TECHNOLOGY Facts

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The AD-1

"Oblique Wing Research Aircraft"

The AD-1 oblique wing research aircraft was photographed during a wing sweep test flight. The aircraft was flown 79 times during the research program conducted at NASA Dryden between 1979 and 1982.

NASA Photo ECN 13305-4

One of aviation's most unconventional concepts, a wing that pivots obliquely, was successfully flight tested at the NASA Dryden Flight Research Center in a program which produced aerodynamic data that would be extremely useful in the future development of a fuel-efficient transonic (just above and below the speed of sound) oblique wing aircraft.

The oblique wing concept was tested on the AD-l (Ames-Dryden 1), a small, subsonic, single-seat research aircraft specifically designed and built for the test and evaluation program which began in 1979 and continued until 1982.

The simple goal of the AD-1 flight test program was to demonstrate that an aircraft with a wing that pivoted obliquely as much as 60 degrees could be safely flown.

The oblique wing concept was developed by Robert T. Jones, a renowned aeronautical engineer who, in 1945, proposed the idea of sweeping wings rearward as a means of delaying the shock waves and compressibility as an aircraft neared the speed of sound (Mach 1), thus allowing aircraft to fly more efficiently at high subsonic speeds. At that time, Jones was an engineer at the NACA (National Advisory Committee for Aeronautics) Langley facility, now the NASA Langley Research Center. When Jones issued his oblique wing concept, he was a senior aeronautical engineer at the NASA Ames Research Center.

Based on wind tunnel studies, Jones believed that a transport-size aircraft with an oblique wing would have better aerodynamic performance than an aircraft with conventional wings at speeds up to Mach 1.4. Studies by Jones also predicted that oblique wing transport aircraft would have the potential of either increased range or reduced gross takeoff weight, and would be twice as fuel efficient as a conventional design. The studies by Jones also suggested that subsonic and transonic aircraft with oblique wings would generate less takeoff noise and would generally have better low-speed performance than aircraft with conventional wings. Jones also predicted that an oblique wing aircraft would generate a "softer" sonic boom than a conventional wing aircraft at speeds up to Mach 1.4.

The AD-1 was flown 79 times during the flight test program and demonstrated acceptable flying qualities up to a pivot angle of 50 degrees (in relation to the fuselage).

Technical information generated by the AD-1 program would be a valuable source of research data for any future effort to develop a state-of-the-art oblique wing aircraft.

Program Background

Initiated in December 1979, the AD-1 program was jointly sponsored by the NASA Dryden and NASA Ames research centers. Program participants also included the Boeing Commercial Airplane Company, which chose the basic configuration of the aircraft; Rutan Aircraft Factory, Mojave, Calif., which performed a detailed design and loads analysis; and the Ames Industrial Company, Bohemia, N.Y., the firm that built the aircraft.

The objectives of the AD-1 program were to evaluate the handling and flying qualities of an oblique wing aircraft, investigate its control system requirements, and compare data obtained during the research project with information generated during earlier wind tunnel tests on scaled models.

The low cost of the program limited the scope of technical research that could be carried out, but the program generated enough information on handling qualities and aerodynamics at various speeds and pivot angles to show the potential capabilities of a larger version with state-of-the-art control systems.

NASA Dryden was responsible for all preflight inspections and activities, flight safety, maintenance, and all flight operations.

Total cost of the aircraft was $240,000 on a fixed-price contract.

The AD-1 Aircraft

The AD-1 was a single-seat aircraft 38.8 feet long. It had a wingspan of 32.3 feet when perpendicular to the fuselage. During the oblique wing sweep, the right half of the wing pivoted forward and the left half pivoted rearward, with a maximum pivot of 60 degrees.

The AD-1 is shown from below during a flight test.
NASA Photo EC81-14632

Two small turbojet engines, each rated at 220 lbs of thrust, were mounted on short pylons just aft of the fuselage mid-point. The engines gave the AD-l a top airspeed of about 200 mph.

Takeoff speed was about 97 mph and the best rate of climb was between 126 mph and 138 mph. During landings, the touchdown speed was 92 mph.

The structure of the aircraft was a fiberglass-reinforced plastic sandwich with a core of rigid foam. The pivoting wing, aeroelastically tailored, was attached to the upper fuselage just aft of the mid-point above the engines. The aircraft featured a conventional vertical rudder and horizontal stabilizer.

Simplicity was the AD-l's hallmark. The tricycle landing gear was fixed and mounted very close to the fuselage, which lessened aerodynamic drag. The aircraft was just 6.75 feet high. There were no hydraulic systems in the aircraft, and the control system -- ailerons, elevator, and rudder -- was composed of cables and torque tubes.

The aircraft was designed and built for visual flying only. Presented on the instrument panel were altitude, airspeed, normal acceleration, angles of attack and sideslip, wing sweep angle, engine parameters, and rudder trim position. The pilot did not have any instruments displaying aircraft attitude, so all handling qualities maneuvers were made using visual references.

The electrical system was a single battery with a generator on each engine. The generators served as starters for the engines. Electrical power was supplied by either the battery or the generators to operate the cockpit gauges, the control-surface trim motors, the wing pivot drive motors, and the on-board data acquisition system.

Among the parameters recorded by the on-board data acquisition system were pitch, roll, and yaw rates; pitch and roll attitudes; lateral and longitudinal acceleration; angles of sideslip and attack; elevator, aileron, rudder, and trim tab positions; wing yaw angle; and left and right wingtip leading edge acceleration rates.

A switch on the instrument panel initiated the wing sweep. The wing could be returned to the unswept position by either the main switch or a trigger on the pilot's center control stick.

With pilot and fuel, the aircraft weighed about 2100 lbs. Empty weight was about 1450 lbs. A full fuel load gave the aircraft a flying time of about 75 minutes and a speed of about 170 mph in level flight at an altitude of 12,500 feet.

All of the basic structural components of the aircraft were designed for a positive 8.0-g load and a negative 4.0-g load. The exception was the wing pivot system. It was designed to 25-g positive and negative forces.

The AD-l Flight Test Program

The first flight of the oblique wing was on Dec. 21, 1979. NASA research pilot Tom McMurtry was the project pilot and flew the first series of missions. Later in the program, a series of pilot evaluation flights were made by guest pilots to obtain a qualitative evaluation of the aircraft's flying qualities for use in future studies of an oblique wing aircraft. The aircraft was flown 79 times, with its final flight on Aug. 7, 1982.

During the initial series of test flights, the aircraft's general handling qualities, stability, and performance were evaluated. Once the basic flight elements were satisfied, the operating envelope was slowly expanded and the wing was moved carefully and incrementally on each succeeding flight until the maximum 60-degree of sweep was safely reached in mid-1981. The aircraft was flown for another full year to obtain additional data at various speeds and wing pivot angles.

A variety of maneuvers were performed during the program to investigate flutter, divergence, and loads, while also studying the aircraft's aerodynamics and evaluation of its handling qualities at various wing angles. The maneuvers included doublets, windup turns, slow sideslip variations, 1-g decelerations, pull-ups and pushovers, descents, and aileron rolls. Most all of these tests were conducted at an altitude of 12,500 feet.

During the guest pilot phase of the test program, each pilot flew the aircraft once to assess its handling qualities. Each of those flights included handling and performance assessments with the wing in a full 60-degree sweep.

Following the program's conclusion, overall evaluations by project test pilots and guest pilots reported that the aircraft had acceptable handling qualities at sweep angles up to 50 degrees, with a degradation in flying qualities reported by some at 45 degrees. The primary degradation occurred between 50 degrees and 60 degrees of sweep.

Degradation in handling qualities at the high sweep angles can be attributed to pitch-roll coupling effects, in addition to the aeroelastic qualities of the wing. The fiberglass structure of the wing limited stiffness that would have improved its handling qualities. Studies on a simulator also showed that control system augmentation would significantly improve flying qualities at sweep angles up to 60 degrees.

The final eight flights of the AD-1 were not made at NASA Dryden. The aircraft was exhibited in 1982 at the Experimental Aircraft Association's (EAA) annual exhibition in Oshkosh, Wisc., where it was flown eight times to publicly display the unique wing concept.

The Future of the Oblique Wing Concept

Final reports from the pilot evaluation program recommended that any future testing of the oblique wing concept be conducted with a fly-by-wire flight control system in the transonic-supersonic regime where the oblique wing is expected to perform the best.

The pilot evaluation reports also suggested that the oblique wing design be looked at closely for a carrier-based anti-submarine role because of its predicted loiter capability, low approach and landing speed, and its expected supersonic dash capability.

Studies also say that the oblique wing concept also has great potential in a fighter aircraft role, again because of predicted loiter and supersonic dash capabilities. These same studies say an oblique wing fighter would show a 17 percent improvement in takeoff weight or a 29 percent mission performance advantage at the same gross weight.