NASA Facts

National Aeronautics and
Space Administration

Dryden Flight Research Center
P.O. Box 273
Edwards, California 93523
Phone 805-258-3449
FAX 805-258-3566

FS-DFRC-95(09)-002

ECN 95-4319710

F-18 High Angle of Attack Research Aircraft

NASA's Dryden Flight Research Center, Edwards, CA, is using an F-18 Hornet fighter aircraft as its High Angle of Attack Research Vehicle (HARV). The aircraft is on loan from the U.S. Navy.

Background

Angle of attack (alpha) is an aeronautical term to describe the angle of an aircraft's body and wings relative to its actual flight path. During maneuvers, pilots often fly at extreme angles of attack -- with the nose pitched up while the aircraft continues in its original direction. This can lead to conditions in which the airflow around the aircraft becomes separated from the airfoils. At high angles of attack, the forces produced by the aerodynamic surfaces - including lift provided by the wings - are reduced. This often results in insufficient lift to maintain altitude or control of the aircraft.

The NASA "high alpha" research program is producing technical data at high angles of attack to validate computer codes and wind tunnel research. Successful validation of these data will give engineers and aircraft designers a better understanding of aerodynamics, effectiveness of flight controls, and airflow phenomena at high angles of attack. This is expected to lead to design methods providing better control and maneuverability in future high performance aircraft and make them safer to fly.

Phase One

The first phase of “high alpha” flights began in mid-1987 and lasted two and one-half years. It consisted of 101 research flights in the specially instrumented F-18 at angles of attack as high as 55 degrees.

Visual studies of the airflow over various parts of the aircraft were made. Special tracer smoke was released through small ports just forward of the leading edge extensions near the nose and photographed as it followed airflow patterns around the aircraft. Also photographed in the airflow were short pieces of yarn (tufts) taped on the aircraft, and an oil-based dye released onto the aircraft surfaces from 500 small orifices around the vehicle’s nose.

The airflow patterns of smoke, dye and tufts were recorded on both film and videotape for a comparison with computer and wind tunnel predictions. Additional data obtained included air pressures recorded by sensors located in a 360-degree pattern around the nose and at other locations on the aircraft.

Phase Two

Phase Two research flights began in the summer of 1991 utilizing a thrust vectoring system for control. The system allows the exhaust flow from the two turbofan engines to be redirected to provide enhanced maneuverability and control in areas where conventional aerodynamic controls -- ailerons, rudders, and elevators -- are ineffective. This results in significantly increased maneuverability at moderate angles of attack, and additional control at angles of attack up to 70 degrees -- and the ability to collect a greater amount of data by remaining at high angles of attack longer.

The thrust vectoring system consists of modified flight control computers to control the vanes and the vanes to direct the engine exhaust flow.

Three paddle-like vanes, made of Inconel metal, are mounted on the airframe around each engine’s exhaust. They provide both pitch (up and down) and yaw (right and left) forces to enhance maneuverability when the aerodynamic controls are either unusable or less effective than desired. The engines have had the external exhaust nozzles removed to shorten the distance the vanes must be cantilevered by about two feet. The subsonic performance of the engines, including afterburning, is unaffected by the modifications, but supersonic flight is no longer possible -- a penalty unique to this experimental project. The thrust vectoring system adds 2,100 pounds to the total weight of the aircraft.

The modified flight control computers use a PACE 1750A computer and specially written flight control laws to command the optimum combination of aerodynamic control and vectored thrust to satisfy pilot demand. Standard cockpit controls are used by the pilot and no special pilot action is required after the system is engaged in flight.

The envelope expansion flights were completed in February l992. Demonstrated capabilities include stable flight at 70 degrees angle of attack (previous maximum was 55 degrees) and rolling at high rates at 65 degrees angle of attack. Controlled rolling was nearly impossible above 40 degrees without vectoring.

Phase Two flights are examining the benefits of using vectored thrust to achieve greater maneuverability and control at high angles of attack while continuing the development of predictive methods begun in Phase One. The initial portion of the Phase Two flight program was completed in January 1993 with a total of 193 flights with the aircraft.

Between January 1993 and January 1994 the aircraft was modified with additional instrumentation, including a sophisticated engine inlet pressure measurements system between the inlet entrance and the engine face. The inlet instruments can measure pressure fluctuations up to 250 Hz at over 2000 samples per second. This information will provide unprecedented understanding of what happens to engine airflow under extreme maneuver conditions. Flights resumed in January 1994 and will continue through June 1994.

Phase Three

A Phase Three effort is currently underway to evaluate moveable strakes on both sides of the aircraft's nose which provide yaw control at high angles of attack. These strakes, 4 feet long and 6 inches wide, are hinged on one side and mounted to the forward sides of the fuselage. At low angles of attack, they are folded flush against the aircraft skin. At higher angles of attack, they are extended to interact with the strong vortices generated along the nose and produce large side forces for control. Wind tunnel tests indicate strakes can be as effective at high angles of attack as rudders are at lower angles. Flights with the moveable strakes began in July 1995. The strake project is expected to conclude by the end of calendar year 1995, with a total of about 65 flights.

Program Management

The high angle of attack technology program is a joint effort of NASA's Dryden, Ames, Langley, and Lewis Research Centers. Flight operations are based at Dryden, while wind tunnel and computational experiments are carried out at the other sites. All experiments have the eventual goal of flight on the HARV and use models which are geometrically accurate representations of the HARV.

The project manager at Dryden is Denis Bessette.

Aircraft Specifications

The HARV has been developed from a pre-production model of the F-18, a single-seat fighter/attack aircraft built by the McDonnell Aircraft Co., St. Louis, MO. The F-18 is currently in service with the U.S. Navy and Marine Corps.

The aircraft has a wing span of 40 feet 5 inches. The fuselage is 56 feet long and 10 feet 6 inches high at the canopy.

The HARV is powered by two General Electric F404-GE-400 turbofan engines, each producing 16,000 pounds of thrust in afterburner.

Typical takeoff weight of the HARV is 39,000 pounds, with 10,000 pounds of internal fuel and the thrust vectoring and spin recovery parachute systems installed.

The F-18 is an exceptionally fine high angle of attack aircraft in its production form and has no angle of attack restrictions at normal center of gravity positions. It is this characteristic that made it NASA's choice as a research vehicle.

-nasa-

August 1995