NASA Facts

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'Back to the Future'

Active Aeroelastic Wing Flight Research

Project Summary

NASA's Dryden Flight Research Center, Edwards, Calif., in cooperation with the U.S. Air Force Research Laboratory (AFRL) and Boeing Phantom Works, is researching a high-tech adaptation of the Wright Brothers rudimentary "wing-warping" approach to aircraft flight control in the Active Aeroelastic Wing (AAW) flight research program. The focus of AAW research is on developing and validating the concept of aircraft roll control by twisting a flexible wing on a full-size aircraft. The aerodynamic forces acting on the traditional aircraft control surfaces, such as ailerons and leading-edge flaps, will be used to twist a flexible wing to provide aircraft roll maneuvering control. The test aircraft chosen for the AAW research is a modified F/A-18A obtained from the U.S. Navy in 1999.

Historical Background

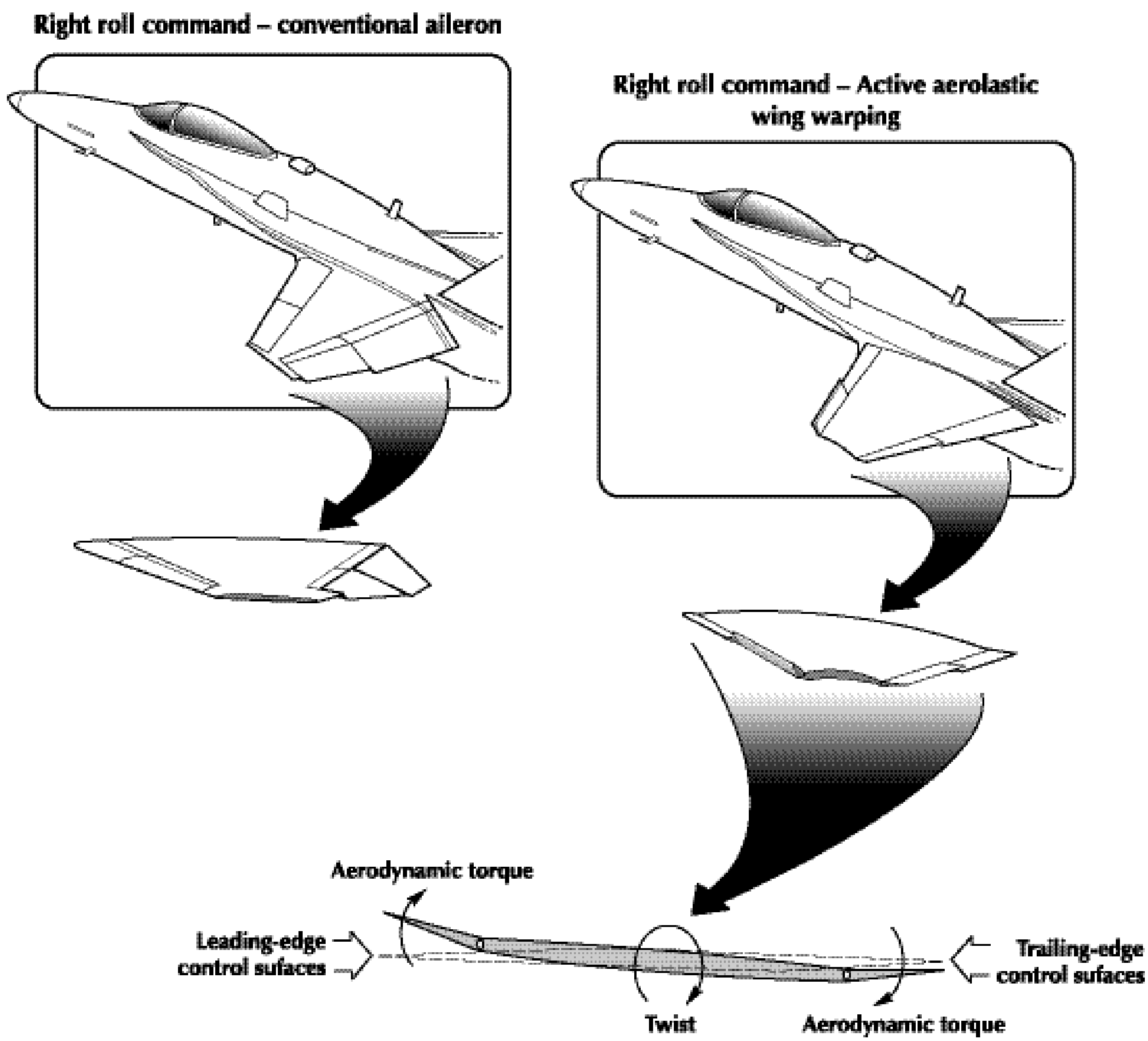
When Orville Wright first took to the air on Dec. 17, 1903, he didn't have ailerons or flaps to control his airplane. Instead, the Wright brothers had chosen to twist or "warp" the wingtips of their craft in order to control its rolling or banking motion. Rather than using one of the craft's two control sticks to make the wingtips twist, they had devised a "saddle" in which the pilot lay. Cables connected the saddle to the tips of both wings. By moving his hips from side-to-side, the pilot warped the wingtips either up or down, providing the necessary control for the Wright Flyer to make turns.

Current Status

Begun in 1996, the AAW flight research program has completed detailed design and the wing modifications required for the program have been completed. The test aircraft has been extensively instrumented, and reassembly was completed by early 2001. Over the course of the year, the AAW test aircraft was subjected to extensive structural loads, wing stiffness and vibration tests, installation of the initial control software into the aircraft's research flight control computer, systems checkout and flight simulation activity. The first parameter identification flights in the two-phase flight test program are expected to begin in mid-2002 and continue for about six months. These flights will be used to measure the forces available from each surface to twist the wing and control the aircraft. That will be followed by a yearlong period of data analysis and control software redesign to optimize the performance of the flexible wing. The final phase of flight tests are expected to be flown in 2003, and will evaluate the handling and performance qualities available from the flexible wing concept.

Goals

The program goal is to demonstrate improved aircraft roll control through aerodynamically induced wing twist on a full-scale high performance aircraft at transonic and supersonic speeds. Data will be obtained to develop design information for blending flexible wing structures with control law techniques to obtain the performance of current day aircraft with much lighter wing structures. The flight data will include aerodynamic, structural and flight control characteristics that demonstrate and measure the AAW concept in a comparatively low cost, effective manner. The data also will provide benchmark design criteria as guidance for future aircraft designs.



Comparison of conventional and active aerolastic wings.

Aircraft Modifications

The wings from Dryden's F-18 #840, formerly used in the High-Alpha Research Vehicle (HARV) program, have been modified for the AAW flight research program and installed on the AAW test aircraft. Several of the existing wing skin panels along the rear section of the wing just ahead of the trailing-edge flaps and ailerons have been replaced with thinner, more flexible skin panels and structure, similar to the prototype F-18 wings.

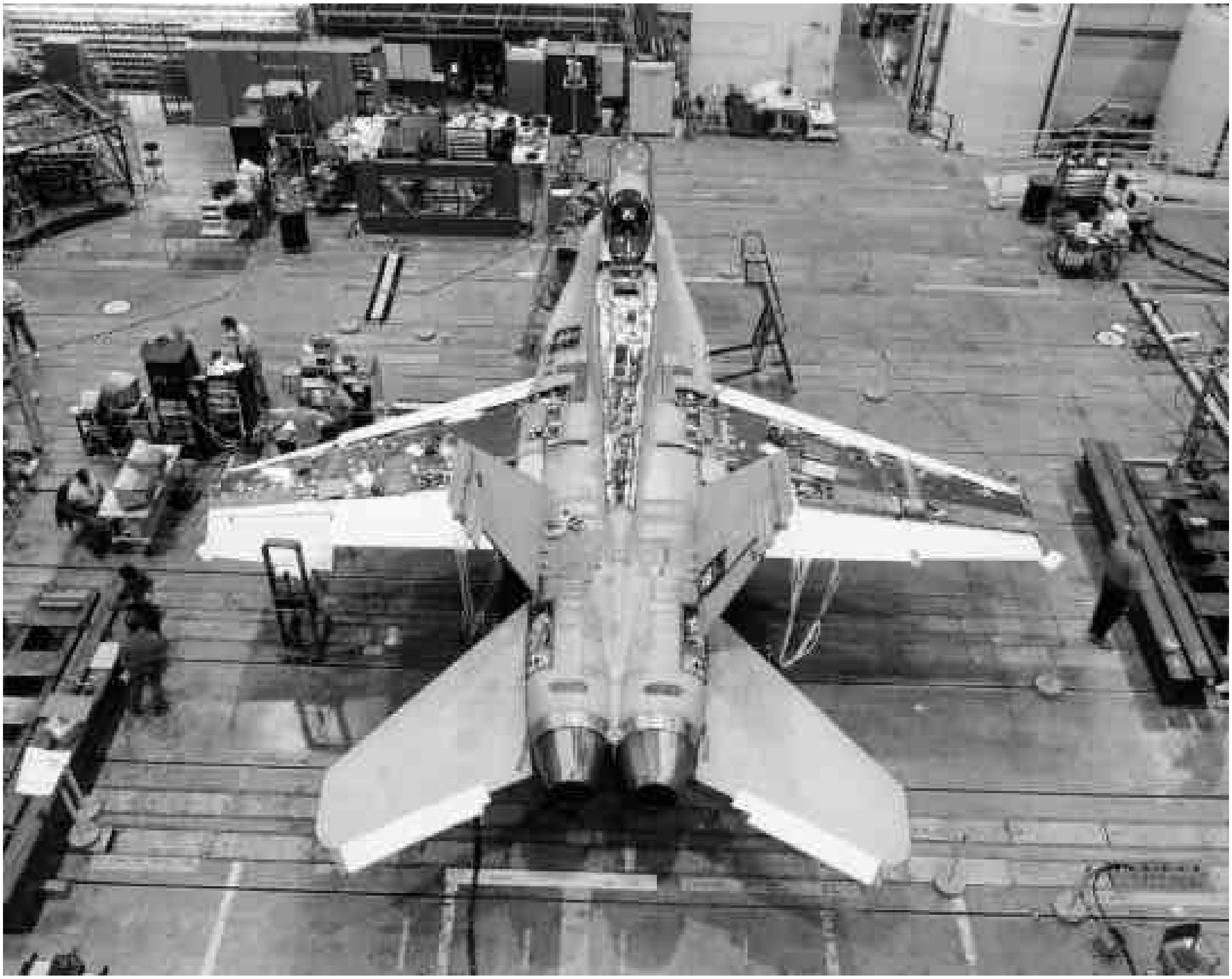
Original F-18 wing panels were light and flexible. During early F-18 flight tests, however, the wings were observed to be too flexible at high speeds for the ailerons to provide the specified roll rates. This was because the high aerodynamic forces against a deflected aileron would cause the wing to deflect in the opposite direction.

In addition, the F/A-18's leading-edge flap has been divided into separate inboard and outboard segments, and additional actuators have been added to operate the outboard leading-edge flaps separately from the inboard leading-edge surfaces. By using the outboard leading-edge flap and the aileron to twist the wing, the aerodynamic force on the twisted wing will provide the roll forces desired. Now, a flexible wing will have a positive control benefit rather than a negative one.

In addition to the wing modifications, a new research flight control computer has been developed for the AAW test aircraft, and extensive research instrumentation, including more than 350 strain gauges, have been installed on each wing.

Funding

The AAW project receives its funding from NASA's Office of Aerospace Technology, as well as from the U.S. Air Force Research Laboratory. The Boeing Company's Phantom Works division in St. Louis, Mo., performed the AAW wing modifications, installed portions of the wing instrumentation and assisted in software development under contract with the Air Force Research Laboratory and NASA. Lockheed-Martin developed the AAW research flight control computer. The total budget for the entire AAW project is approximately $41 million, including



NASA's AAW aircraft undergoes structural loads testing prior to begining flight tests.

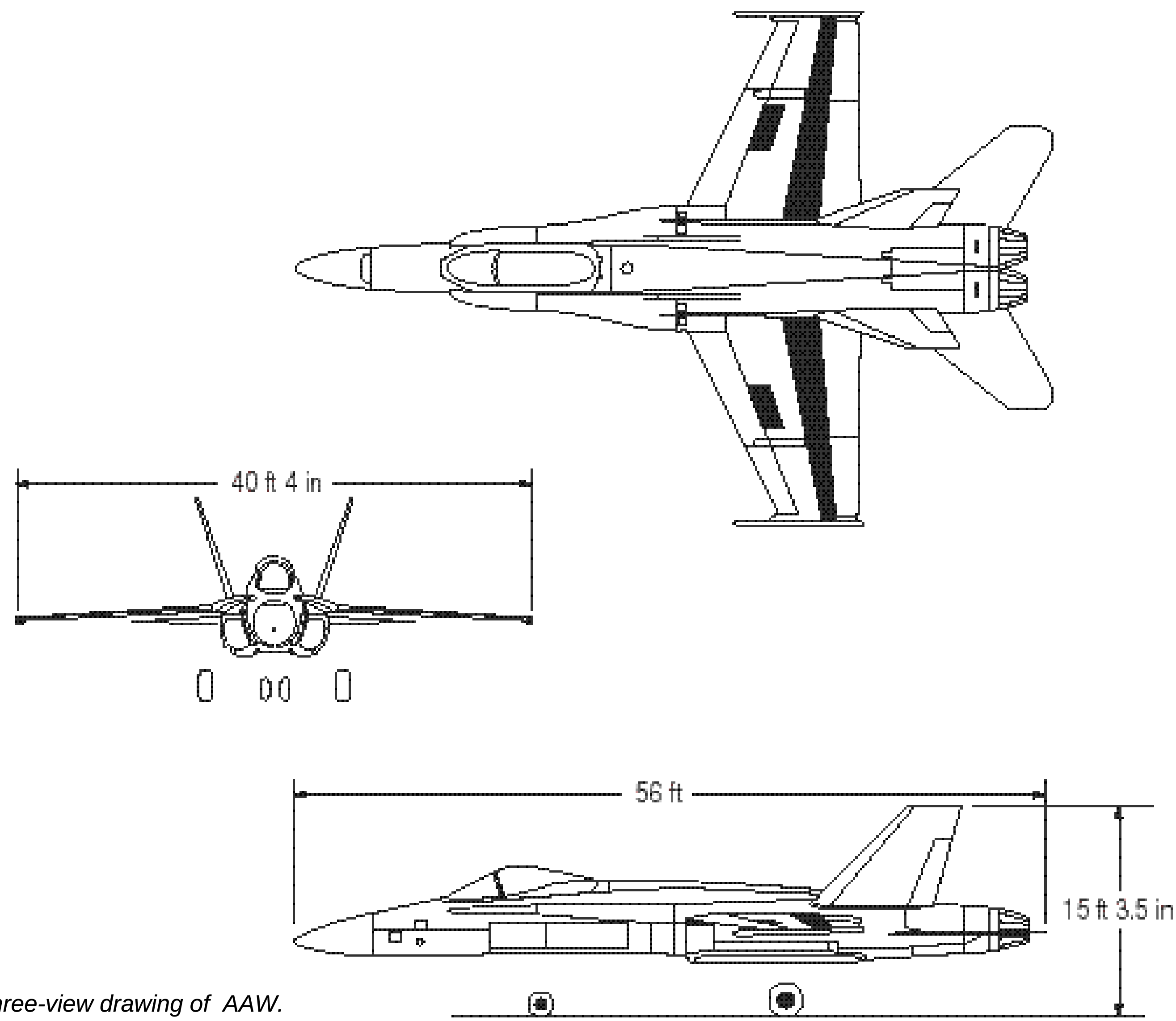
about $25 million in direct monetary outlay and about $16 million for in-kind support, spread over eight years.

NASA's Aeronautics Blueprint

The AAW program supports the second of four primary long-range elements of NASA's Aerospace Technology Enterprise Aeronautics Blueprint, known as "Revolutionary Vehicles." In particular, the element's challenge is to create environmentally compatible aircraft with revolutionary capabilities for unprecedented levels of performance and safety. AAW falls within one of the objective's five technology solutions to provide "morphing" and self-healing airframes that could expand aircraft performance and capabilities. NASA's Aerospace Technology Enterprise is one of the four NASA strategic enterprises established to address key agency activities in distinctly different areas.

Technology Commercialization

If the wing warping techniques for aircraft roll control being explored in the Active Aeroelastic Wing project are successful, engineers will have more freedom in designing more efficient, thinner, higher aspect-ratio wings for future high-performance aircraft while reducing the structural weight of the wings by 10 to 20 per cent. This will allow increased fuel efficiency or payload capability. In addition, other possible benefits include reduced radar signature.



Three-view drawing of AAW.