NASA Facts

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Dryden Flight Research Center

The Dryden Flight Research Center is NASA's premier installation for aeronautical flight research. Dryden is the "Center of Excellence" for atmospheric flight operations. The Center's charter is to research, develop, verify, and transfer advanced aeronautics, space and related technologies. It is located at Edwards, Calif., on the western edge of the Mojave Desert, 80 miles north of Los Angeles.

In addition to carrying out aeronautical research, the Center also supports the space shuttle program as a backup landing site and as a facility to test and validate design concepts and systems used in development and operation of the orbiters. Dryden, a civilian tenant organization within the boundaries of Edwards Air Force Base, is on the northwest edge of Rogers Dry Lake, a 44-square-mile area used for aviation research and test operations. An additional 22 square miles of similar smooth clay surface is provided by nearby Rosamond Dry Lake. The desert environment provides good flying weather an average of 345 days a year, and the absence of large population centers throughout the high desert helps eliminate problems associated with aircraft noise and flight patterns.

The Early Years

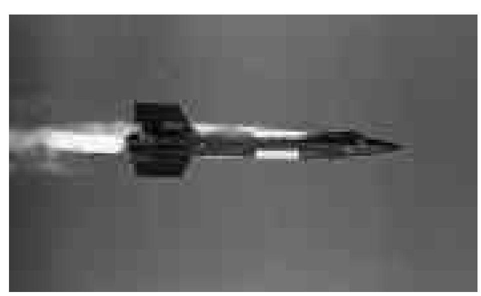
Dryden's history dates back to the early fall of 1946, when a group of five aeronautical engineers arrived at what is now Edwards from the National Advisory Committee for Aeronautics' Langley Memorial Aeronautical Laboratory, Hampton, Va. Their goal was to prepare for the X-l supersonic research flights in a joint NACA-U.S. Army Air Forces-Bell Aircraft Corp. program. The NACA was the predecessor organization of today's NASA.

Since the days of the X-l, the first aircraft to fly faster than the speed of sound, the installation has grown in size and significance and is associated with many important developments in aviation-supersonic and hypersonic flight, wingless lifting bodies, digital fly-by-wire, supercritical and forward-swept wings, and the space shuttles. Among the aircraft flown by the NACA and NASA pilots at Dryden in earlier years were:

• The original X Series included the A, B, and E models of the X-l, the X-3, X-4, and X-5 aircraft. These research vehicles pioneered flight at and beyond the speed of sound, and proved the concepts of swept and variable-sweep wings.

• D-558-1 and 2: The D-558-1 "Skystreak" investigated stability and control at transonic speeds, while the D-558-2 "Skyrocket" became the first aircraft to fly twice the speed of sound.

• X-15: This rocket-powered vehicle extended piloted aircraft flight to more than 4,500 mph and to altitudes of more than 350,000 feet. It was the first aircraft to use thrusters for pitch, yaw and roll control at the fringes of the atmosphere. Data collected on stability, flight controls, thermal heating, materials and other similar



disciplines were used to develop spacecraft and many of today's operational aircraft. Flown between 1959 and 1968, the X-15 is considered by many to be the most productive and successful research aircraft to date.

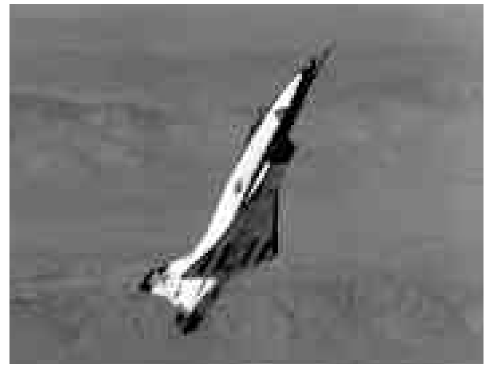
• Lunar Landing Research Vehicles (LLRVs): The LLRVs, humorously referred to as "flying bedsteads," were created by the Flight Research Center (now Dryden Flight Research Center) to study and analyze piloting techniques needed to fly and land the tiny Apollo Lunar Module in the moon's airless environment. The success of the LLRVs led to the building of three Lunar Landing Training Vehicles (LLTVs) used by Apollo astronauts at the Manned Spacecraft Center (now Johnson Space Center), Houston, Texas. Apollo 11 astronaut, Neil Armstrong-first human to step onto the moon's surface-said the mission would not have been successful without the type of simulation that resulted from the LLRVs.

• Lifting Bodies: Five wingless designs-M2-F2, M2-F3, HL-10, X-24A and X-24B-were flown from 1966 to 1975 in a program to obtain data about flying and landing aircraft designed for reentry from space. These aircraft contributed to the development of the space shuttles. An earlier Dryden-built lightweight lifting body, the plywood M2-F1, pioneered the concept and paved the way for the formal program with the heavyweight vehicles.

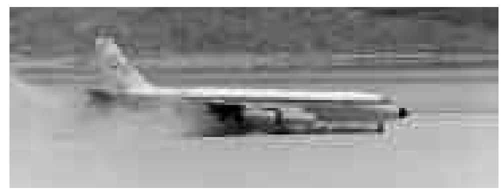
The Recent Years

• X-29: Initial flight with the X-29 forward-swept-wing research aircraft, beginning in 1984, showed that the unusual configuration, coupled with movable canards, enhanced maneuvering and cruise capabilities at transonic speeds. That phase was flown with the No. 1 X-29 aircraft and ended in 1989. NASA's high-angle-of-attack research program with X-29 No. 2 ended in 1991 and demonstrated that the aircraft design had better-than-expected control and maneuverability at angles of attack up to 45 degrees.

• X-31: Two X-31s were flown at Dryden from April 1992 until May 1995 by the International Test Organization (ITO), in a program managed by the Advanced Research Projects Agency. The X-31s demonstrated the value of thrust vectoring, coupled with an advanced flight control system, for close-in air maneuvering at high angles of attack. The two aircraft logged the most research missions of any X-plane program with 559 research flights.



• CV-990: A highly modified NASA Convair 990, then called the Landing Systems Research Aircraft (LSRA), was used to test space shuttle landing gear assemblies from 1993-95. These tests helped NASA select a different runway surface at the Kennedy Space Center that allowed for higher crosswind landing limits of the orbiters.



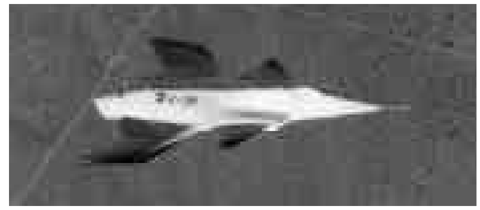
• F-18 High Alpha Research Vehicle (HARV): Between mid-1987 and spring 1996, Dryden flew a modified F-18 to study airflow, aircraft control, and engine performance at high angles of attack. Flight research with the HARV increased our understanding of flight at high angles of attack, enabling makers of U.S. fighter aircraft to design airplanes that will fly safely in portions of the flight envelope that pilots previously had to avoid. During the second phase of flight research, a thrust-vectoring system using spoon-shaped paddles was installed on the aircraft to direct engine exhaust flow and provide pitch and yaw control. This enhanced maneuverability and control of the research aircraft at high angles of attack. A follow-on phase of research began in July 1995 and investigated the use of movable strakes on both sides of the aircraft's nose to produce yaw control at high angles of attack.

• AFTI/F-16: The Advanced Fighter Technology Integration (AFTI) F-16 program was a joint NASA/USAF effort evaluating

advanced digital flight controls, automated maneuvering, voice-activated controls, sensors, and close-air support attack systems on a modified F-16. Research and test results could be applied to existing or future military aircraft.

• Propulsion Controlled Aircraft (PCA): The computer-assisted engine control system developed in this program enables a pilot to land a plane safely when its normal control surfaces are disabled. The system uses standard autopilot controls already present in the cockpit, together with the new programming in the aircraft's flight control computers. The PCA concept is simple-for pitch control, the program increases thrust to climb and reduces thrust to descend. To turn to the right, the autopilot increases the left engine thrust while decreasing the right engine thrust. On Aug. 29, 1995, an MD-11 became the first transport aircraft to land using only the thrust of its engines. This landing took place with still-developing software and required the pilot to use cockpit knobs and thumbwheels to effect the landing. On Nov. 28 and 30, 1995, the improved system enabled the pilot to land virtually without manual manipulation beyond using an auto-land control. The initial PCA studies were carried out at Dryden with a modified twin-engine F-15 research aircraft-the same aircraft used in the Highly Integrated Digital Electronic Control (HIDEC) program, which concluded in late 1993. The HIDEC project integrated the flight-control and airdata systems on the aircraft with electronic engine controls, permitting researchers to adjust the operation of the engines to suit the flight conditionsof the aircraft.

• Laminar Flow Studies: NASA flew two F-16XL aircraft in a project to study a method of achieving laminar (smooth) airflow to increase performance and improve fuel efficiency at supersonic speeds. The Dryden effort was focused on the use of an experimental perforated wing "glove" equipped with a suction system installed over the upper surface of the left wing that drew off most of the turbulent air to achieve laminar flow. The first demonstration of supersonic laminar flow was achieved in 1991 and 1992 using the single-seat F-16XL. During the second phase of flight testing, which concluded in the fall of 1996, NASA flew more than 40 flights over a 13-month time span at speeds up to Mach 2, using the two-seat "XL" fitted with a larger glove.



• X-36: The X-36 is a small, remotely piloted jet designed by industry to fly without the traditional tail surfaces common on most aircraft. During 1997, two 28-percent scale aircraft demonstrated the feasibility of future tailless, fighter-type aircraft achieving levels of agility superior to today's best military fighter aircraft. Dryden hosted the project, providing engineering and range support, as well as safety oversight. In a follow-on effort, the Air Force Research Lab (AFRL) contracted Boeing to fly AFRL's Reconfigurable Control for Tailless Fighter Aircraft (RESTORE) software in the X-36 as a demonstration of the adaptability of the neural-net algorithm to compensate for in-flight damage or malfunction of effectors, i.e., flaps, ailerons and rudders. Two RESTORE research flights were flown in December 1998, proving the viability of the software approach.

• Advanced Control Technology for Integrated Vehicles (ACTIVE): A highly modified F-15 was flown from 1996 through 1999 in a project to explore advanced control and propulsion system technologies which could improve the cruising and maneuvering capabilities of future military and civil aircraft. The ACTIVE project incorporated multi-axis thrust vectoring engine nozzles linked to an advanced flight control system. The integrated control system used both thrust vectoring and traditional aerodynamic control surfaces for maneuvering at speeds up to Mach 2. The project also validated an adaptive-performance software program installed in the test aircraft's flight control computer that enabled improved cruise performance at no increase in engine power.

Today at Dryden

Dryden continues to pioneer programs that support NASA's Aerospace Technology Enterprise by contributing to revolutionary leaps in technology, access to space at reduced cost, and global civil aviation.

Current projects include:

• Intelligent Flight Control System: The Intelligent Flight Control System (IFCS) project is developing a revolutionary control system that could enable future aircraft suffering major system failures or combat damage to be flown to a safe, controlled landing.

This research, aboard a highly-modified NASA F-15B aircraft, focuses on development of "self-learning" neural network software for aircraft flight control computers. In its final form, the software would compare data from how the aircraft and its systems are operating with a database of how it would normally operate, and automatically adjust the flight controls to compensate for any damaged or inoperative control surfaces or systems.

• F-15B Research Testbed: Dryden's F-15B Research Testbed aircraft is used to fly advanced aerodynamic and propulsion experiments in high performance flight conditions up to Mach 2. The aircraft has flown space shuttle thermal protection system (TPS) tiles, space shuttle main tank insulation samples, and various aerodynamic experiments. A propulsion flight test fixture allows the aircraft to carry and test advanced prototype engines and propulsion technology. The F-15B provides the actual, demanding high-speed and high-performance maneuvering flight conditions and environment that few testbed aircraft can match.

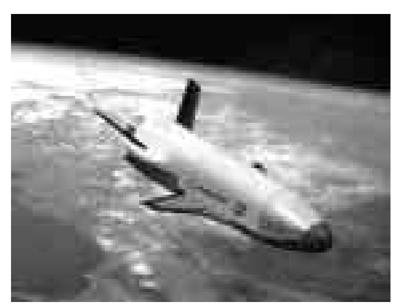
• Environmental Research Aircraft and Sensor Technology (ERAST): ERAST is an effort by a NASA-industry alliance to develop aeronautical technologies that could lead to a family of unpiloted aircraft designed to carry out high-altitude, long-endurance atmospheric science and telecommunications relay missions. Begun in 1993, the Dryden-managed ERAST project evaluated several remotely controlled prototype aircraft in such areas as propulsion, aerodynamics, structures, materials, avionics and sensor technology. On July 7, 1997, one of the prototypes, the solar-electric Pathfinder flying wing developed by AeroVironment, Inc., reached an altitude of 71,500 feet, setting an unofficial record for aircraft of its type. The upgraded Pathfinder-Plus version of the same aircraft achieved an altitude of 80,285 feet a year later, establshing a new world alttitude record for propeller-driven as well as solar-powered aircraft.

At present, the ERAST project is focused on the technological development of two follow-on aircraft - AeroVironment's solar-powered Helios Prototype and the conventionally powered Altair, being developed by General Atomics Aeronautical Systems, Inc.

The Helios Prototype, whose 247-foot wingspan is 2 1/2 times that of the original Pathfinder, achieve d an altitude record of 96,863 feet in August 2001. In the summer of 2003, the aircraft will attempt long-duration flights above 50,000 feet with the assistance of a regenerative energy storage system now being developed. The closed-loop system, based on hydrogen-oxygen fuel cell technology, will operate much like a lightweight rechargeable battery, enabling the Helios Prototype to store excess electricity generated by the solar arrays during the daytime for use in powering the aircraft at night.

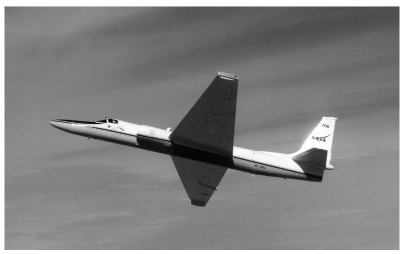
The Altair, a modified civil version of the Predator B reconnaissance aircraft now in development, is designed to meet performance and payload requirements set by NASA's Earth Science Enterprise for high-altitude, long-duration environmental science missions. Among technological issues being addressed are certification of uninhabited air vehicles to operate in civilian controlled airspace, integration of scientific and commercial payloads, "see and avoid" collision-avoidance systems and over-the-horizon command and control communications. Powered by a rear-mounted turboprop engine, the Altair is designed to carry a 700-lb. payload at altitudes of up to 52,000 feet for up to 32 hours.

• B-52: Two NASA B-52 aircraft serve as air launch platforms supporting Dryden research projects. In the past, the B-52B was used for many drop-test projects, including one that verified the parachute recovery system on the space shuttle's solid rocket boosters and drag chute. With a tail number of "008," it is the same launch aircraft used in the X-15 and lifting body programs and is the oldest B-52 still flying. Currently, the B-52B is the launch aircraft for the X-43A hypersonic research vehicle. A B-52H was recently added to the Dryden support fleet of aircraft. This aircraft will boost both NASA and Air Force efforts in researching and demonstrating technologies for future access-to-space vehicles, including the X-37.



• X-37: The Approach and Landing Test Vehicle (ALTV) is an experimental autonomous reusable launch vehicle that is designed to reduce access to space costs and to make space transportation significantly safer. Atmospheric tests will be perfomed at Dryden.

• X-43: The X-43As are 12-foot-long test vehicles for NASA's Hyper-X multi-year program on hypersonic research. The program is to demonstrate airframe-integrated, air-breathing engine technologies that promise to increase payload capacity for future vehicles by consuming ambient oxygen at altitudes higher than previously possible. This will remove the need for carrying oxygen tanks on board to promote combustion, as traditional rockets must do now. Flights are planned at Mach 7-approximately 5,000 mph-and Mach 10, close to 7,200 mph. By comparison, the world's fastest air-breathing plane to date, the SR-71, can fly at Mach 3.



• Airborne Science: Dryden maintains and operates two ER-2s and a DC-8. The aircraft collect data for many experiments in support of projects serving the world scientific community. Included in this community are NASA, other government agencies, academia and private industry and supports the requirements of NASA's Earth Science Enterprise. The high-altitude ER-2s carry experiments to gather information about our surroundings, including earth resources, celestial observations, atmospheric chemistry and oceanic processes. The aircraft also are used for electronic sensor research and development, satellite calibration and satellite data validation. Data gathered by the DC-8 at flight altitude and by remote sensing have been used for scientific studies in archaeology, ecology, geography, hydrology, meteorology, oceanography, volcanology, atmospheric chemistry, soil science and biology. The DC-8 also flies sensor development and satellite sensor verification missions.

• Active Aeroelastic Wing: The Active Aeroelastic Wing (AAW) project is researching an approach to flight control which is a modern outgrowth of the "wing warping" technique used by the Wright brothers to maneuver their first aircraft. This active flexible wing concept uses traditional aircraft control surfaces, such as ailerons and leading-edge flaps, to twist or "warp" a flexible wing to produce roll control. If these wing warping techniques for roll control are successful, wing weight of future military combat aircraft could be lowered, radar signature could be minimized and aerodynamic drag could be reduced at transonic speeds, increasing fuel efficiency.

The testbed aircraft chosen for the AAW research is an F/A-18A obtained from the Navy which has been extensively modified for this research project. Several of the existing wing skin panels along the rear section of the wing have been replaced with thinner, more flexible skin panels and structure. In addition to the wing modifications, a new research flight control computer has been developed for the AAW test aircraft and extensive instrumentation has been installed on each wing.

Space Shuttles

Among the most visible projects involving Dryden has been the space shuttle. Dryden was the site of the space shuttle Approach and Landing Tests (ALT) in 1977. The prototype orbiter Enterprise was used in ALT to verify the glide and handling qualities of the vehicle following its return into the atmosphere from space. During ALT, Enterprise was taken aloft on the NASA 747 Shuttle Carrier Aircraft and air launched for the glide flights back to the lakebed and to the main runway at Edwards.

Subsequent flight research at Dryden also contributed significantly to the development of the space shuttle thermal protection system, solid rocket booster recovery system, flight control system computer software, and the drag chutes designed to help increase landing efficiency and safety.

Dryden has been the site of 49 shuttle landings since the first orbital flight occurred in April 1981. After the landings, the orbiters are prepared at Dryden for the ferry flights back to the Kennedy Space Center in Florida atop a NASA Boeing 747 Shuttle Carrier Aircraft.

The ALT program and the early orbital landings during the shuttle's test and development stage were at Dryden because of the safety margin of Rogers Dry Lake. Planned landings are at the Kennedy Space Center now that braking and nose wheel steering systems have been tested, additional aerodynamic and handling data have been obtained, and better landing site weather forecasting is available. Dryden, however, remains a desirable landing site for future missions if there is unfavorable weather in Florida at the time of the planned landing. Dryden is a backup landing site because of the many landing options presented by the concrete and lakebed runways at Edwards when heavy payloads are being returned to Earth or for contingency reasons. Rosamond Dry Lake at Edwards also has two lakebed runways available for contingency landings, if needed.

Facilities

Dryden has grown from an initial group of five engineers in 1946 to a facility of approximately 1,400 civilian and contractor personnel.

Along with a varied fleet of research and support aircraft, Dryden facilities include a high temperature and loads calibration laboratory to ground test aircraft and structural components for the combined effects of loads and heat; a highly developed aircraft flight instrumentation capability; a flow visualization facility to study flow patterns on models and small aircraft components; a data analysis facility to process flight research data; and a facility to carry out flight research with remotely piloted vehicles.

Dryden's Research Aircraft Integration Facility (RAIF), which became operational in 1992, is used to carry out simultaneous checks of flight controls, avionics, electronics and other systems on a variety of aircraft. It is the only facility of its type in NASA and is designed to speed up and enhance systems integration and preflight checks on all types of research aircraft. Working in these facilities has given Dryden pilots, engineers, scientists, and technicians a unique and highly specialized capability to conduct flight research programs unmatched anywhere in the world.

In addition, more than 12,000 square miles of special-use airspace over California's high desert are available for research flights. Agencies monitoring flights in the area are linked directly to the Western Aeronautical Test Range (WATR). The WATR provides tracking and data acquisition support through a highly automated complex of computer-controlled tracking, telemetry, and communications systems and control room complexes.

Hugh L. Dryden

The Dryden Flight Research Center is named for Hugh L. Dryden, Ph.D., an internationally known aeronautical scientist who became a member of the NACA in 1931 while working for the Bureau of Standards. In 1946, he was appointed the NACA's Director of Aeronautical Research, then organization's highest full-time position. He was responsible for making Dryden a permanent facility in 1947, and was named to the newly created post of NACA Director in 1949. When the NACA became part of a new agency, NASA, in 1958, Dryden remained as Deputy Administrator until he died on Dec. 2, 1965. The facility was named the NASA Hugh L. Dryden Flight Research Center, in his honor, on March 26, 1976.

Dryden Flight Research Center "Center of Excellence" for atmospheric flight operations