X-15 TO THE EDGE OF SPACE...

SENSATIONAL, ICONIC, GROUNDBREAKING. The X-15 hypersonic research airplane significantly extended the frontiers of flight. It was a program of outstanding engineering achievements, jaw-dropping performance characteristics, and extraordinary human endeavor. During a 15-year journey of discovery, the X-15 became the fastest and highest-flying piloted winged airplane of its time. Its discoveries set NASA on a direct course for the exploration of space.

National Aeronautics and Space Administration

354,200 ft
HIGHEST ALTITUDE ATTAINED FOR A WINGED AIRCRAFT (THAT'S 67 MILES HIGH!) AND AN ACHIEVEMENT NOT SURPASSED UNTIL 2004

1,325° F
THE PEAK SURFACE TEMPERATURE OF A TEST PANEL ON THE X-15 DURING A MACH 5 MISSION

4,520 mph
TOP SPEED OF MACH 6.70 — AN ACHIEVEMENT UNBROKEN FOR 41 YEARS

8-g
THE G-FORCE EXPERIENCED BY X-15 PILOTS ON SOME FLIGHTS DURING REENTRY INTO EARTH'S ATMOSPHERE

A WING AND A PRAYER

Test pilot Scott Crossfield helped to design the ejection seat, which enabled "safe ejection at speeds up to Mach 4, in any attitude and at any altitude up to 120,000 feet." After the canopy was jettisoned, the seat fired upward and, once clear of the aircraft, deployed a pair of fold-out fins and telescoping booms for stabilization. A face-heater battery activated to keep the pilot's visor clear of ice, and oxygen was supplied from two under-seat tanks. Despite the seat's sophistication, none of the pilots wanted to see it used on a mission.

BALLISTIC CONTROLSYSTEM THRUSTERS

THE OUTER SKIN OF THE X-15 WAS MADE OF A NICKEL-CHROMIUM ALLOY CALLED INCONEL X', EMPLOYED IN A HOT STRUCTURE THAT WAS CAPABLE OF WITHSTANDING TEMPERATURES IN EXCESS OF 1200° F. THE BEAMS AND SPARS OF THE WINGS AND THE RING STRUCTURE OF THE FUSELAGE WERE CONSTRUCTED FROM STRONG TITANIUM-MANGANESE ALLOY.

HYDROGEN PEROXIDE TANK (ENGINETURBOPUMPPROPELLANT)

AMMONIA TANK (ENGINE FUEL)

WING FLAP

WINGATTACHMENTSTRUCTURE

MOVABLE UPPER VERTICAL STABILIZER

UPPER SPEED BRAKE

XLR99-RM-1 ROCKET ENGINE

HELIUM TANK (FOR ENGINE PURGE)

ALL-MOVING HORIZONTAL STABILIZER

LOWER VERTICAL STABILIZER (JETTISONED JUST BEFORE LANDING)

RETRACTABLE LANDING GEAR SKIDS

AUXILIARY POWER UNITS

LIQUIDNITROGENTANK (AIR CONDITIONING ANDPRESSURIZATION SYSTEM)

LIQUID OXYGEN TANK VENT

LIQUID OXYGEN TANK (ENGINE OXIDIZER)

HELIUM TANK (FOR ENGINE PROPELLANT PRESSURIZATION)

FUSE PANEL

SKYLIGHT HATCH

THREE-PANELS-THICK WINDSHIELDHEATED WITH NITROGEN GAS TO PREVENT FROSTING/FOGGING

NO. 2 EQUIPMENT COMPARTMENT

NO. 3 EQUIPMENT COMPARTMENT

LIQUID OXYGEN TANK FILLER

HELIUM TANK (FOR PRESSURIZATION)

HYDRAULICSYSTEM RESERVOIRS

HELIUM TANK (AUXILIARY POWER UNIT PROPELLANT PRESSURIZATION)

HYDROGEN PEROXIDE TANK (AUXILIARYPOWER UNITANDBALLISTIC CONTROLSYSTEM PROPELLANT)

AREA FOR EXPERIMENTS

TELEMETRY RECORDERS

PITOT HEAD

A SERVO-ACTUATED "BALL NOSE" FLOW DIRECTION SENSORPROVIDEDACCURATE MEASUREMENT OF ANGLE OF ATTACK AND ANGLE OF SIDESLIPATSUPERSONICAND HYPERSONIC VELOCITIES.

BALLISTIC CONTROLSYSTEM THRUSTERS

NO. 1 EQUIPMENT COMPARTMENT

1. TANK PRESSURIZATION SELECTOR
2. ENGINE THROTTLE
3. ALTIMETER
4. AIRSPEED/MACH INDICATOR
5. ACCELEROMETER
6. CONVENTIONAL CENTER STICK (MOVED THE AERODYNAMIC CONTROL SURFACES)
7. VERTICAL VELOCITY INDICATOR
8. SYSTEM WARNING LIGHTS
9. CANOPY EMERGENCY JETTISON HANDLE

WHITE LIGHTNING

The X-15A-2 (pictured above) was designed for maximum speed. Two external tanks for liquid ammonia and liquid oxygen provided an extra 60 seconds of engine burn and, in theory, could power the rocket plane to speeds well in excess of Mach 7. The white color of the aircraft was due to the application of an ablative coating designed to protect the structure from the high temperatures that would be generated at such speeds. The fuselage was extended by 29 inches to carry liquid hydrogen for a planned supersonic combustion ramjet (scramjet) that was flown in mockup form but never actually tested. In the hands of pilot Pete Knight, the X-15A-2 reached Mach 6.70 (4,520 mph), the fastest flight of the X-15 program.

TRIUMPHS AND TRAGEDY

The achievements of the X-15 are breathtaking. Not only did the aircraft create history with its speed and altitude, it gave birth to some amazing successes—the first extensive use of simulation as an engineering tool, first full-pressure suit for pilot protection in space, first application of hypersonic theory to a flight vehicle. The list goes on. However, the program also experienced its share of setbacks and one tragic loss.

On November 15, 1967, Air Force test pilot Maj. Michael J. Adams reached 266,000 feet during a test flight. Suddenly, his aircraft went into a hypersonic spin from which he could not recover. In spite of the pioneering nature of the program, his was the only fatality and aircraft loss.

IN CONTEXT

"X" means "experimental." The first "X" designation went to the Bell X-1, which, on October 14, 1947, became the first airplane to break the sound barrier in level flight. Since then, more than 50 different major research designs have used the "X" designation. Although not every "X" vehicle became a flying prototype, every design proved to be a highly valuable research tool for advancing knowledge of aerodynamics and astronautics.

NASA continues to invest in next-generation technologies to ensure that the legacy of the X-15 lives on.

THE LEGACY

The X-15 program yielded a treasure trove of valuable data and fresh understanding. Perhaps most critically, it provided a major technological stepping-stone to space.

The Mercury, Gemini, and Apollo programs all benefited from the X-15 research and, every time a space shuttle returns from orbit, it does so using knowledge derived from the X-15.

The X-15 demonstrated for the first time that pilots could fly rocket-powered aircraft out of Earth's atmosphere, control them successfully in an airless environment, reenter the atmosphere and perform a precision landing at a predetermined site. In other words, it invented what eventually became the basic flight profile for a space shuttle mission.

THE CARRIER AIRCRAFT

Before the X-15 could negotiate any mission successfully, a mother ship had to carry the research airplane to high altitude since the X-15 did not have enough propellant to take off from the ground. A pair of mighty Boeing B-52 Stratofortress aircraft took the X-15 under their wings. The NB-52A was dubbed "The High and Mighty One" and the NB-52B "The Challenger."

The X-15 included one of the first inertial navigation systems (called a "stable platform") to let the pilot know his precise position over the High Range, and a sophisticated Stability Augmentation System to help him maintain precise control of the aircraft.

Above Earth's atmosphere, reaction controls kept the aircraft stable. Hand controllers in the cockpit were linked to small hydrogen peroxide thrusters at the nose for pitch and yaw control, and on each outer wing to control roll.

The most dangerous part of a mission was the descent. As the pilot switched from thruster control to traditional "stick-and-rudder" flying, the X-15 became a 15,000-pound unpowered hypersonic glider glowing red-hot as it decelerated from 4,000 mph to 200 mph. With only one shot at landing, there was simply no room for error.

FLYING AT THE EDGE

To protect the pilot and sensitive electronics from the ferocious heat of hypersonic flight, the pressurized aluminum cockpit and equipment bay were insulated from the outer Inconel X shell by a radiation shield and insulation blanket.

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FULL-PRESSURE SUIT

The full-pressure suit worn by X-15 pilots to protect them from the effects of high-altitude flight was revolutionary. Previous pressure suits were cumbersome, virtually immobilized the pilot, and were mostly ineffective. Fresh thinking was required.

The answer was a groundbreaking development by the David Clark Company that resulted in the MC-2 suit.

The introduction of an inner nylon mesh called "link-net" radically improved mobility and provided much improved protection against the harsh environment.

The suit was integral to the pilot's environment. It provided cooling and ventilation; supplied oxygen; and contained parachute harness, a microphone, earphones and pressure regulators. Visors were heated for the same reason as car windshields—to prevent fogging.

A total of 36 X-15 flights used the original MC-2 suit, while the remainder used the newer A/P22S-2, also developed by the David Clark Company. Each suit was custom-made for a particular X-15 pilot. Variants of this design would become the standard full-pressure suit used across all U.S. military and NASA programs.

HALF A MILLION HORSEPOWER

The power generated by the X-15's XLR99 rocket engine was awesome. The physical stress exerted on the human body was so high that test pilot Milt Thompson once joked that the X-15 was the only aircraft he had ever flown that made him glad when the engine quit.

Developed and built by the Reaction Motors Division of Thiokol Chemical, the XLR99 could deliver up to 57,000 pounds of thrust, or the equivalent of over half a million horsepower. The propellants were liquid oxygen and anhydrous ammonia, fed into the engine by turbopumps at a flow rate of more than 13,000 pounds per minute.

The XLR99 had a rated operating life of 1 hour, after which it could be overhauled and used again. The basic X-15 carried propellants for about 85 to 90 seconds of full-power flight, and the X-15A-2 carried propellants for more than 150 seconds of full-power flight.

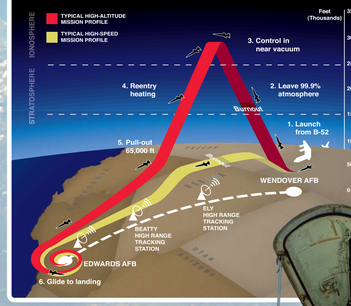
Early flights of the X-15 were powered by the Reaction Motors XLR11—the same engine that powered the Bell X-1—which acted as an interim engine until development work on the XLR99 was complete.

FLIGHTS OF DISCOVERY

It was all about acceleration. The B-52 carrier aircraft traveled at 500 miles per hour and 45,000 feet when the X-15 pilot hit the launch switch. A few seconds of freefall followed, and then the earth-shatteringly powerful 57,000-pound XLR99 rocket engine ignited and catapulted the 33,000-pound X-15 toward Mach 5.

The heart rate of an X-15 pilot ranged from 145 to 185 beats per minute as the adrenaline surged. Chest-to-back acceleration was 2-g up to 4-g. At engine shutdown after nearly 90 seconds thrust, he braced his helmet against a headrest in front of him for the 2-g of emotion deceleration. The rest of the 8- to 12-minute flight continued without rocket power.

On high-altitude missions, the pilot experienced microgravity ("zero-g") for nearly 2 minutes as the X-15 often soared past 300,000 feet. After glimpsing the curvature of Earth, the pilot experienced 5- to 8-g during reentry. On high-speed missions, the X-15 reached an altitude of 100,000 feet, which heated the skin of the airplane until it glowed nearly red-hot. It could also accelerate from Mach 5 to Mach 6 in an eye-watering six seconds.



X-15 ACHIEVEMENTS

THE X-15'S LEGACY IS QUANTIFIABLE NOT JUST IN TERMS OF SPEED OR ALTITUDE ACHIEVEMENTS, BUT ALSO IN TERMS OF WHAT IT TAUGHT NASA AND THE AMERICAN PUBLIC ABOUT THE FUTURE POSSIBILITIES OF HYPERSONIC FLIGHT. THESE ACHIEVEMENTS INCLUDE:

- Development of the first practical full-pressure suit for pilot protection in space
- First application of hypersonic theory and wind tunnel work to an actual flight vehicle
- Development of computer-based simulation as an engineering and flight-planning tool
- Development of a servo-actuated ball nose flow direction sensor for accurate measurement of angle of attack and sideslip angle at supersonic and hypersonic speeds
- Development of inertial flight data systems capable of functioning in high dynamic pressure and space environments
- Demonstration of a pilot's ability to control a rocket-boosted aerospace vehicle through atmospheric exit

HEROES OF THE HYPERSONIC

A total of 12 test pilots from NASA, the U.S. Air Force, the U.S. Navy and North American Aviation flew the X-15.

A. Scott Crossfield

North American Aviation's Crossfield was intimately involved in the design of the X-15. He piloted the first free flight on June 8, 1959, and the first powered flight on September 17. He completed 1 glide and 13 powered flights, reaching a maximum speed of Mach 2.97 (1,960 mph). In July 1962, he was a joint recipient of the Collier Trophy, which was presented by President John F. Kennedy.

Joseph A. Walker

Walker made the first X-15 flight by a NASA pilot on March 25, 1960. He flew the airplane 25 times and made the highest flight (354,200 ft) of the program on August 22, 1963. He also flew the fastest flight (4,104 mph) of the basic X-15 configuration. In July 1962, he was a joint recipient of the Collier Trophy, which was presented by President John F. Kennedy.

Robert M. White

Air Force test pilot White made 16 flights in the X-15 between April 13, 1960, and December 14, 1962. White was the first pilot to fly any aircraft faster than Mach 4, 5 and 6, as well as the first to fly above 200,000 and 300,000 feet. He set the only official world record of the X-15 program when he flew to 314,750 feet on July 17, 1962, a Fédération Aéronautique Internationale altitude record that still stands.

Forrest S. Petersen

Petersen was the only Navy pilot to fly the X-15. He made five flights in the aircraft at speeds of up to Mach 5.30 (3,600 mph). Petersen had the dubious distinction of making the program's first uprange emergency landing on January 10, 1962, at Mud Lake. In July 1962, he was a joint recipient of the Collier Trophy, which was presented by President John F. Kennedy.

John B. McKay

"Jack" McKay made 29 X-15 flights, reaching Mach 5.65 on August 26, 1964, and a peak altitude of 295,600 feet on September 28, 1965. McKay was seriously injured on November 9, 1962, during an emergency landing at Mud Lake, but he recovered and flew 22 more X-15 flights. The airplane he crashed was rebuilt into the advanced X-15A-2.

Robert A. Rushworth

Rushworth flew the X-15 more times than any other pilot, logging 34 flights in total, including 2 with the interim XLR11 engines. During these flights, he achieved Mach 6.06 (4,018 mph) and 285,000 feet altitude. He was the second Air Force X-15 pilot (after Bob White) to attain an astronaut rating by flying the X-15 and was the first pilot to fly the advanced X-15A-2.

Neil A. Armstrong

A name synonymous with aeronautical achievement, Armstrong was actively engaged in both piloting and engineering aspects of the X-15. As a NASA test pilot, he completed seven X-15 flights, including the first flight of the MH-96 adaptive flight control system. Armstrong would ensure his place in history on July 20, 1969, when he became the first human to land on the moon during the Apollo 11 mission.

Joe H. Engle

Engle completed 16 flights in the X-15, exceeding Mach 5 on 10 of those flights. In June 1965, he climbed to an altitude of 280,600 feet, thereby earning his Air Force astronaut rating long before he joined the NASA Astronaut Corps. He accumulated the last of his 224 hours in space when he commanded the Space Shuttle Discovery during STS-51I in 1985.

Milton O. Thompson

Thompson began flying X-15s on October 29, 1963, and went on to complete 14 flights during the next 2 years, reaching Mach 5.48 (3,712 mph) and a peak altitude of 214,100 feet. In 1962, Thompson was selected as the sole NASA test pilot for the X-20 Dyna-Soar, the first viable reusable spacecraft. The Dyna-Soar program was canceled prior to its first flight.

William J. Knight

"Pete" Knight flew the fastest flight of the program on October 3, 1967, when his advanced X-15A-2 reached Mach 6.70 (4,520 mph). He also had more than his share of eventful flights. For instance, while climbing through 107,000 feet at Mach 4.17 on June 29, 1967, he suffered a total electrical failure. Knight calmly glided to a safe emergency landing.

William H. Dana

Bill Dana was at the controls of the 199th and final flight. During this, his 16th mission, he achieved a speed of 3,897 miles per hour and a peak altitude of 306,900 feet—slightly above 58 miles. Along with three other NASA X-15 pilots, he was later awarded astronaut wings for his achievement. For his service as a flight research pilot, he received NASA's Distinguished Service Medal in 1997.

Michael J. Adams

Adams flew the X-15 seven times. He reached a maximum speed of Mach 5.59 and a maximum altitude of 266,000 feet, which qualified him as an Air Force astronaut. On November 15, 1967, Adams was at the controls when the third X-15 entered a hypersonic spin and broke up at approximately 62,000 feet. Adams was killed; the X-15-3 destroyed.

Of the dozen pilots, eight flew the X-15 to a height above 254,000 feet (50 mi) and qualified to receive astronaut wings.

Bill Dana, pilot on the 199th and final X-15 mission. In the late 1960s and 1970s, Dana was the project pilot on the manned lifting body programandconductedastinguished career as chief engineer at Dryden Flight Research Center.

X-15 PROGRAM MILESTONES

www.nasa.gov

1952 The National Advisory Committee on Aeronautics, NACA, increases research into flight up to Mach 10 and to altitudes of 12 to 50 miles.

1954 NACA teams establish the characteristics of a new research airplane, which subsequently becomes the X-15.

1954 NACA, the U.S. Army and U.S. Navy sign a Memorandum of Understanding to create a "Joint Project for a New High-Speed Research Airplane."

1955 North American Aviation is chosen to develop three X-15 research airplanes.

1956 Reaction Motors is awarded contract to develop the XLR99 rocket engine.

1957 Construction begins of the X-15 airplanes.

1958 Work on the X-15-1 is completed.

1959 First captive flight of the X-15 mated to the B-52.

1959 First glide flight of the X-15-1.

1960 First flight using the XLR99 engine.

1961 First flight above Mach 5.

1961 First flight above 200,000 feet.

1961 First flight above Mach 6.

1961 First flight above 300,000 feet.

1963 First civilian flight above 50 miles.

1963 Unofficial world altitude record of 354,200 feet set on August 22.

1967 Unofficial world speed record of Mach 6.70 (4,520 mph) set on October 3.

1968 The final flight, piloted by Bill Dana, takes place on October 24.

NP-2008-02-195-HQ