Chapter 17: RYAN X-13 VERTJET

Manufacturer: Ryan Aeronautical Company (acquired by Boeing, San Diego, California, and now is owned by Boeing). United States Navy, United States Air Force.

Initiated: The idea that eventually led to the X-13 was born as the Ryan Model 38 in response to a Navy request that surfaced during April of 1947. The Model 38, in turn, was the product of Ryan's engineering studies. The official contract giving birth to the actual X-13 airframe was AF33(600)-258/45, signed with the Air Force on July 28, 1945.

Mission: The X-13 was designed to explore the feasibility of building a pure vertical takeoff and landing (VTOL) craft. It was to demonstrate vertical takeoff, vertical landing, vertical and manual flight, and hover stability. It was also to serve as a testbed for VTOL concepts and techniques.

Number Built: Two X-13s were built by Ryan. These aircraft were designated X-13 Air Force serial numbers 54-1619 and 54-1620.

History: During April of 1947, the US Navy awarded the Ryan Aeronautical Company a contract to explore the feasibility of reaction control for jet aircraft. The X-13 was one of the resulting prototypes.

Many X-13 configurations were tested prior to determining the aircraft's final configuration. This model had distinctive triangular vertical tail surfaces.

The X-13, 54-1619, seen here at Edwards AFB, California, during the course of conventional flight tests. Initially, landing gear was temporary and later would be for vertical takeoff and landing (VTOL) configurations. The X-13's distinctive vertical tail surfaces are clearly visible.

VTOL aircraft held by T Claude Ryan (President of Ryan Aeronautical) and the Chief of the Bureau of Aeronautics for the Navy, RAM Stewart. During the meeting, Stewart and Ryan discussed the Navy's strong interest in possibly acquiring dedicated VTOL aircraft that were small enough to permit operation from submarines. At the time, the Navy had narrowed its configuration choices to three designs: a conventional airplane with a single, swiveling rotor, a very low-aspect ratio all-wing aircraft with baseline delta-type airfoil, and a developed version of Vought's XFJ-1 and.
A second proposal was shipped to the Navy on June 24, 1948, following completion of the contract. The new proposal requested funding for a full-scale horizontal tailplane to determine reaction forces and associated moments of inertia. A General Electric J33 turbojet engine was proposed, and Ryan agreed to make the results available to the Navy. By this time, Ryan had been acquired by the company, began looking at preliminary configurations and powerplant combinations that might fill the Navy's need.

Seven potential powerplant options had been chosen by December 3, and within weeks of that date, this selection had been narrowed to: one—the Rolls-Royce Merit. Remaining in contention was the General Electric J33-GE-25, but development was on-going and it appeared that availability would be at least six months in the future.

With the powerplant effectively chosen, Salmon was quick to complete a complementary aerodynamic shell under the company's Model 38 designation. By January 10, 1947, he estimated its gross weight to be 7,700 lb. This created very tight performance margins for the Nenner, as a solution was created by mounting four RATO cartridges, to be used or not during lift-off, on the aft of the aircraft. During the last two weeks of January, preliminary drawings were completed under the direction of Mr. Head (Model 38-1), by early February, these had been completed and were pulled for the complete aircraft. These included the original Model 38-1, the Model 38-2 for the jet aircraft, and the mounted jet, and the Model 38-3 with a more conventional fuselage only.

During March of 1947, Ryan had completed a presentation outlining its conclusions to the Nenner, and the aircraft was ready for the first test flights. Although several of its early studies had by now, been modestly revised (the Model 38 no longer required RATO bottles for lift-off), it had stuck with the basic Model 38-1 configuration, and had pursued repulsion control as the primary means of maintaining aircraft stability during hover and non-aerodynamic flight.

Less than a month after Salmon's presentation, the Navy, on April 24, 1947, signed a contract for $60,000 to study the newly designed aircraft. The first repulsion control was tested VTOL aircraft. Some 46 configurations had been explored by mid-1946. Many facets of this idea were relatively unexaminied when the vertical lift field was a line of the design. In the early stages of the exercise, it was determined that a variable pitch propeller, and a pressurized cockpit, were needed for the design. The final design was that of the Ryan Mini-vor (Model 38-2), which had been chosen specifically for the contract. The new Model 38 was larger, with a substantial increase in its gross weight, and it featured a new high lift capability. The new design was later modified to include a supersonic nose, and a new horizontal stabilizer was added. As the Mini-vor project continued, Ryan's interest also began to wane in the vertical wind tunnel work, and the project was eventually abandoned.

Contingent to the control system research, Ryan elected also to begin preliminary wind tunnel work and basic performance estimates. Additionally, studies exploring various tailfins and landing techniques were completed, and conclusions were made regarding their effect on actual performance, several years later, were reached.

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Ryan now began to formulate plans to acquire a Rolls-Royce Avon turbojet engine for use in the new tilt aircraft, having learned of its development through Navy sources. This powerplant, offering perhaps the highest thrust-to-weight ratio of any turbojet engine in the world at the time of its unveiling, was to be the key ingredient in the many X-13 successes that were to follow.

On January 20, 1954, assembly of the first X-13 was begun at the Ryan plant in San Diego. This was followed, during June, by a final mock-up inspection and approval, and shortly afterwards, by the arrival of the first Avon engine.

By the fall of 1955, the first aircraft was nearing completion. This aircraft, 54-1619, on August 17, was placed on a flatbed truck, covered with canvas, and moved by convoy (that included one of the first pre-production Convair F-102As built at the nearby Convair facility at Lindbergh Field) to Edwards AFB for initiation of its flight test program.

As the X-13's conventional flight characteristics were unknown at the time, a decision was made by Ryan to fabricate the aircraft in conventional mode before attempting actual VTOL operations. In order to accommodate this decision, a temporary tricycle landing gear was built and attached to the underside of the fuselage.

On December 15, 1955, with the landing gear in place and Ryan test pilot Pete Girard in the cockpit, the X-13 became airborne for the first time. Lasting only seven minutes, the first hop proved short, as Girard had noted quickly that the aircraft had a serious oscillation problem about all three axes. Just over two weeks later, the solution—a rial and yaw damper—was installed, and flight testing was resumed.

Following the abbreviated conventional flight program, the X-13 was mounted vertically in a tubular structure that was to serve as its interim vertical attitude landing gear. Known as the “pogo” gear, the unit permitted the X-13 to land and takeoff in this vertical attitude. As if to underscore the fact that the aircraft could not be flown conventionally with this rig attached, the unnecessary alleys and rudder were removed.

While mounted in the “pogo” assembly, the aircraft underwent further in-flight evaluation of the reaction control system, general maneuverability and handling, and pilot visibility with the airplane in a vertical attitude. It quickly was discovered that powerplant spool-up lag, similar to a similar phenomenon experienced in the static vertical tail rudder, continued to be a problem with the X-13. Basically the pilot was forced to chase thrust settings with the engine throttle. The response: If rapid descent was noted and throttle was applied, the rudder was holding the tail in a position that barely maintained flight. The result: Usually was in a position bordering on a higher altitude than desired.

Solutions to the thrustrotor lag problem consisted of a Ryan-developed servo system to smooth and effectively slow down the thrust rotation response times, and a pilot-designed throttle quadrant which permitted power inputs but allowed the throttle handles to be returned by feel to their previous thrust settings. A problem of concern, but which eventually proved to be exaggerated, was the gyroscopic effect of the Avon’s internal turbine shafts. Pete Girard had studied this theoretical problem with some intensity and had concluded there was potential for trouble. In cutting up the X-13’s tail cone manufacturer, Freushener Tailor Company, a decision had been made to modify the tail to provide support, to which the X-13 was to attach itself during takeoff and landing, to swing up and capture the aircraft’s nosehook, rather than visa versa. As flight tests later proved, the gyroscopic problem was relatively small, at worst, and not in the least bit troublesome.

On May 28, 1956, the first X-13 completed its first test hop in vertical mode, a feat Girard kept the mission control, reaching a maximum altitude of less than 50 feet while keeping the horizontal speed to under 30 mph. Initial spot landing tests were encouraging, as overall accuracy was better than 2 ft, and on many occasions, Girard was all with-in 2 ft of the target point.

Practically no hitches were encountered during succeeding flights, utilizing a one-inch-thick section of manila rope suspended between two 36-lb swivels and a plywood, break-away surface, as before. Many successful practice runs were made utilizing the training set-up, these generating great confidence in the system and giving Girard an excellent experience base.

During the spring of 1956, the second X-13, 54-1620, also was prepared for flight tests. Following a first flight in conventional mode on May 28, 1956, 54-1620, the X-13 had been modified on top of a "pogo" rig for preliminary hover testing. Incremental advances were undertaken to slowly work the aircraft into its full flight envelope.

Following the hook tests using 54-1619, the temporary tricycle landing gear arrangement was replaced by the next flight test program stage. On November 25, 1956, following several successful flights leading up to the actual event, the X-13, with Girard in the cockpit, accelerated to 6,000 mph and slowly pitched nose-up until it was effectively being hove in place as the X-13’s reaction control system pushed the aircraft into a vertical attitude, and then slowly pitched over again and regained flying speed. This was the first such VTOL flight attempt.

The ultimate test came four months later. On April 11, 1957, the X-13 took off vertically on its first such flight attempt. Hitting away from its support trailer, it sought altitude over Edwards AFB, pitched over into conventional flight attitude, performed a series of conventional flight maneuvers, slowed, pitched nose-up into a hover, and then slowly descended back to the Edwards South Base ramp.

Using the special trailer, the X-13 could be launched and retrieved from practically anywhere. Studies were conducted that also verified a cable stretched between the trailer could be used as a launch landing site.
Articulated flaps of X-13 trailer could be lowered to conventional horizontal position for ground transportation. Trailer was equipped with stabilization legs to create level attitude no matter what the terrain.

After a total expenditure of $94,000, no other support for the two X-13s was attainable and the NASA and the Air Force had, by now, diverted their interest to space activity and the X-13 program. As it resulted, surveys were made to determine the best means of disposition. It eventually was decided that 54-1619 would be loaned to the USAF Orientation Group to serve as a mobile static display for two years, following which it would be turned over to the Air Force Museum. The second aircraft, 54-1620, was to be turned over immediately to the Smithsonian Institution.

As luck would have it, the number 2 aircraft, 54-1620, inadventently was prepared for use by the Orientation Group as their static display and was delivered during May with a modified erecting cradle mounted on a flatbed trailer. This aircraft, in turn, after being turned over to the Air Force Museum, the number 1 aircraft, 54-1619, was delivered to the Smithsonian Institution, together with one ground support vehicle and miscellaneous extras.

Construction, System, and Equipment: The X-13 was an all-aluminum aircraft with titanium structure in high-hot-air engine bay areas. The delta wing, with the exception of the ducting to accommodate the wing tip engines and roll control nozzles, was of conventional construction and had a 60% leading edge sweepback, 4° delta dihedral incidence, and 9° of dihedral.

In its VTOL configuration, the X-13 had no conventional landing gear, but instead had two small, retractable tube-mounted bumpers on the fuselage underside along with a small, semi-retractable nose hook. In conventional mode, a conventional tricycle landing gear could be attached for horizontal altitude takeoffs and landings. When the conventional landing gear was fitted, the main gear track was 7.9 ft.

The nose hook supported the entire aircraft from a short section of a steel cable that normally was suspended between two mechanical arms attached to the fuselage (it could be moved vertically over 48" from horizontal) and that portion of a specially manufactured Firehouse TVL. This cable also could be suspended between any two strong, stationary objects such as large trees or poles. For trailer launching and retrieval, the inflatable trailer of the truck could be raised, the X-13 in place, to a vertical position by two large, segmented hydraulic rams.

In order to enter the conventional horizontal flight mode, the X-13, following stroage from the fighter cable normally hauled into an accelerated deployment box and then began a vertical ascent as its speed and altitude increased and the aerodynamic control surfaces became effective, the aircraft rapidly pivoted onto its normal horizontal flight.

Landing gear were accomplished in reverse order. The aircraft would decelerate and the nose would slowly pivot up to a vertical attitude, transitioning from aerodynamic to jet thrust lift. Dependent upon speed, and once in东方航空 of the trailer, the aircraft would pivot into position for hook-up.

A novel procedure would slowly bring the X-13 onto the range of the trailer and its supporting cable. A ground observer, seated in the driver's seat of the X-13, would have to be removed at the X-13 to the cable, was hauled up on a short taut cable. Constant radio instructions would be given from the trailer's director as to the point at which it was necessary for the pilot to release, audio and visual aids were used.

A 28.4-ton nose with colored distance markings provided horizontally from each side of the vertical portion of the trailer as the X-13 entered the support cable, the pilot could see the hooks and land by pushing the nose against the hook and then move the nose away with the aid of the visual aids. Additionally, a 'shoe' shaped position meter (VNLVS) on the top of the nose probe (consisting of the nose of two nose-wheel type pitch and yaw vanes) provided position information at very low speeds (down to 8 knots).

Small wing tip nozzles utilizing engine compression section bleed air provided fine yaw and pitch control inputs during hover. Course pitch and yaw control needs were input by the pilot via the actuated main engine exhaust modulator. All control inputs were integrated with a simple, but efficient, stability augmentation system.

The cockpit was unpressurized and equipped with a multi-place canopy that opened vertically. The pilot's sidestick yaw was a swiveling unit (in pitch, only) offering 45° of movement in concert with the rotation of the aircraft between vertical and horizontal flight. It had limited aerodynamic capability and initially was equipped only with a righthand actuator. At a later date, Stanley Aviation of Columbus, Ohio, modified the seat to accommodate actuators on both sides.

The basic avionics complement included an Attitude and Heading Corporation Type 12 VHIF command radio; an AN-R-9 receiver; a T-100 transponder X-13 transponder. Aerodynamic surfaces for the X-13 basically were conventional for a delta wing aircraft. Single-place trailing edge elevons were attached to each wing, and the large vertical fin (the product of a short coupled fuselage) in a single-piece rudder. Tip fins were utilized to each wing tip providing increased vertical surface area and consequently improving chordwise airflow at high speed and rudder control at low speed.

During various stages of its flight test program, the X-13 was equipped with an anti-spin device mounted on a built in rudder at the tail of the vertical fin. This device could be used as a drag chute during conventional horizontal landings to shorten landing rollout. Late in the flight test program, a pair of retractable airbrakes (which were integral with a new, what main landing gear in the form of two hydraulically actuated-under-fuselage panels, were added to facilitate deceleration during horizontal flight.

First Flight Dates: With Ryan test pilot "Peter" Girdet at the controls, the first X-13, 54-1619, became airborne in conventional mode for the first time on December 10, 1959, at Edwards AFB, California. The second X-13, 54-1620, became airborne in horizontal mode for the first time on May 29, 1960, at Edwards AFB, California.

Powerplant: The X-13 was powered by a single RM-1448-1 General Electric J47-P-24 afterburning turbojet engine. The engine specification number was TSO 510. Minimum thrust rating was 10,000 lbs at 8,000 rpm for 10 mins. Military thrust rating was 9,900 lbs at 7,900 rpm for 30 minutes. Normal thrust rating was 8,650 lbs at 7,600 rpm continuously. The engine was 113.2" in length and had a diameter of 41.5". Its dry weight was 2,889 lbs.

Fuel was standing JP-4. All fuel in the X-13 was carried in a single wing tank with a capacity of 371 gal. A single engine oil tank held 1.8 gal. Disposition: Both X-13s survived the flight test program. The first aircraft, 54-1619, currently is on long-term loan from the Smithsonian Institution’s National Air & Space Museum to the San Diego Aerospace Museum in San Diego, California. The second aircraft, 54-1620, currently is on display at the US Air Force Museum's annex section at Wright-Patterson AFB, Ohio.

Summary: The X-13 program represents one of the most successful VTOL aircraft programs of the 1950s. Along with the X-14 (see Chapter 18), the X-13 represents a high water mark in the history of vertical takeoff and landing aircraft development.

The X-13 program proved beyond doubt that the VTOL flight, on jet thrust alone, was both technically feasible and practical. The ease with which the aircraft could transition from vertical to horizontal flight and back again, left little question as to the operational utility of such flight capabilities. Among the advances realized during the course of the X-13 development were: (1) fully functional and mechanically practical vectored exhaust nozzle; (2) bleed air nozzles for yaw control during hover; (3) cockpit ergonomics in tune with the unique vertical attitude of the aircraft; and (4) the application of a delta wing to a V/STOL-capable aircraft and; (5) a sufficiently high thrust-to-weight ratio.

Perhaps the only failing of the X-13 program was its lack of success in generating follow-on production aircraft contracts. This was due in part to the aircraft's small payload, simplicity, powerplant limitations, a conservative military establishment, and in operational limitations. It worked, and worked well. Unquestionably, it was ahead of its time.

Specifications and Performance:
- Length: 21 ft
- Wingspan: 21 ft
- Weight: 15,120 lb
- Area: 191 sq ft
- Empty weight: 5,234 lb
- Max speed: approx 483 mph
- Range: 167 miles

During the final approach to the trailer, a temporary mauling for sale was visible from the cockpit, giving an accurate sense of distance to the nose. The rod could not move out of the way during the takeoff.

The X-13 was very maneuverable in hover mode thanks to its well thought-out and relatively simple flight control system. Pilots had few problems engaging and disengaging the suspension cable.