White Rocket

How all U.S. Air Force pilots since 1968 have met their Mach.

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Excellent visibility helps T-38 pilots fly tight formations. (Northrop Grumman Corporation (NASM SI NEG. #00079050))

WENTY-THREE YEARS OLD, FRESH OUT OF COLLEGE, and a newly minted Air Force lieutenant, Howard Morland reported to Reese Air Force Base in Lubbock, Texas, for flight training in January 1966. In place of the fleet of Lockheed T-33s in which the previous generation of pilots had trained were precise rows of brand-new Northrop T-38 Talons blazing chalk-white under the winter sun. "There was nothing bird-like about them," Morland remembers. "Their wings were so far back and so small and thin that some of the new students believed that they functioned more like the feathers on an arrow, and that most of the lift came from the fuselage." Another rumor, likewise false, was that the airplane accelerated so rapidly on takeoff that the hydraulics couldn't get the wheels up before the aircraft exceeded the speed for wheels-down flight; little wings had to be added to the landing gear to hurry it along.

This was heady stuff, but shortly after Morland arrived, a student pilot who had recently soloed died in the crash of a T-38. "We all made a pilgrimage to the wreckage, a mile beyond the end of the runway," Morland recalls. "The ribs of the burned-out fuselage reminded me of the rotting carcass of a beached whale.” Overhead, the number of T-38s practicing landings was unusually large. “Everybody had to go aloft and shake it off.”

Morland spent a few months of flight training in the Cessna T-37, a fat, sluggish tadpole of a jet trainer. T-38s worked out on a parallel runway. “During every touch-and-go landing in the T-37, I would see a T-38 flash by at nearly twice my speed,” he recalls. “It looked like a comic book superhero.”

In those days, the very first lesson in the T-38 syllabus was supersonic flight at 40,000 feet. “In a matter of minutes we were going faster and higher than anyone outside the military aviation fraternity had ever gone,” Morland says. Flying in supersonic formation, the wing kept bumping into an invisible but seemingly solid object: the lead airplane’s shock wave.

The supersonic component is gone today, but much of the training syllabus is unchanged: formation, blind flying, slow flight, approaches to stalls, single-engine procedures, and landing…and landing…and landing.

Now, as then, landing is the great challenge of flying the T-38. “Instructors always did it right,” Morland says, “but they seemed to be in conspiracy not to tell students the secret.” The underlying aerodynamic problem was the tiny wing; it offered little forgiveness to a student who didn’t have the proper attitude, height, and power as the runway threshold flashed beneath the tires.

The T-38 began life in 1954 as the N-156, Northrop Aircraft’s 156th design project. Originally, it was supposed to be a small supersonic fighter capable of operating from the Navy’s short-deck “jeep” escort carriers. But in the mid-1950s, Navy doctrine changed: Little carriers were out, big ones were in, and the small supersonic carrier-based fighter was no longer needed. Northrop, an independent-minded company, went ahead with the project on its own, recasting it as a lightweight fighter, tagged N-156F, for export. At about the same time, the Air Force issued a General Operating Requirement for a supersonic trainer to replace its obsolescent straight-wing T-33s and prepare pilots for the faster, heavier fighters of the Century Series, the F-100 through F-106. Thus the N-156T was born.

The N-156 story had really begun even earlier. In 1952 Northrop had been working on a fighter project, the N-102, called the Fang. It had a shoulder-mounted delta wing, an F-16-like underbelly airscoop, and a single General Electric J79 turbojet engine. At the time, there were two standard fighter engines: the Pratt & Whitney J57, 14 feet long, weighing 4,000 pounds, and developing 18,000 pounds of thrust with afterburning; and General Electric’s larger and more powerful J79. These two engines were the principal reason jet fighters looked as big as locomotives alongside the more human-scale single-seaters of World War II.

One day a couple of engineers from General Electric’s newly formed Small Aircraft Engine Department—in those days engineers were also salesmen—turned up at Northrop with a tiny engine they had brought along as baggage on an airline flight from the East Coast. They claimed it would develop 2,500 pounds of thrust. “What scale is this model?” the Northrop people asked. “This isn’t a model,” replied the GE men. “This is the engine!”

Northrop's vice president for engineering, Edgar Schmued, saw in the tiny engines the possibility of reversing what he believed to be a pernicious trend toward ever larger, heavier, and costlier fighters. Engine weight was critical because, by a rule of thumb, each extra pound of engine weight would require six additional pounds of airframe. The J85—the brainchild of Ed Woll, one of GE's most gifted and influential engineers—was 22 inches in diameter and weighed less than 600 pounds, and in the form in which it would be used in the T-38, it developed 3,850 pounds of static thrust. Its thrust-to-weight ratio was superior to that of any other jet engine of its time. It sounded the death knell of the Fang project, from the ashes of which the N-156 arose.

In the initial stages of the N-156 project, Schmued favored a layout in which the engines were mounted on the wings, a location that he thought would make them easily accessible for maintenance. His chief engineer, Welko Gasich, disagreed: Wing-mounted engines produced excessive drag and aerodynamic disturbances. In Gasich's opinion, the engines had to be within the fuselage. Schmued resisted for a long time but eventually capitulated, and a buried-engine mockup was built. Designer Lee Begin laid down the mold lines—the outer shape of the airplane. It was a thrilling shape, different from that of any other airplane of its era. The wings were vestigial, the vertical fin huge. The immensely long nose, exotically contoured and tapering practically to a point, seemed so far from the wing as almost to belong to another airplane. The swellings and hollows of its mid and aft fuselage—scooped out at the waist in accordance with aeronautical engineer Richard Whitcomb's transonic area rule and expanding thereafter to envelop the engines—gave the fuselage a reclining-nude quality.

Northrop's competitor for the supersonic trainer contract was the F-100F, a two-seat variant of North American's F-100 Super Sabre. At the time, Northrop was not a supplier particularly in favor with the Air Force; North American was. Among Northrop's pitches was one that is so obvious today that it is hard to believe that it was new to procurement offices in 1956. It was the idea of "life cycle costs," which Gasich had brought with him from his previous employer, the RAND Corporation. While North American argued that the initial acquisition of the F-100F would be cheaper because the production line and the infrastructure for supporting the airframe and its engine were already in place, Northrop countered that in the long run, its new trainer would be cheaper because it used far less fuel and incurred lower maintenance costs. With two engines, it would also be safer; Northrop believed that it could bring the serious-mishap rate, then around 25 per 100,000 flight hours for the F-100, down to the range of seven to 10. The Air Force was persuaded. On June 15, 1956, a letter of intent was signed for what was now called the YT-38 Talon.

Several features changed during development. One was the arrangement of the vertical fin. A T-tail arrangement, like that of the F-104, with the stabilizer set atop the fin, had been considered and discarded early on, but the fin was originally designed with moderate sweep, like the wing. Flutter analysis indicated that the swept version might present difficulties. The crux of the matter was the stiffness of the aft fuselage, large portions of which had to be removable for engine access. In some jets, removing an engine required first removing the vertical fin, but it was a difficult design problem to make the fin easily detachable and yet sufficiently strong and stiff. Engineer Julius Villepique proposed what proved to be a key innovation. He fixed the fin to the keel structure that ran between the engines, and made the horizontal stabilizer, rather than the fin, the removable component, along with the “boat tail”—the entire aft shell of the fuselage surrounding the engines. The process of getting at the engines was extremely simple. Apart from the fasteners holding the fuselage shell together, the only parts that had to be disconnected were two push rods that connected the pilot’s control stick to the valve controlling the horizontal stabilizer’s hydraulic actuators. Hydraulic lines—there were only two—mated automatically, with internal check valves preventing loss of fluid.

The engines hung from rails on either side of the central keel. To avoid having to break and reconnect multiple hydraulic lines, designers mounted the hydraulic pump and other accessory drives on the fuselage, joined to the engine by a short driveshaft. Thanks to the rail support and the fuselage-mounted gearbox, once the boat tail had been detached, an engine could be removed and replaced in an hour.

Weight control was always a key factor in the trainer’s design. The N-156 was intended to weigh 10,900 pounds full up—a fantastically low figure when you consider that the fighters of the time generally weighed between 30,000 and 45,000 pounds. Eventually it would grow by about a ton—but even then it was a model of weight control. Its systems were simple. The hydraulically powered flight controls lacked manual reversion, and if both engines failed, the pilots’ only recourse was to eject. There was no fuel in the wings, no provision for external stores, and only basic systems for navigation and communication. Test pilot Lew Nelson took the prototype on its uneventful first flight on April 10, 1959.

“Science is done by single individuals, but engineering is done by a team, and I had a great team,” recalls Welko Gasich today. In his voice you can hear his affection for the airplane and its creators, and for a halcyon period—“the height of the great 1950s and ’60s screwdriver technology,” one pilot called it—during which every choice his team made turned out to be the right one.

Despite its radical appearance, the T-38 is a gentle airplane in the air, straightforward in character, almost viceless, and thoroughly conventional in handling. An unmistakable buffet gives ample notice of an impending stall. For a long time the aircraft refused to spin at all. The Air Force’s training command initially complained that the T-38 was too easy to fly, compared with the fighters for which it was supposed to be preparing new pilots. Gasich retorted that the Air Force ought to demand fighters that flew better—and that’s what eventually happened. Today’s fighters are so docile and forgiving that the T-38 is now, according to former instructor pilot Lewis Shaw, “the hardest airplane to fly in the Air Force’s fleet.”

It trains not only Air Force cadets, but test pilots as well. Says Northrop test pilot Roy Martin, “It replicates theory great; that’s what makes it such a marvelous teaching tool.” It flies just as textbooks say airplanes should. Lockheed Martin test pilot Dan Canin agrees with Martin up to a point, but adds that as far as test pilot training goes, the T-38’s main defect is that it’s too good an airplane—it doesn’t give students enough faults to identify. Canin’s favorite test pilot trainer was the de Havilland Beaver—“It had so many things wrong with it.”

Since Lee Begin first shaped it, the T-38 has continually inspired affection. Lewis Shaw still calls it “the 36-24-36 blonde on the beach.” Dan Canin raves: “I absolutely love the airplane. The T-38 and its siblings [F-5/F-20] are absolutely beautiful things…iconic, really…designed, it always seems to me, exactly as one would sculpt a fighter if he didn’t have to worry about anything practical…like fuel, weapon systems, etc. As we go exclusively with stealth designs, which are inherently fat to incorporate weapons internally, I doubt we’ll ever see fighters this good-looking again.”

Like all objects of infatuation, however, the T-38 has become encrusted with legend and exaggeration. It’s commonly said to roll at 720 degrees a second; the truth is 280 to 300, and in any case research suggests that anything above 220 merely serves to disorient the pilot. Another oft-repeated claim is that the T-38 climbs 33,000 feet a minute, even though the aircraft’s time-to-climb record, set by Walt Daniel in 1962, is three minutes to 30,000 feet. According to Northrop’s Roy Martin, a normal climb at military power—that is, maximum power without afterburner—is around 6,000 feet per minute.

Four decades have passed since the T-38 joined the Air Force. Its lines are no longer jaw-dropping; other airplanes have come to resemble it. It still clings to its old nickname “the white rocket,” but today’s pilots, comparing it with the F-15 and F-16, find the Talon underpowered. The thrust of present-day fighters is almost equal to their weight, and their maneuverability is superior to that of the T-38, which needs 10,000 feet to execute a loop and can’t maintain both airspeed and altitude in a 5-G turn. (Nevertheless, T-38s were good enough for the Air Force precision aerobatic team, the Thunderbirds, which flew them from 1974 to 1982.) A-10 and B-1 pilots are kinder to it. Beth Makros, a former B-1 pilot now instructing at Vance Air Force Base in Oklahoma, was surprised to find that she felt right at home when she first transitioned from the tiny T-38 to the nearly half-million-pound B-1. “It handled similarly,” she says. “Roll was similar, speeds are the same, it lands the same. They’re surprisingly alike.”

The T-38 does have faults. The J85 engines are temperamental at high altitude, and were prone to damage from ingested ice—the inlets are unheated—until the Air Force stopped flying Talons in icing conditions. The brakes, proportioned to fit into skinny wheels that are sized, in turn, to retract into the paper-thin wing, are barely adequate to stop it on a mile and a half of runway, even with a good deal of help from nose-high aerodynamic braking. Its original engine air intakes, optimized for supersonic performance, were too small to deliver sufficient takeoff thrust at high altitudes and summer temperatures.

The small, thin wing, only 25 feet in span, is responsible for the Talon's most troublesome characteristic: its lack of lift response at low speed. Dan Canin explains that in a significant portion of the low-speed flight regime, the so-called "back side of the power curve," the only way to gain speed is to lose altitude. "If you get slow with a big rate of descent near the runway, pulling the nose up will only result in the airplane hitting the ground in a more nose-up attitude—it won't stop the rate of descent at all." Landing the T-38 reliably requires precise speed and power control on final approach, and in particular not reducing power or raising the nose too early. The wing digs in like a shovel in mud, and once that happens, even the afterburners might not be able to pull it out.

That characteristic was tragically illustrated in 1966, when two NASA astronauts got into trouble at low speed while circling to land under a low overcast (NASA operates a large fleet of T-38s as trainers, space shuttle approach simulators, and astronaut runabouts). Pilot Elliot See kicked in the afterburners, but it was too late. The banking Talon hit the roof of a building and crashed into a courtyard, killing both pilots.

Nevertheless, the T-38 is, and always has been, one of the safest jets in the Air Force. Its serious mishap rate, originally projected to be 7 per 100,000 hours, has, for the past decade, hovered at or below 0.4 per 100,000 hours. Lewis Shaw attributes the safety record at least in part to the Air Force's having "gotten rid of the dark alleys" in the flight training syllabus: low-level single-engine work, formation flights with three solo pilots, and unstabilized approaches during simulated emergencies—flaps inoperative, one engine out, and so forth. Also eliminated were rolling pull-ups from air combat training, which overstressed the wings. Now, he says, "the T-38 is more like a simulator than an airplane." Only 150 of the 1,187 T-38s built between 1961 and 1972 have been lost through attrition, with 45 deaths, while the fleet has logged 25 million hours in the air. Sixty percent of the losses occurred in the first 10 years, when the Air Force was still adjusting the syllabus to the new airplane; only four percent occurred in the last 10 years. Says Northrop historian Ron Gibb, "It's like having a squadron of 16 airplanes fly for 70 years before losing one of them."

T-38 wings were originally designed for 7.33-G loads and a fatigue life of 4,000 hours. The airplanes held up well until the Air Force began using them for dogfight training. "We were very aggressive with the jet," recalls David Rothenanger, who taught at Holloman Air Force Base in New Mexico from 1984 to 1987. "A dogfight by nature gets you that way. During one mission a very high roll rate was executed under almost maximum G, and sproooongggg, bye-bye wingtip. It took almost full aileron to keep the wings level, but they were able to land the airplane." The failure occurred along a structural seam just outboard of the end of the aileron. The area was strengthened, and a new rule was added to the training syllabus: First roll to a desired heading, then level out and pull. Northrop produced new wings with thickened skins, improvements that the T-38 inherited from the parallel production of the heavier but structurally similar F-5 fighter, which Northrop had been selling in large numbers overseas, including, at one time, to the South Vietnam air force. A well-used T-38 today has 18,000 hours; many airplanes have had their wings replaced twice.

Remarkable for having gone through 2,000 hours of initial flight testing without modifications, the Talon has required few modifications in 44 years of active service. There have been only three versions: the original T-38A; an AT-38B, with wing and fuselage hard points, used for ordnance delivery training; and the latest, the T-38C.

The Air Force's entire fleet of more than 500 trainers will eventually be converted to the C model under a service life extension program called Pacer Classic. They will receive new, stronger wings, built of a high-strength alloy that will provide more fatigue resistance and an 8,000-hour life. Fatigue-prone parts of the cockpit structure will be replaced. A more bird-proof polycarbonate windscreen will replace the original, and the airplanes will receive propulsion mods, including larger engine air inlets, originally designed for NASA's fleet, to improve takeoff thrust and engine durability. Most important, under a $750 million contract that Northrop hoped to win but that went to Boeing instead, the original steam-gauge instrument panel is being replaced with a computer-based glass cockpit, complete with a head-up display. The T-38 is now expected to remain the Air Force's intermediate-level trainer until 2040. When the last student in the last T-38 takes to the air, he will be flying a design nearly 90 years old—almost as though today's pilots had trained in SPADs or Sopwith Camels.

On the wall of Howard Morland's Arlington, Virginia living room is a framed photograph of a pair of T-38s. He acquired it, along with a recurring dream of joyriding in a stolen T-38 that haunted him for years, when he graduated from flight training in 1967. A couple of years ago, at an airshow at nearby Andrews Air Force Base, a T-38 was on display, guarded by a young instructor pilot. "The airplane was at least a dozen years older than he was," Morland recounts. "I climbed the platform and looked down into the cockpit. It seemed like yesterday. I had a hard time shaking the idea that I was suddenly 40 years younger, with my life ahead of me."
Not so the T-38. At 40, half its life is still ahead.

Sidebar: Test Drive

"You're low! You're low!" Chuck Thornton's voice in my headset is uncharacteristically brusque. We're approaching the long runway at Mojave, California, and I'm making the classic T-38 mistake of getting low and slow on the turn to final approach. After 20 minutes of rolls and 4-G turns, I can barely tell up from down. "My airplane," he says, and I feel the stick tugged from my grasp.

We've been at 14,000 feet in the airspace of Edwards Air Force Base. It's a beautiful desert spring day with tall cumulus buildups, and we've screeched around the columns of cloud in near-vertical banks and rolled inverted to skim their tops. I'm in the back seat, but I'm still so far out in front of the rest of the airplane that the only way I know it has wings is by peering in the rear-view mirrors on the canopy bow. Being in the front seat must be like floating in the sky without any airplane at all.

A few flight characteristics stand out. One is the buffeting during maneuvering, the result of having the stabilizer low in the wake of the wing. The T-38’s pre-stall buffet starts long before the actual stall, unpacking a rich vocabulary of rattles and rumbles that turn to rapid thuds as you get slow—“slow” being 160 mph or so. Another is the T-38’s extreme smoothness and stability in cruise; hands off, you’d think it was on autopilot. There’s the disorienting roll rate—I made only small inputs to the control stick for rolls because a maximum-per-formance roll is over practically as soon as it starts. There’s also the not-too-shabby (at least to a civilian pilot like me) rate of climb, which I can’t quantify because at 345 mph the vertical speed indicator simply pegged at its maximum indication, 6,000 feet per minute. And there was the long rollout after landing, using all 8,000 feet of a Van Nuys, California runway.

Thornton Aircraft specializes in restoring T-38s and F-5s for civilian use. In 1985, the first T-38 the company restored took Grand Champion Warbird honors at the annual Oshkosh, Wisconsin fly-in, beating the usual formidable competition. Three and a half million bucks buys you just about the hottest airplane, short of the occasional MiG-25, that can be found out of uniform. It cruises at Mach 0.9 with a range of about 1,000 miles. No supercar on earth can match the impression you make taking your date to Vegas in a supersonic jet—but keep in mind that the total baggage allowance for the two of you is one cubic foot.