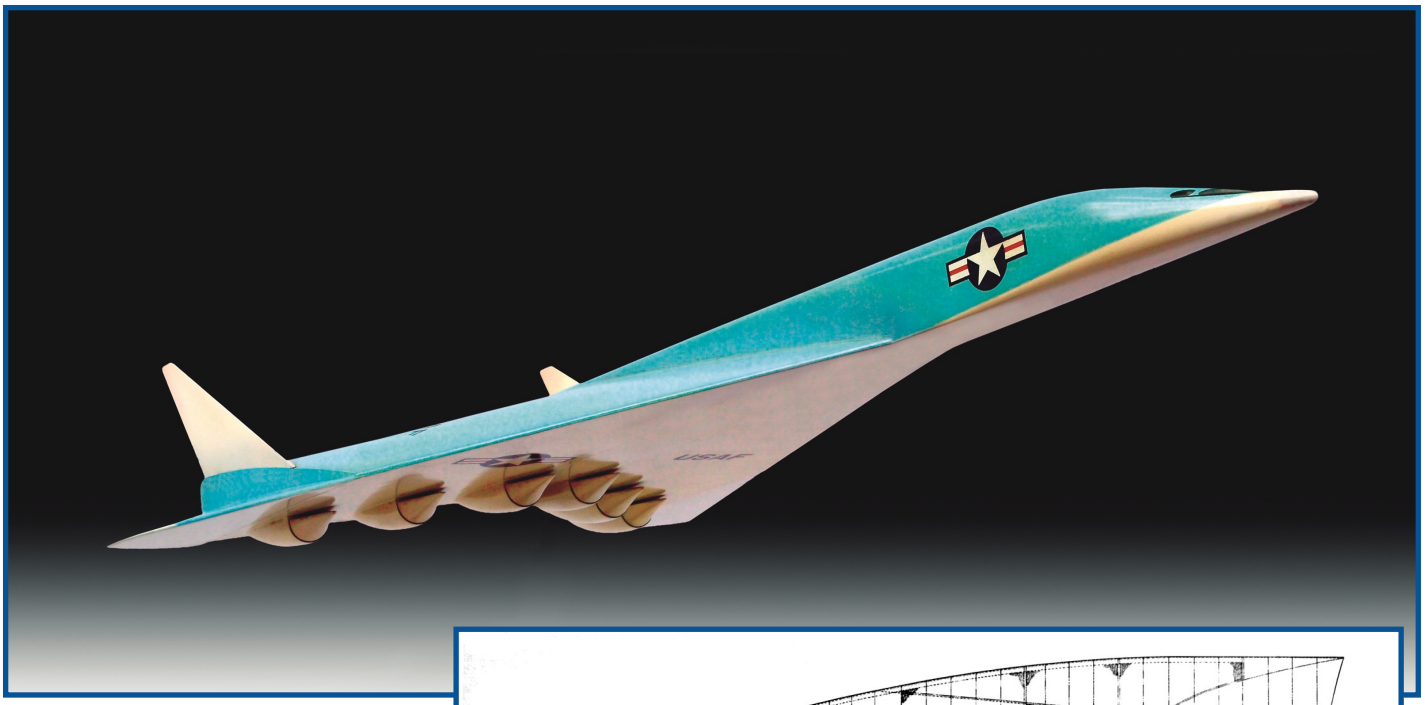


Above: This transparent model of a scramjet-powered Aerospaceplane from General Dynamics Astronautics, displays the internal arrangement of significant internal components. A smaller space plane or winged missile could be carried internally in the central payload bay (inset).

Left: NASA Ames Research Center wind tunnel model of an advanced Aerospaceplane folding wing design with hinges installed at wing attach points to test different flight configurations using the same model.

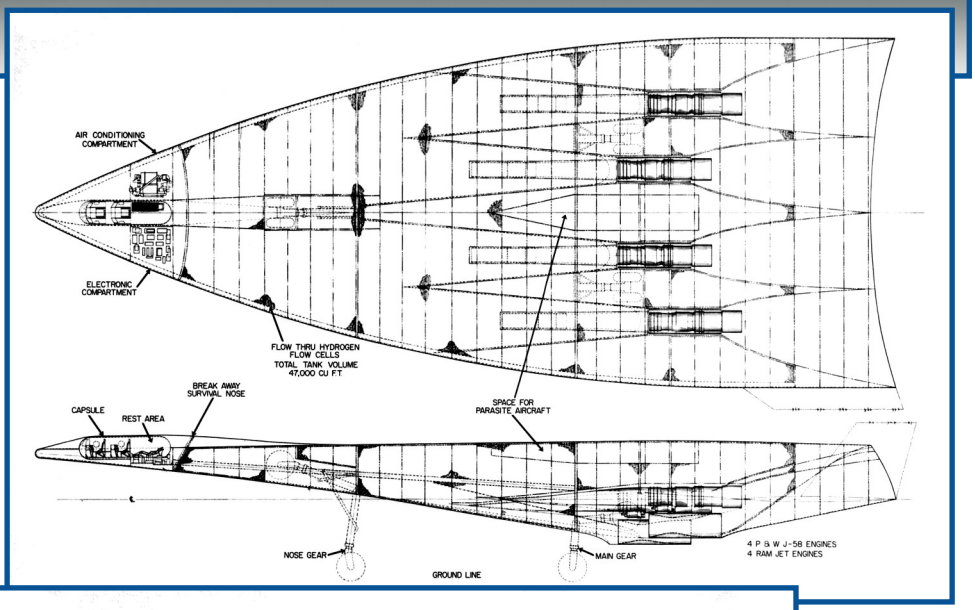


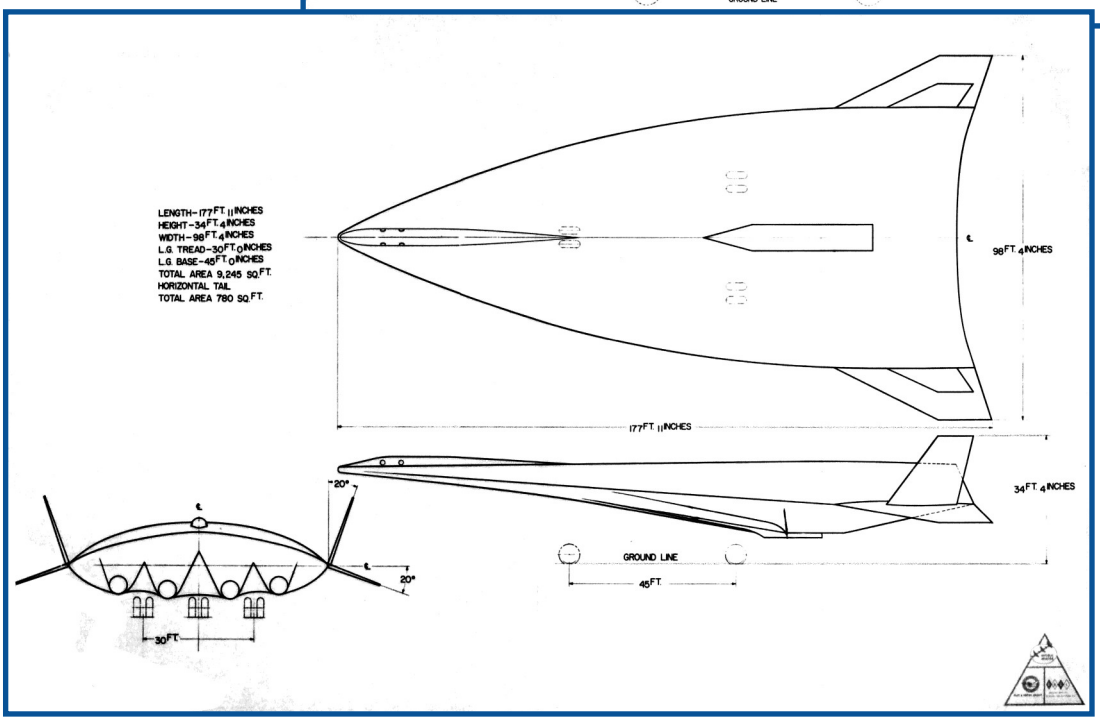
Right: More of a hypersonic bomber design, than actual booster, this Mach 7, Republic Aircraft concept from 1960 made use of compression lift to carry a 2,000 pound payload at an altitude of 120,000 feet utilizing two turbojet and two ramjet engines for propulsion.

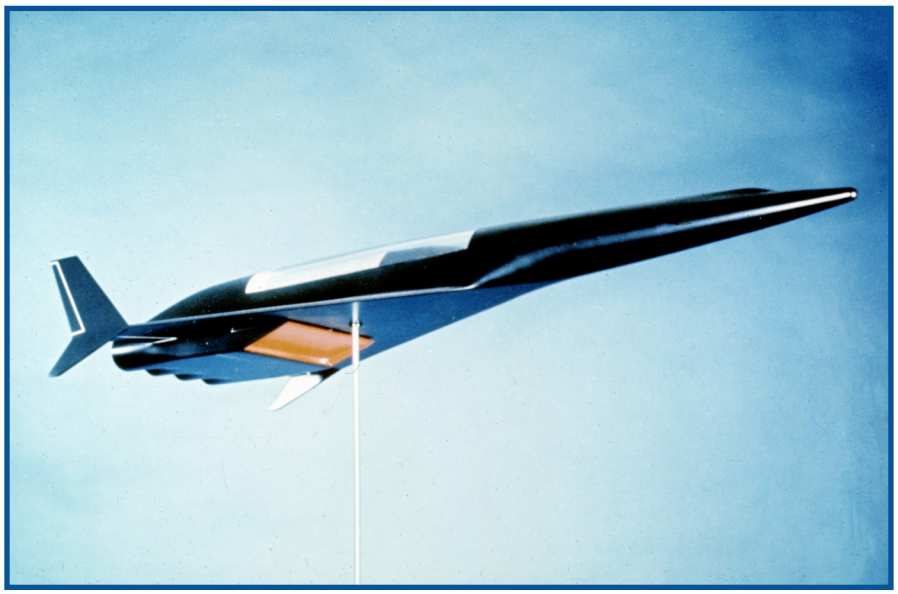


Above: Convair Versatile Spaceplane concept for the U.S. Air Force made use of six, large scramjet engines mounted under the wing.

Right and Below: This Republic Aircraft Aerospaceplane design from 1960 made use of 4 Pratt & Whitney J58 turbojet engines plus 4 ramjet engines to achieve the Mach 25 speed required for orbital flight.

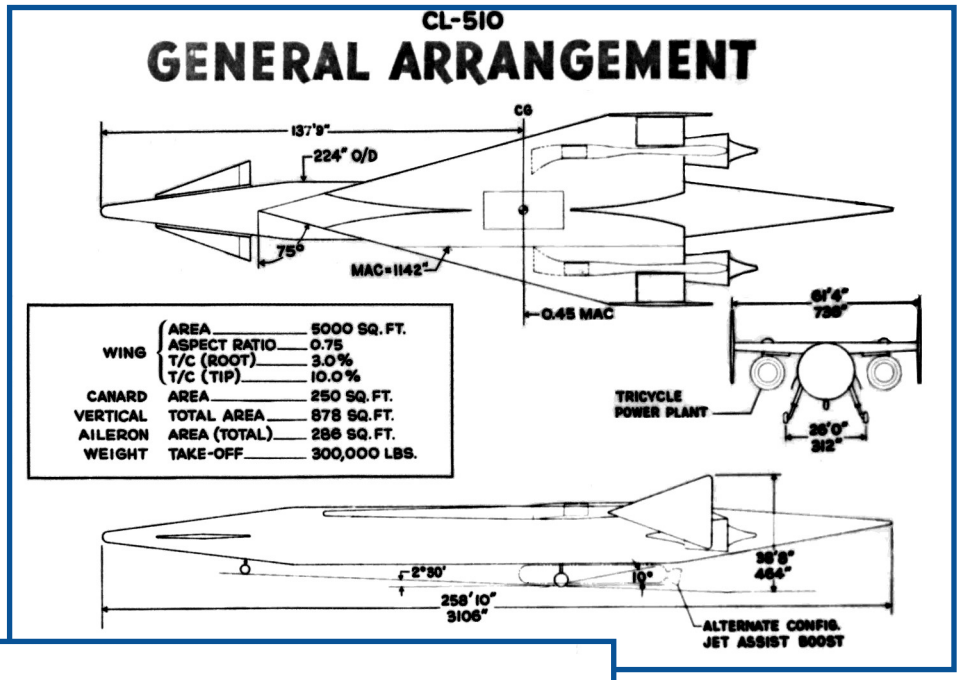


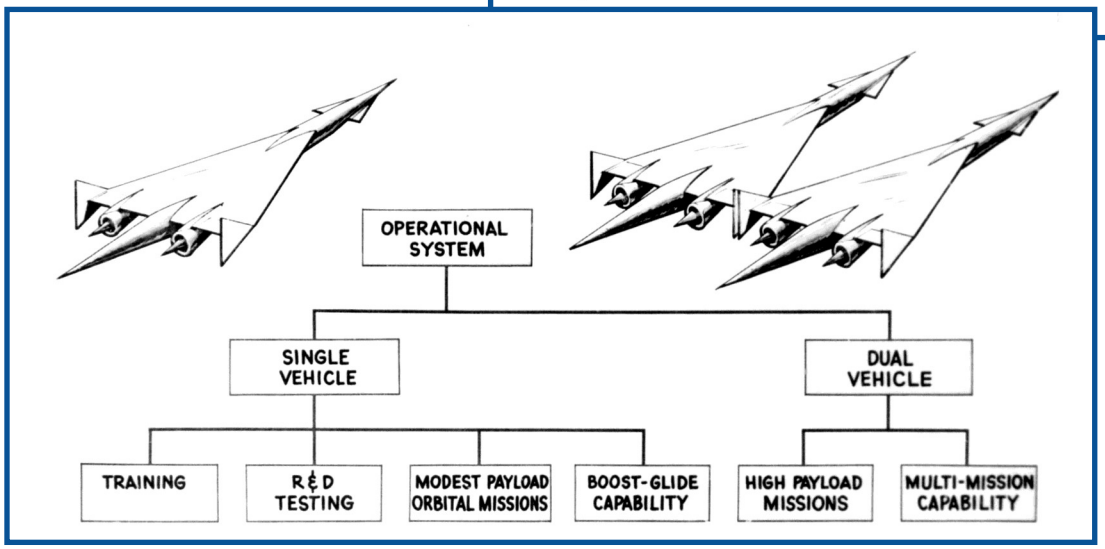


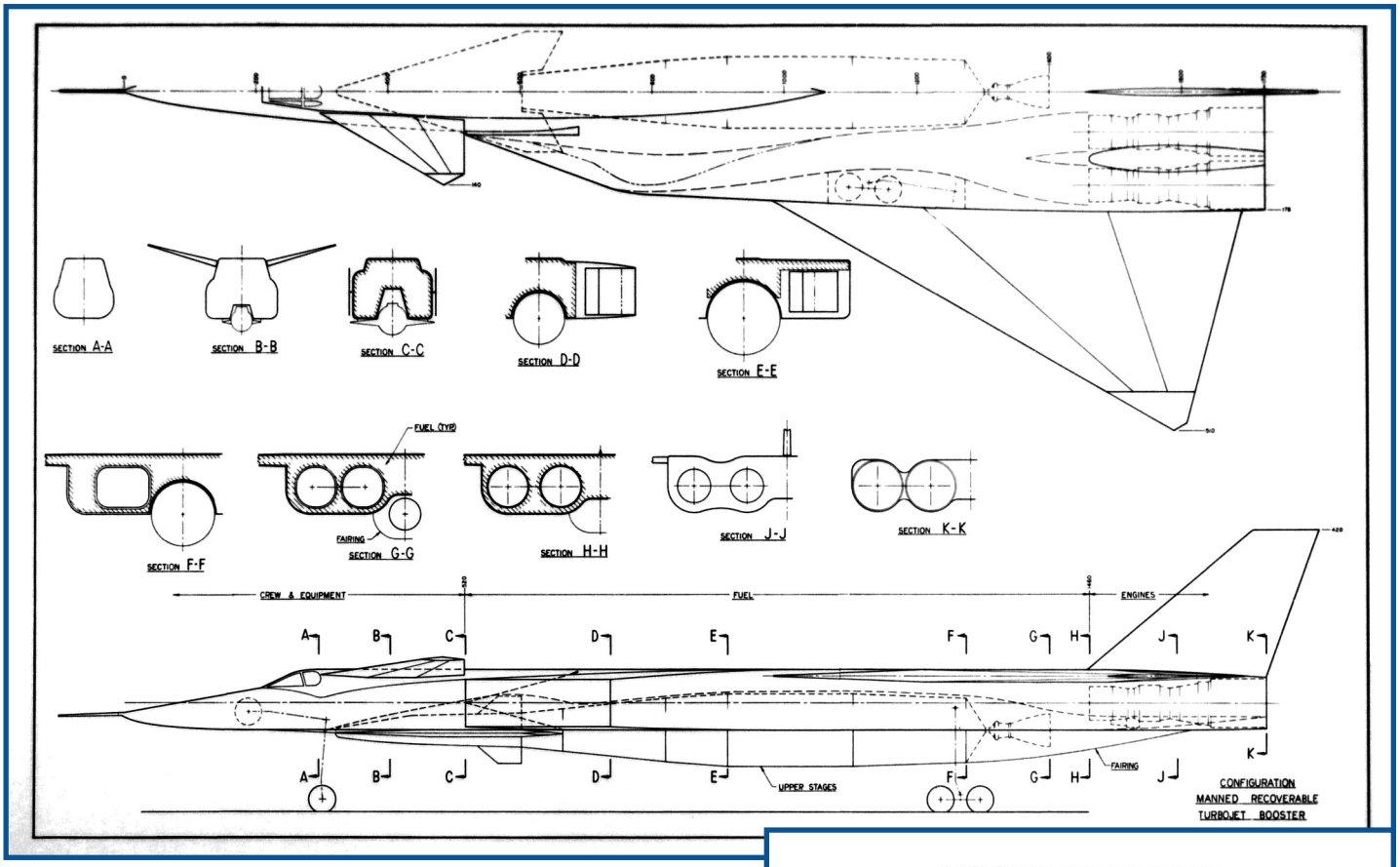


Above (2): Several contractors submitted proposals under the Advanced Interceptor study from the U.S. Air Force in the late 1960's. This design proposed using scramjet engines as well as an internal payload bay on the upper fuselage. Much of the information gathered from this study was applied to the hypersonic X-24C designs.

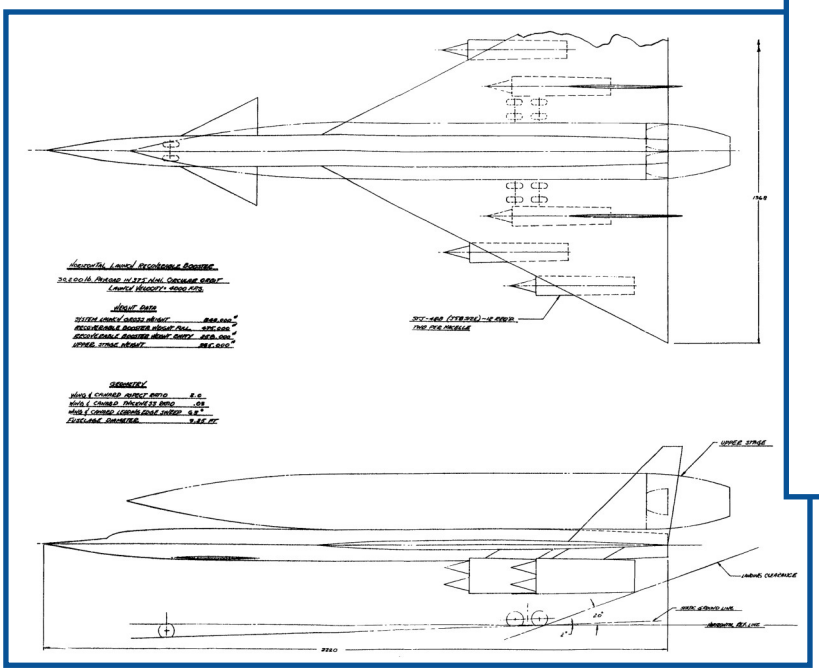
Right: Lockheed Aircraft proposed their CL-510 vehicle for SR-89774-Recoverable Booster Support System (RBSS). The 300,000 pound vehicle would use Rene 41 for the primary structure and Liquid Air Cycle Engine (LACE), engine-ramjet-rocket in the form of a single tricycle system. A launch dolly would be used for takeoff while landing performed on standard landing gear. A dual-vehicle approach is also proposed to increase payload capacity.

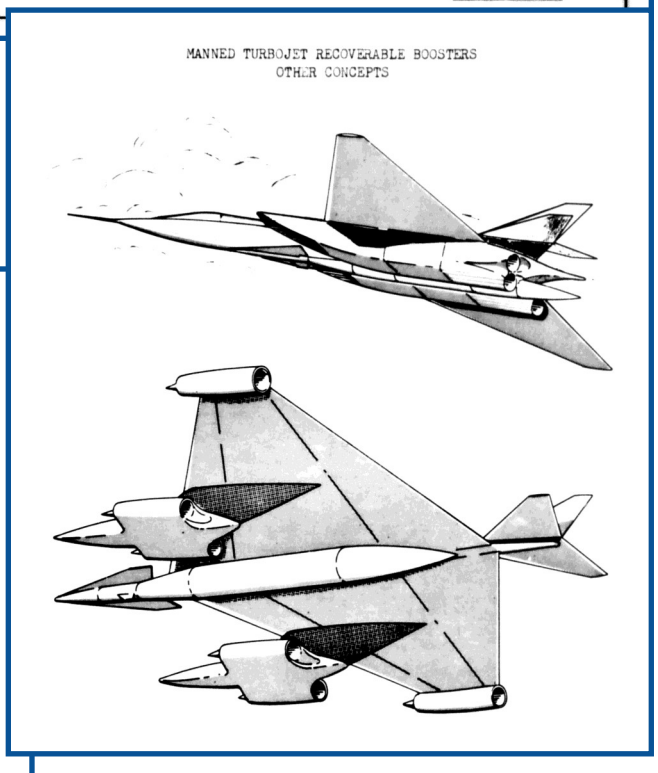






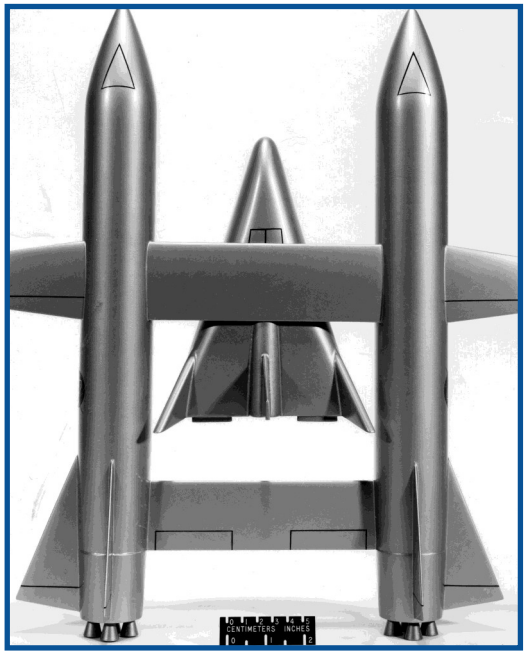
Top: North American Aviation proposed this unique design known as the Manned Turbojet Recoverable Booster using 4 Pratt & Whitney J91 nuclear powerplants to launch the expendable payload carried beneath the fuselage.

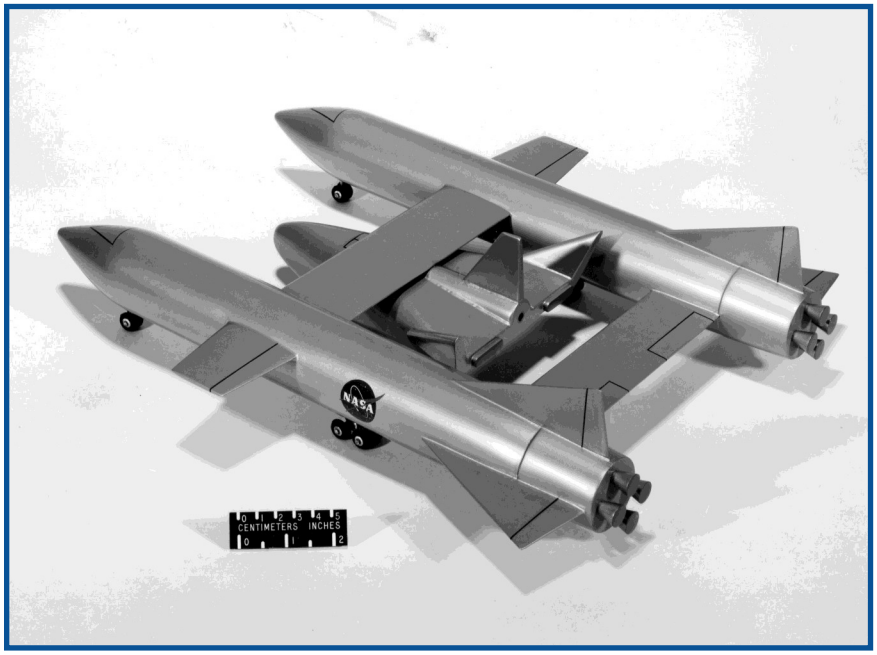




Above: North American Aviation concept art for Manned Turbojet Recoverable Booster study.

Above: This HTOHL design proposed the capability of placing a 30,200 pound payload into a 375 mile circular orbit powered by 12 Pratt & Whitney J58-sized engines paired vertically in pylons mounted beneath the wing with the expendable payload carried on top of the fuselage.

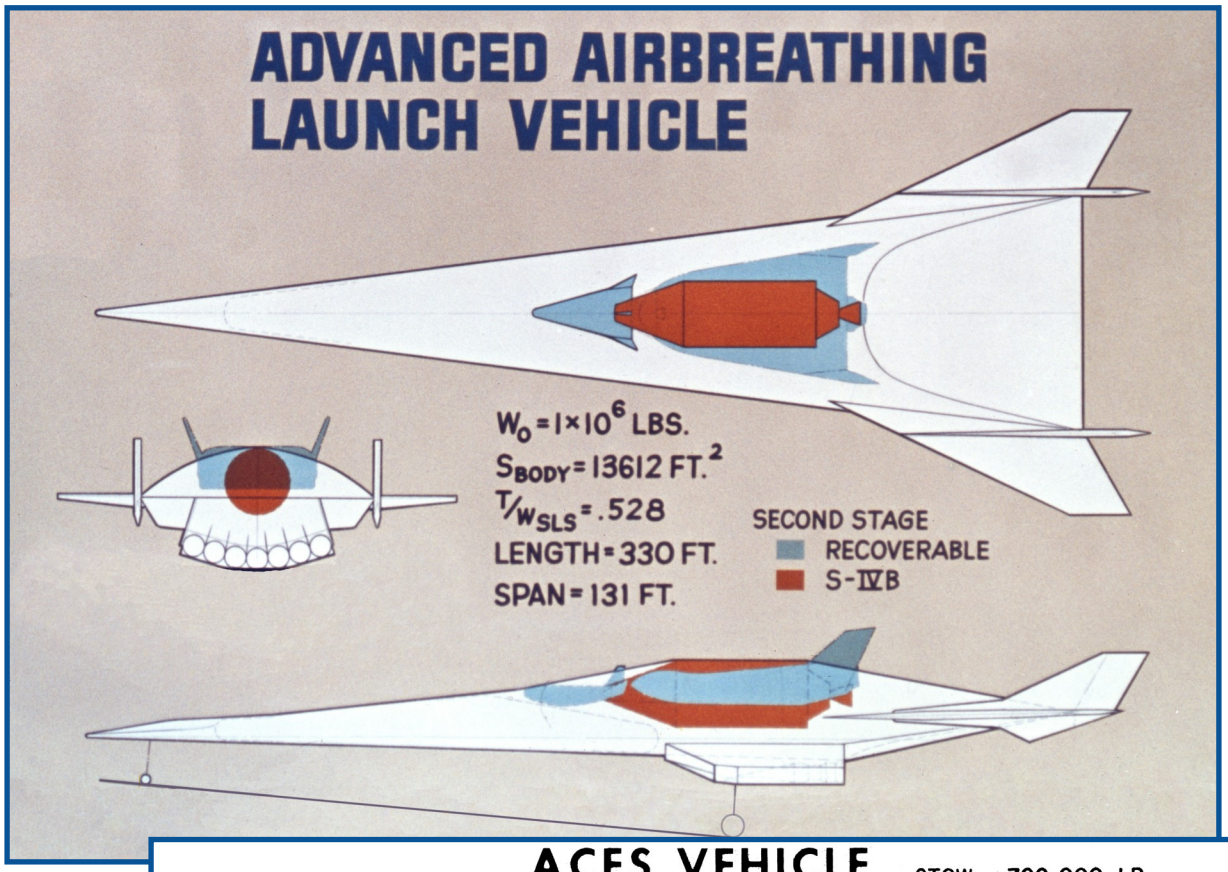


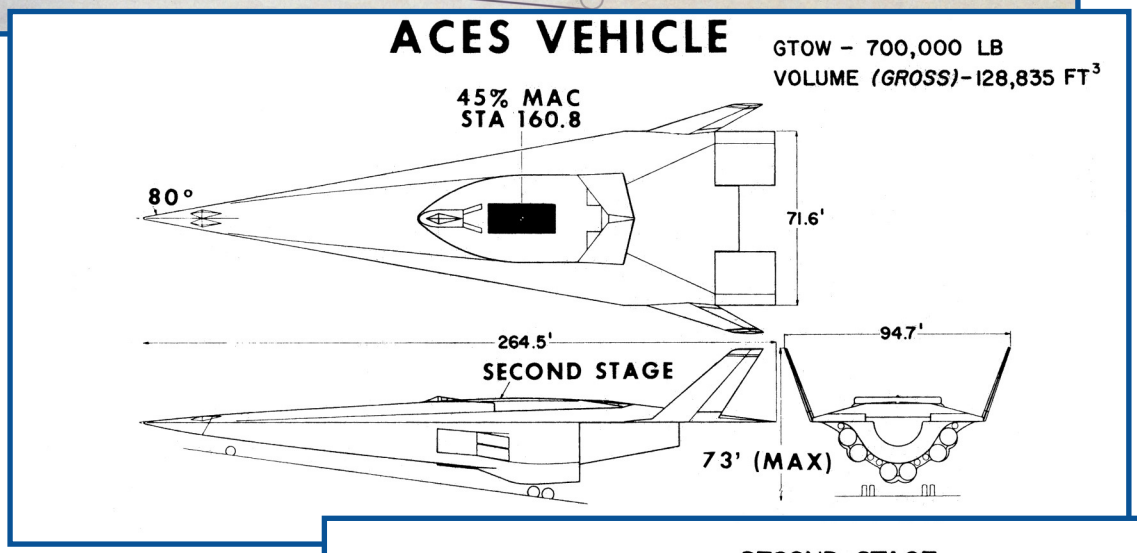


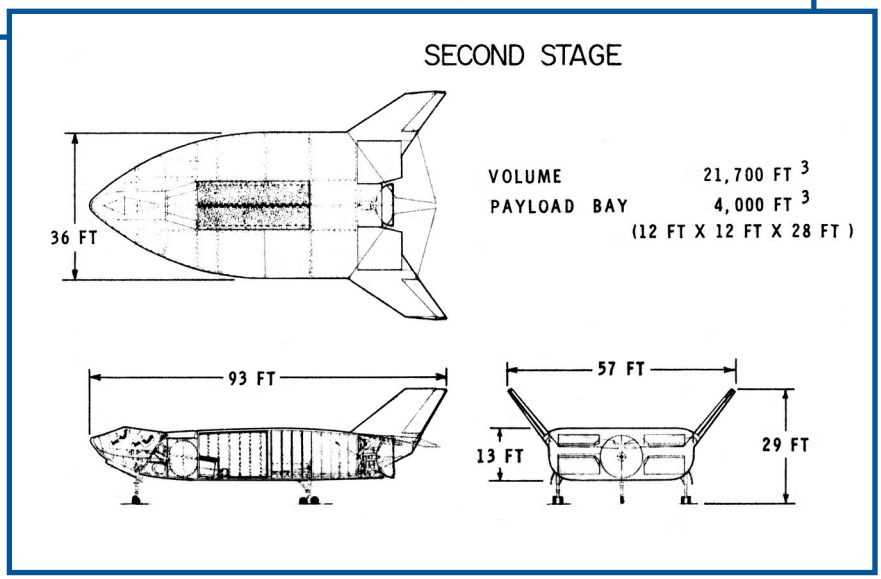
Above: This twin-boom design from NASA Langley Research Center carried a vehicle based on the HL-10 lifting body and was similar in design to the Martin Marietta Spacemaster. The twin-boom concept would make a comeback with the Scaled Composites Model 351 Stratolaunch vehicle, first flown in April 2019.

Middle: Little is known about this two-vehicle spaceplane design from Lockheed which appears to use three reusable winged vehicles to achieve its mission.

Right: The Boeing Company proposed a similar layout in their eight-engine spaceplane design used for launching a winged vehicle into low earth orbit.

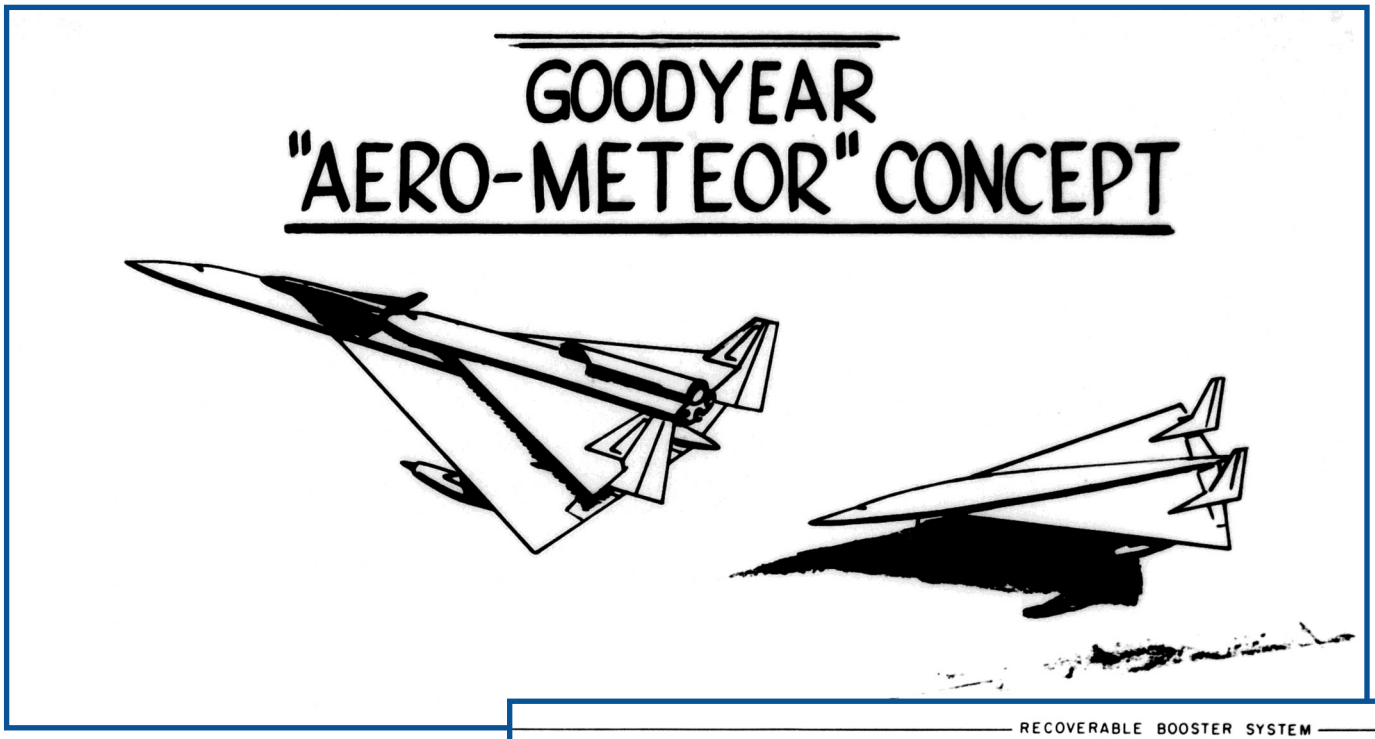




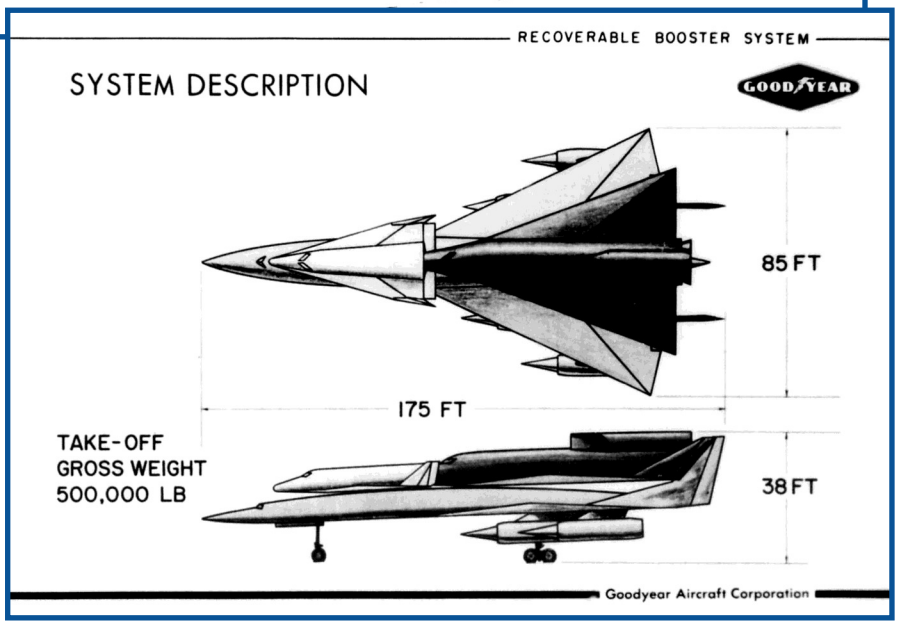


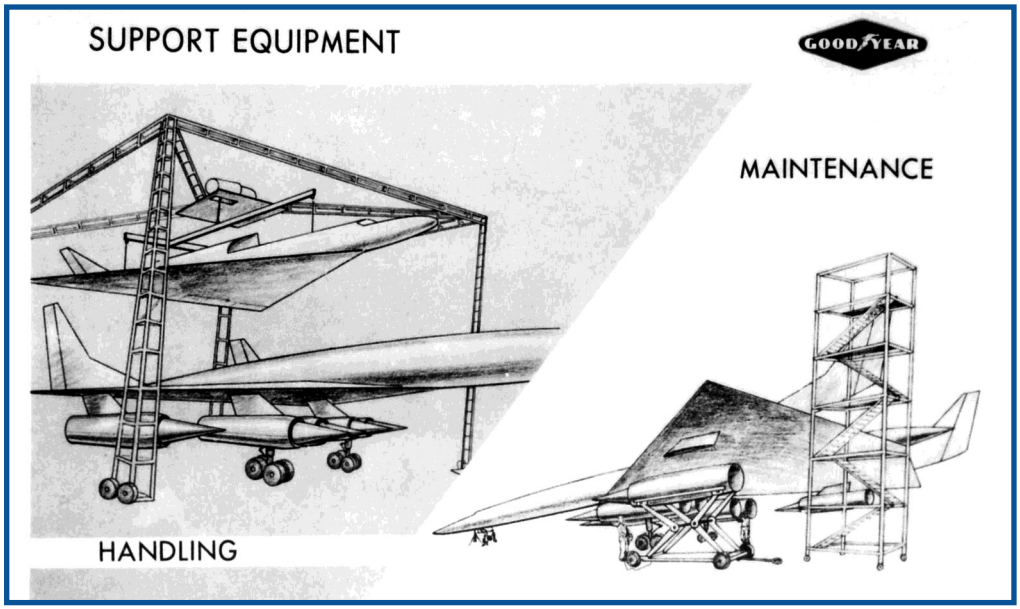
Top: Lockheed's Advanced Airbreathing Launch Vehicle made use of 7 scramjet engines in the first stage to carry a space vehicle propelled by either a recoverable, winged second stage or an expendable S-IVB stage from the Saturn booster.

Middle and Right: Aerospaceplane design known as ACES (Air Collection and Enrichment System), a two-vehicle, fully recoverable launch system. The complexity of the design could not justify the limited payload capability and was not pursued further.

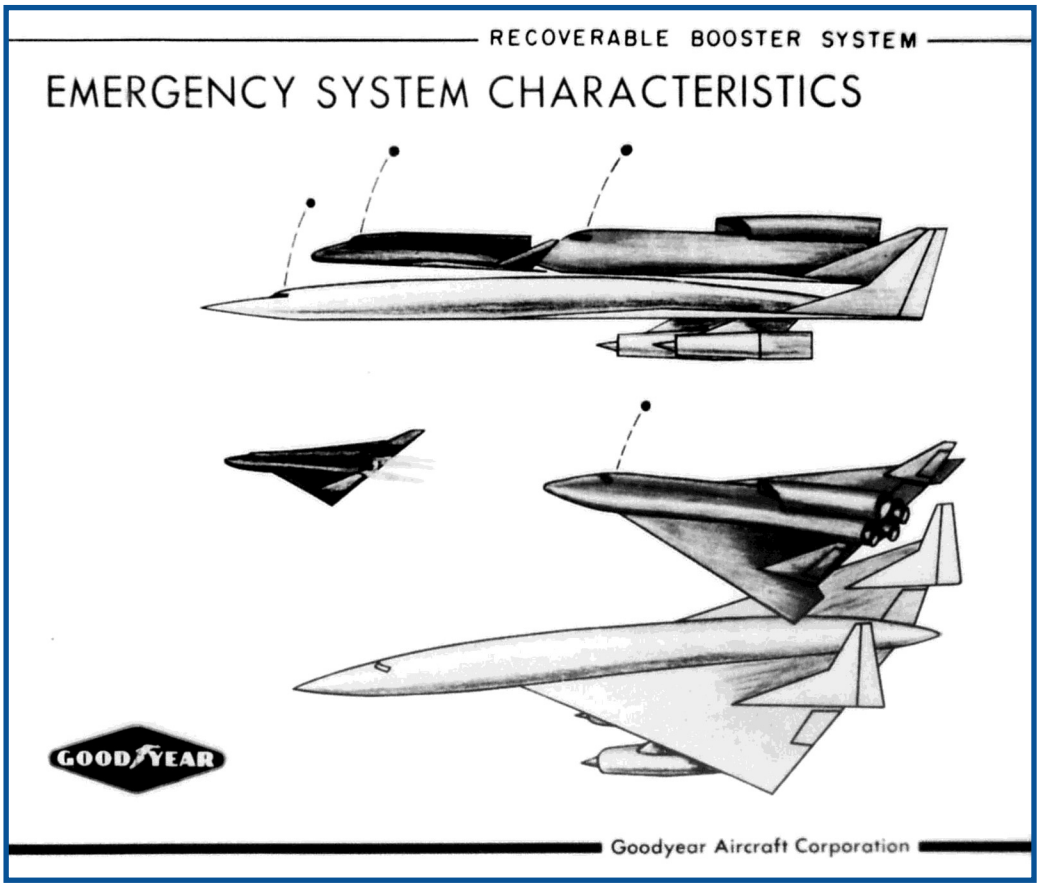


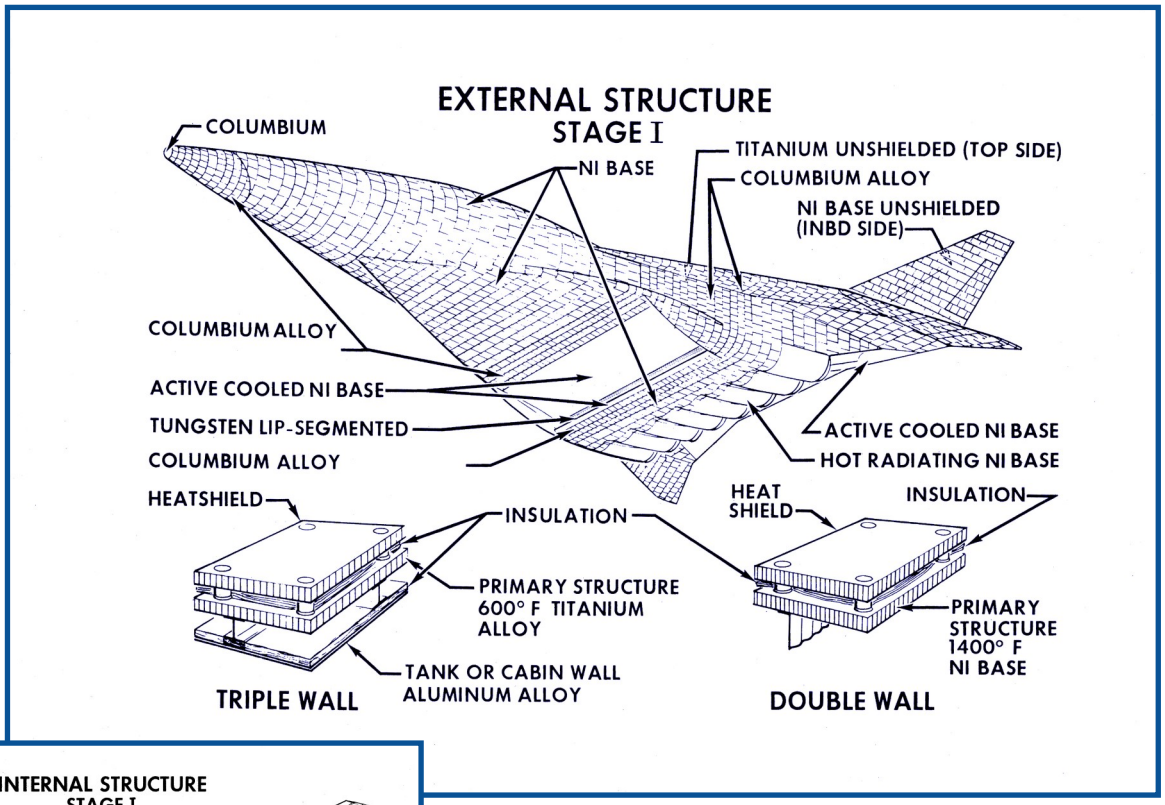
All: Goodyear Aerospace spent many years studying the use of recoverable booster systems. This later design, known as the Aero-Meteor made use of 3 winged vehicles to achieve orbital flight. The first stage used 6 hydrogen -powered, Pratt & Whitney (P&W) STRJ-84D turbo-ramjet engines, the second stage 2 Rocketdyne J-2 rockets plus a single turbo-ramjet engine and third stage utilized 2 P&W LR-115 rockets along with a single General Electric J85 turbojet for landing.

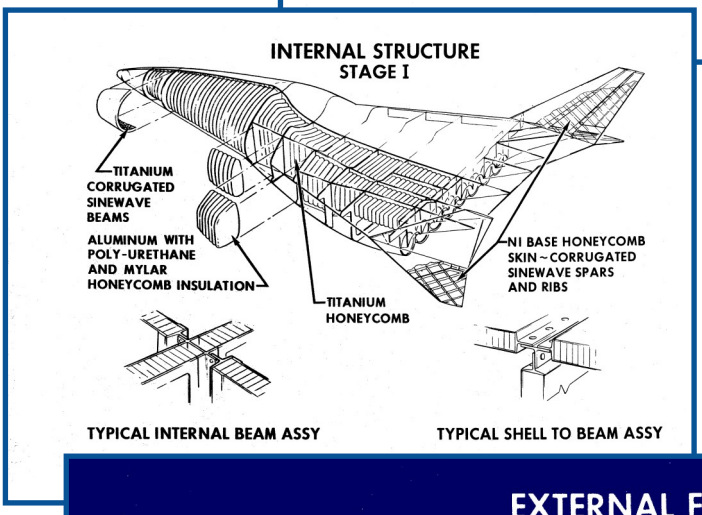




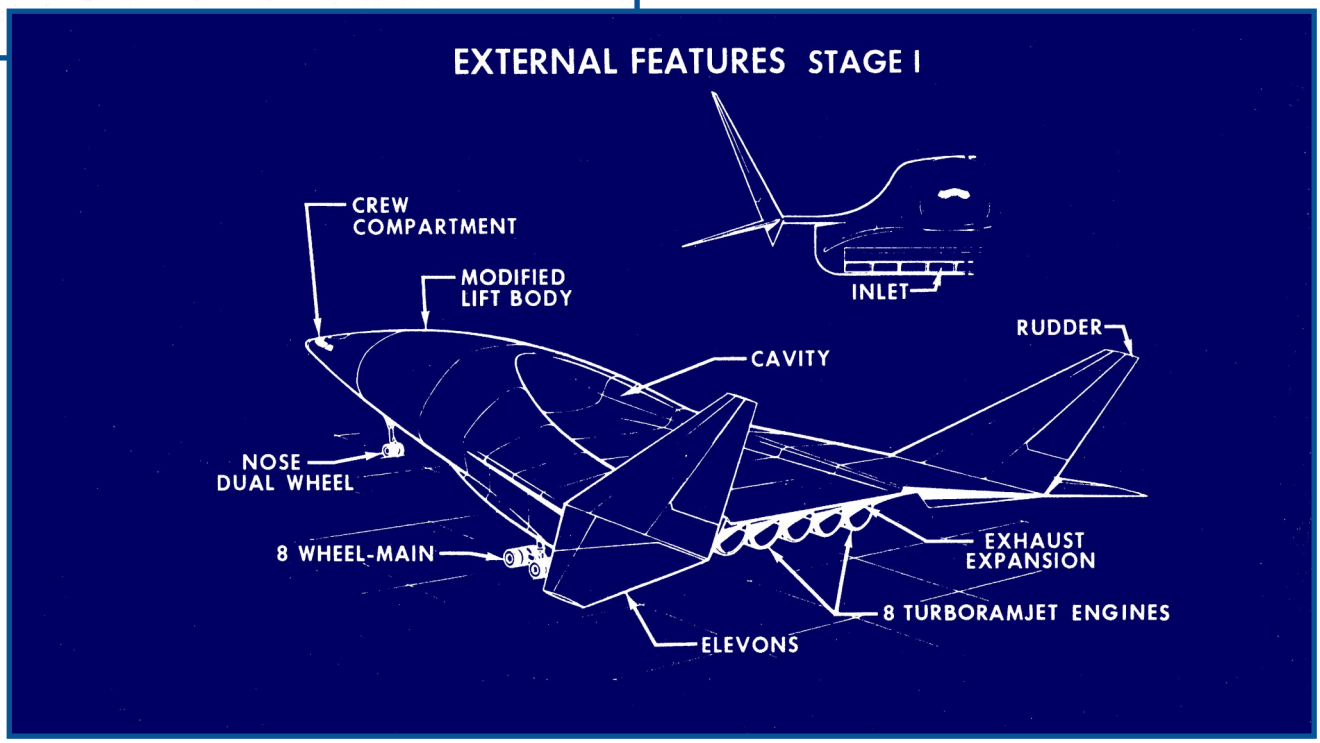
Both: In addition to operating from most Strategic Air Command (SAC) bases, the Aero-Meteor also had a ferry capability. Goodyear predicted a cost per pound to orbit as $1,850 by the 10th flight, falling to a mere $60 per pound by the 330th. First stage separation occurred at 102,000 feet altitude and returned to its departure location. Second stage separation at 330,000 feet with a landing at the nearest auxiliary base. Third stage rockets placed the winged glider into orbit and after mission completion would use the J85 turbojet to land at any designated air base.

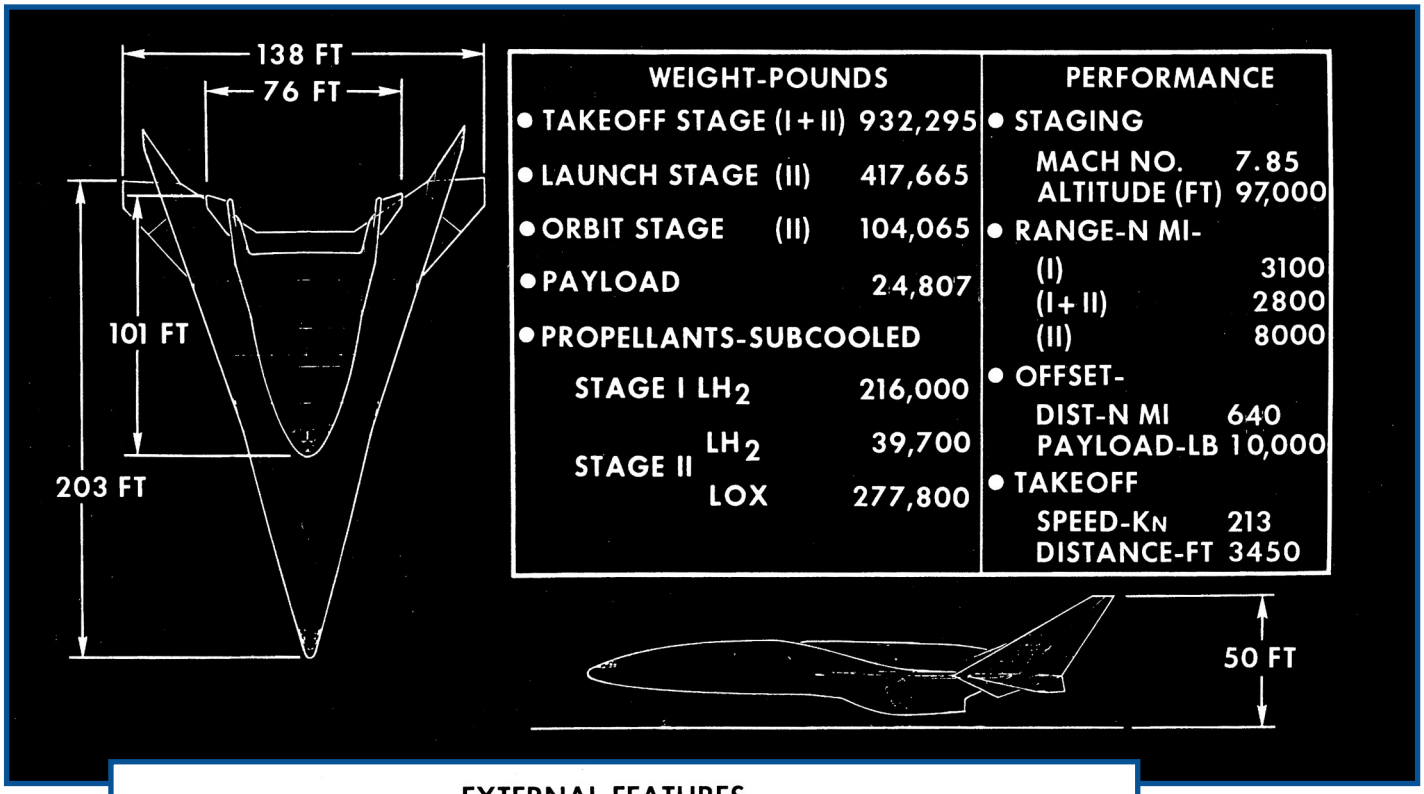


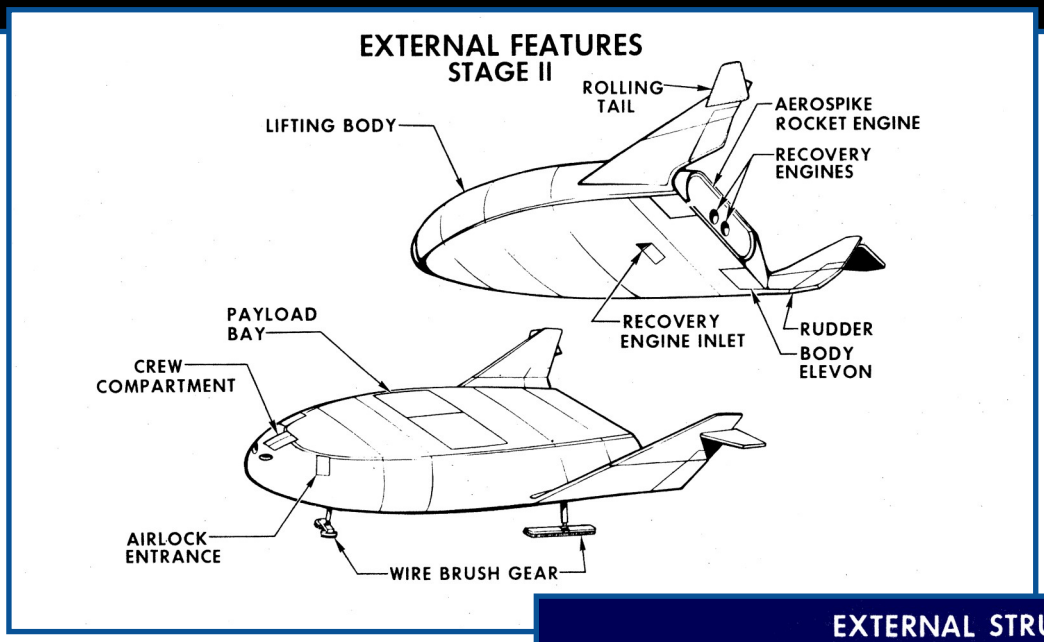




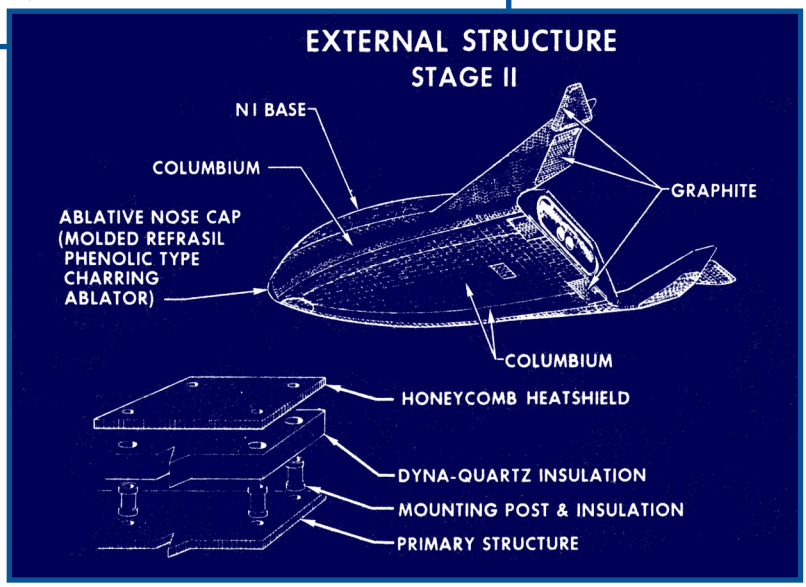
All: Under the Aerospaceplane Development Planning Studies program, North American received $500,000 to study the POBATO (Propellants On Board At Take Off) concept. The two-stage POBATO made use of 8 turbo-ramjet engines on the modified lifting body first stage with the entire external structure made of metallic honeycomb sandwich material for reusability.

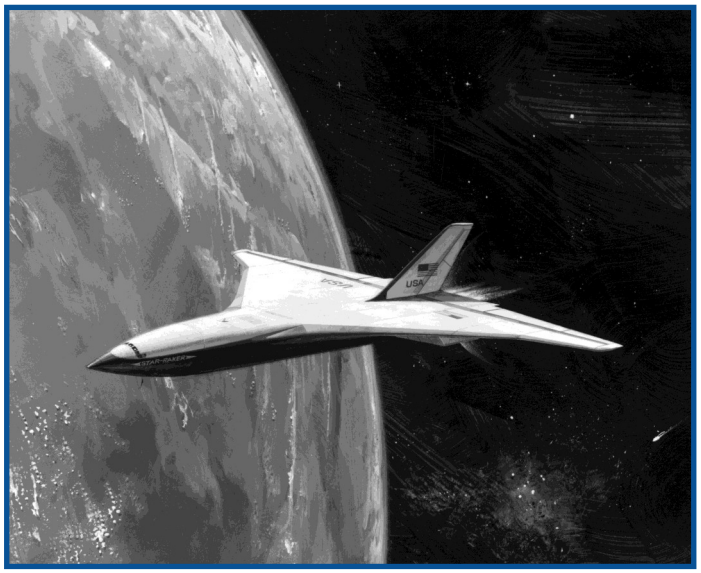






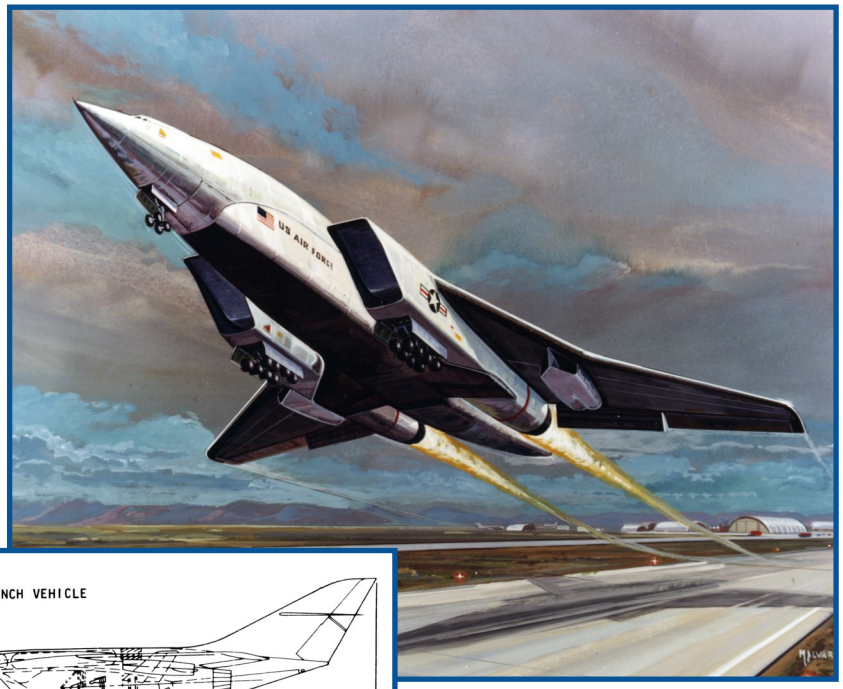
All: The POBATO second stage was of similar construction and included a moderate payload bay atop the vehicle. The wire brush landing skid system is noteworthy as is the use of aerospike rocket engines for main propulsion. Although the POBATO system was preferred over the ACES concept, the decision was made to place the entire Aerospaceplane project on the back burner until firm military space mission requirements had been defined.

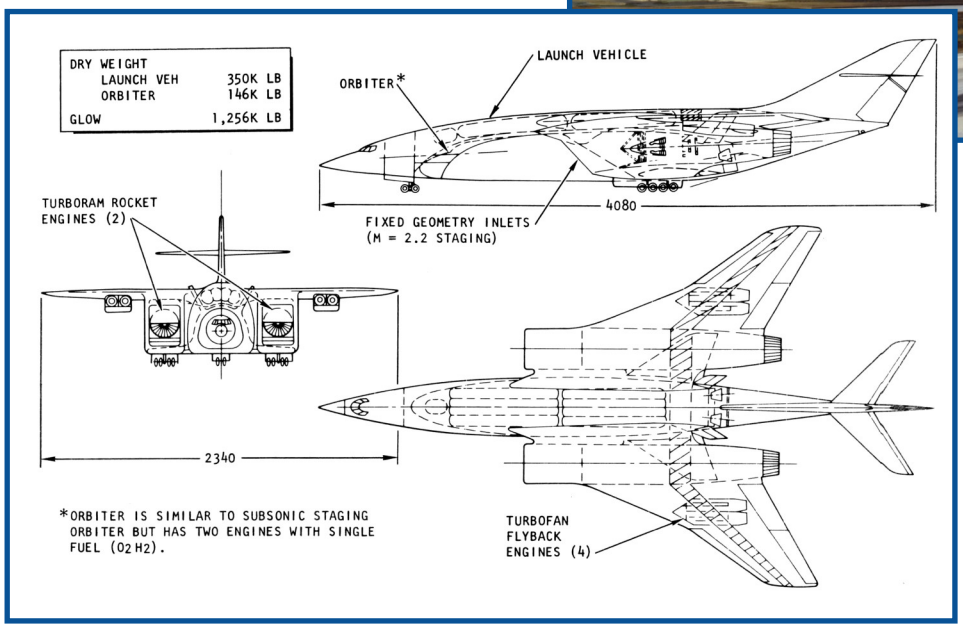


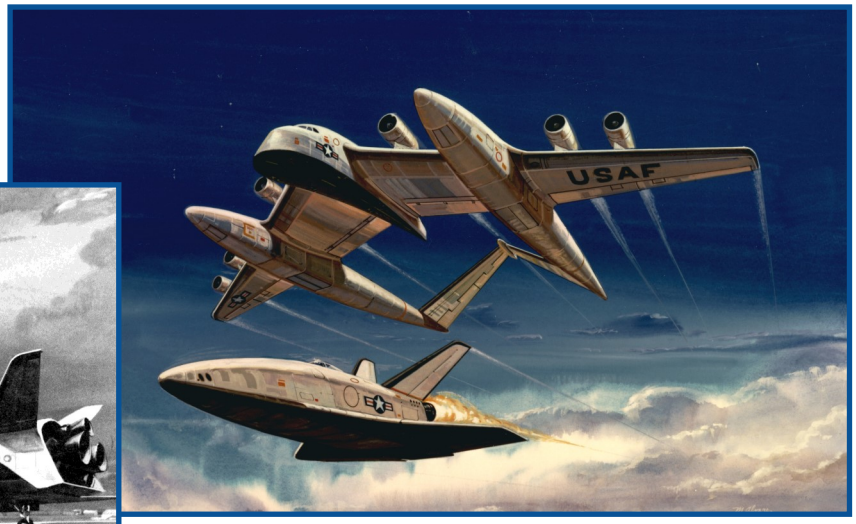


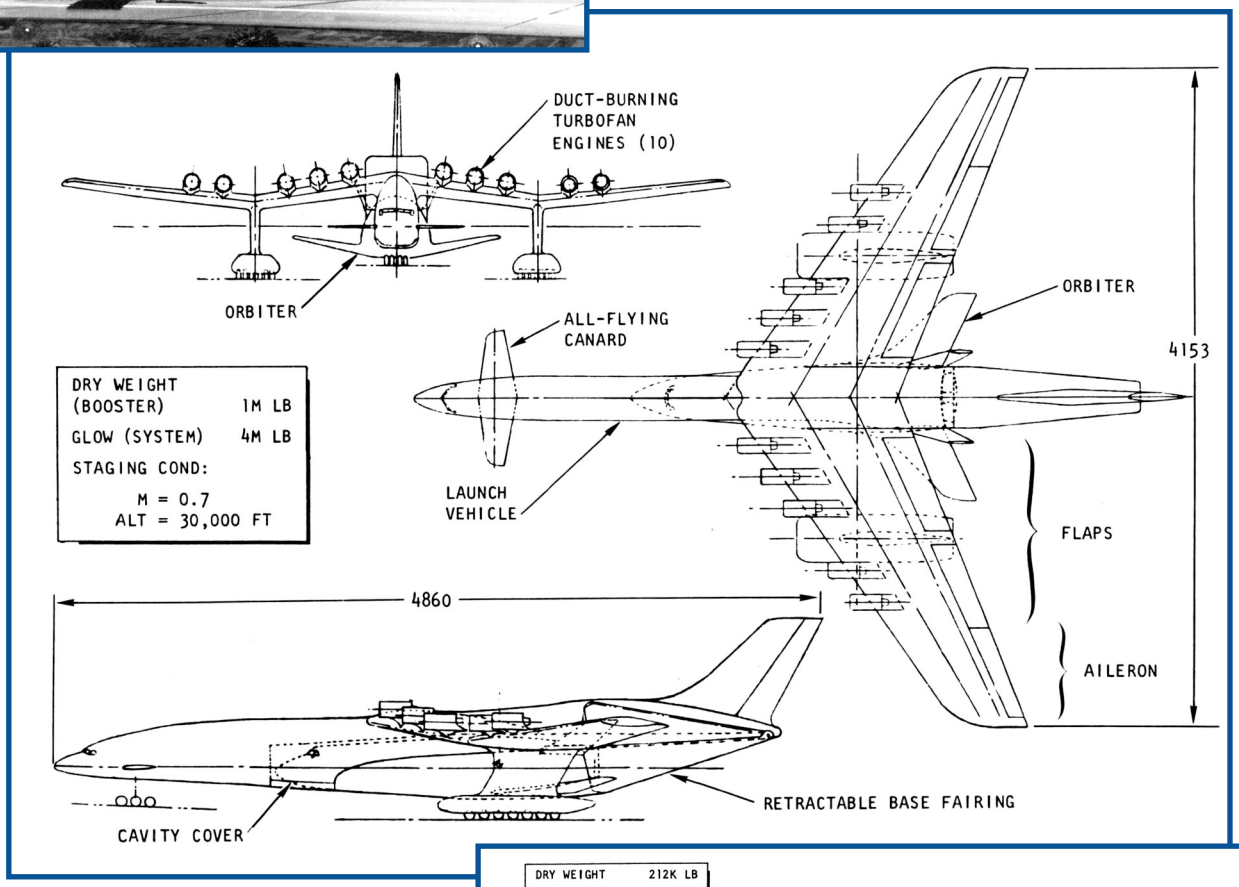
Above: The use of reusable launch systems is revisited in the 1970's by Rockwell International with their Star-raker concept. The HTOHL, single-stage-to-orbit design made use of 10 Mach 6-capable turbo-ramjet engines for atmospheric flight and 3 liquid-propellant rocket engines for orbital flight. Large for its time, the Star-raker had a 360 foot wingspan and payload capacity near 200,000 pounds.

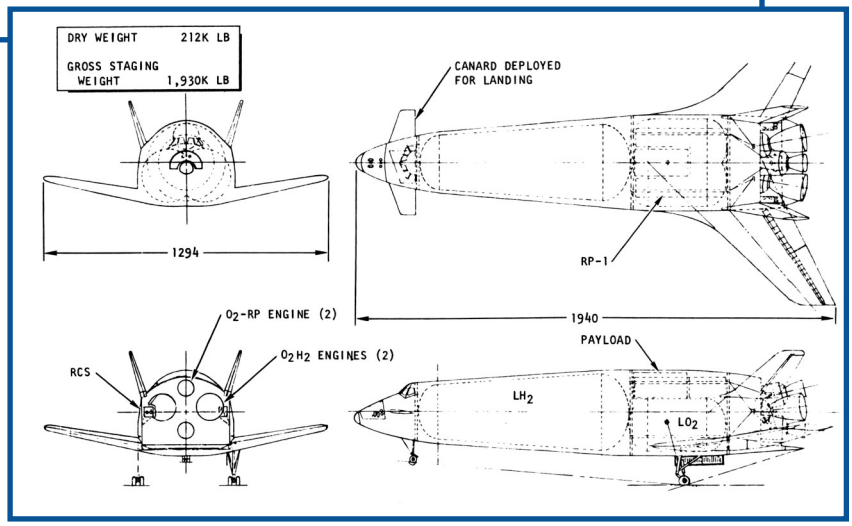
Right: The 1980's brought about a new name for recoverable designs, Advanced Military Spaceflight Capability (AMSC). Rockwell International presented two proposals for the new vehicle; supersonic launch (right and below) and subsonic launch (page 39). The supersonic-capable carried a smaller orbiter to Mach 4 and 90,000 feet for separation, after launch the orbiter's twin rocket engines placed it in orbit.



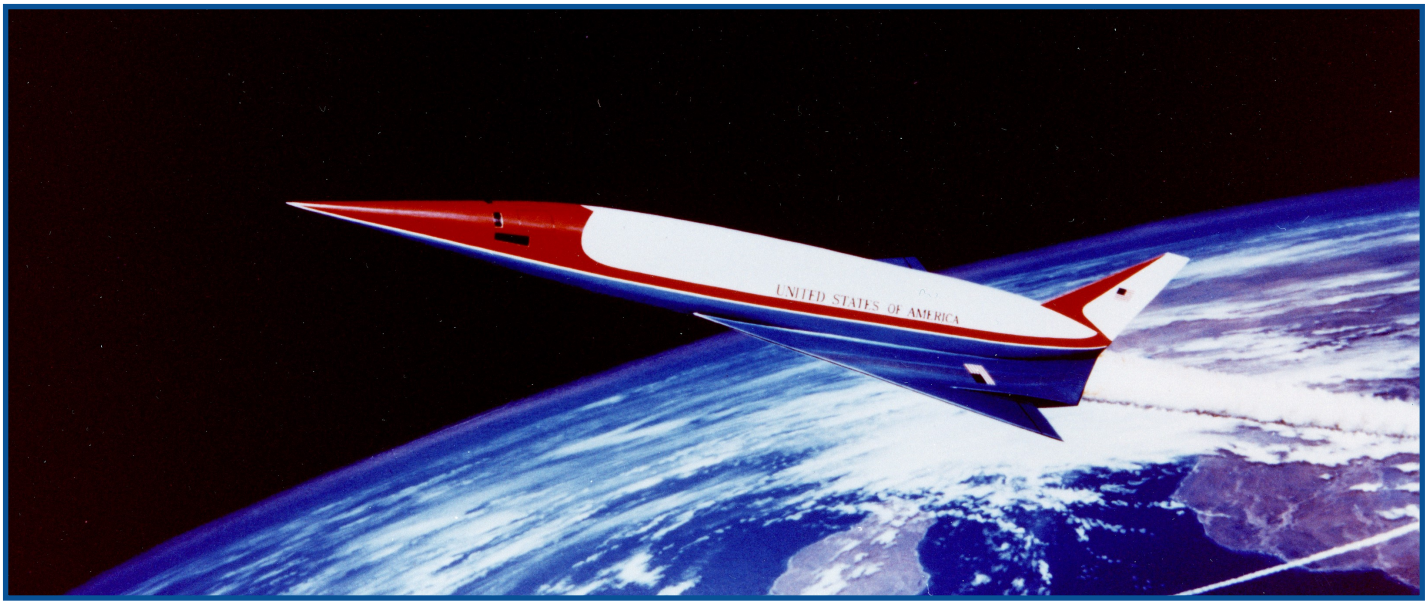








All: Rockwell's subsonic concept placed 10 duct-burning turbofan engines on top of the wing with the orbiter carried beneath. The subsonic carrier vehicle carried a larger orbital vehicle, powered by 2 RP-1-fueled rocket engines and 2 liquid hydrogen-powered engines, to an altitude of 30,000 feet and Mach 0.7 for release. All four engines on the orbiter firing simultaneously at launch to propel the orbiter into space.



Above and Below: The National Aerospace Plane (NASP), a single-stage-to-orbit, HTOHL design began as the classified Defense Advanced Research Projects Agency (DARPA) project, Copper Canyon, in the mid 1980's. While NASP became a public project, making it easier for the many aerospace companies to solve the technological issues required, the military had their own plans for using the spaceplane on classified missions for the Department of Defense (DOD).

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