In-House Flight Research Experiment in Flight Test Phase

Vortex Flap Promises Increased Maneuverability for Fighter Aircraft

Take an old aircraft and a new concept. Gradually add the intuitive minds and skilled hands of over 200 Langley researchers, engineers and technicians. The result is a flight research experiment that promises to increase the maneuverability of swept wing fighter aircraft by as much as 20 percent.

Flight testing of the vortex flap research experiment began this month. First flight occurred shortly after 11 a.m. on Tuesday, August 2. Initial results delighted team members who reported “no surprises” — a good sign indicating verification of research expectations.

Phil Brown, NASA research pilot, was in the cockpit for the first flight. “Although pitch stability was reduced by adding the vortex flap to the F-106B, the airplane has, so far, proved to be only slightly more demanding to fly than the basic airplane and considerably easier to control approximately 220 people on Center were involved in one way or another. Support for the vortex flap experiment spanned three Directorates. “It’s been a Center project from beginning to end, involving lots of truly committed people and making maximum use of existing resources,” says Smith.

The vortex flap is an addition to the front of the wing designed to improve the performance capabilities of swept wing aircraft. The concept, identified in the late 70s, promises to address the dilemma faced by designers of fighter aircraft: speed vs maneuverability. Highly swept wings assure speed; but unswept wings are preferable for the high lift needed for combat maneuvers and short takeoffs and landings.

Even more radical than just extending the forward edge of the wing, the vortex flap is a sharp extension of the leading edge. This sharp extension, deflected downward, purposely detaches the airflow over the wing and forms a tornado-like vortex on the flap, thereby creating a suction force that reduces drag.

The Langley F-106B was identified as the focus aircraft for this flight research experiment. Chosen from three candidate vehicles, the F-106 offered the right wing sweep and the relative ease of structural modifications to accommodate the vortex flap.

Principal investigator Jim Hallissy teamed with Neal Frink to do a preliminary assessment of the realistic constraints of the aircraft that had to be dealt with in designing the vortex flap. Taking a 30-year-old airplane and refitting it to evaluate the concept was their challenge. Hallissy cites...
Flight testing of the vortex flap follows five years of study encompassing nearly 3,000 hours of wind tunnel testing and hundreds of computer design hours as well as a series of high-speed taxi tests conducted in late July.

Ron Smith, flight project engineer, estimates that

A close up look at the vortex flap—a sharp extension to the leading edge of Langley’s F-106B. Now in the flight test phase, the vortex flap experiment promises to increase the maneuverability of swept wing fighter aircraft by as much as 20 percent.

(See Vortex Flap on page 4.)
Vortex Flap Experiment: An Extensive In-House Effort (Continued from page 3.)

As a result of that assessment, several design points were identified around which initial shapes for the vortex flap were developed. From the geometry developed here, airplane model parts were built and tested in the 7 ft. by 10 ft. wind tunnel and later in the transonic tunnels at Langley and Ames.

Low-speed evaluations shop—were involved. “It was an extensive in-house effort.” A few changes along the way were necessary as we tried to custom fit to an airplane that was manufactured over 30 years ago, Pride adds.

It’s been a Center project from beginning to end. Joe Pride and his team were involved in the mechanical design and fabrication of the vortex flap—a program he refers to as “an ambitious use of in-house resources.”

Garland Goodwin, engineering specialist, PRC Kentron, describes his function as “the translation from theory to practice.” He was tasked by Pride to “find a way to transport propulsion systems. Then, at Langley, the F-106 was used in storm hazards research. Now the 30-year-old airplane is matched with another new idea—to improve maneuverability of fighter aircraft.

Ron Smith looks ahead to further advantages of the vortex flap concept. “On any similar delta wing
on a 15 percent scale model were conducted by a team assembled by Joe Johnson. Additional testing was performed on a full-scale F-106 that had been sawed in half (dubbed the F-53) and tested in the Langley 30 ft. by 60 ft. full scale wind tunnel.

Flight characteristics and handling qualities were further investigated through a piloted-simulation study developed by Jay Brandon and piloted by NASA research pilot Phil Brown and USAF test pilot Al Wunschel. Computational, wind tunnel and simulation data gathered, the engineers were called in.

In 1985 an engineering feasibility study commenced to investigate how the research concept would be integrated to the airplane. Pride's concern was what the loads on the aircraft would be in flight and how to size the structural members. “Our major job in engineering,” says Pride, “was to come up with the basic structural design. We had to turn out 70-75 drawings and then do the proper analysis work.”

Over a period of two years a lot of fabrication people—from the fab shop, the machine shop, the model shop—were involved in the model building process. There were no alarms during the first flight!

Roy Harris, director for aeronautics, remarked in a recent Researcher News editorial: “The vortex flap is an excellent example of the kind of Langley research that can be carried all the way from idea, to calculations, to sub-scale tests, to flight validation, and provide “real world” feedback to the researchers.”

The F-106B has had a long history with NASA. First entering the inventory in the mid 1960s, it was used by Lewis Research Center to investigate supersonic configuration, you could probably design the vortex flap to improve takeoff and landing characteristics. The implication is that on a supersonic transport, if you could improve the lift to drag ratio by 20 percent and take off with better aerodynamics—more lift, then you wouldn’t have to light the afterburner and the noise would be significantly lower. That’s another potential we see.”

Roy Harris passes on a tip: “Watch the skies above Langley in the months ahead. You just may get a glimpse of the ‘future.”

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**F-106VF**

**2 FLAP POSITIONS**

The only difference is the width of the Link Strip indicated by arrow.

- **WING LEADING EDGE**
- **SUPPORT**
- **VORTEX FLAP**
- **LINK STRIP**

Pull hinge pins to change Flap angle.

- **LINK STRIP** One required for each Flap position.

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**GARLAND GOODWIN'S SOLUTION to attaching the vortex flap to the existing leading edge of the F-106B involves a hinged attachment, a link strip and a support structure. The vortex flap, which ideally will be moveable in flight, can be fixed to four different angles by pulling the hinge pins and inserting the appropriate link strip for the angle desired.**

**VORTEX FLAP COMES TO LIFE** in the fabrication shop in Building 1232A. On an extremely long surface table lies the leading edges of an F-106B to which support structures have been mounted and the vortex flap attached. A wooden cradle was fashioned to maintain alignment of the existing leading edges while each segment of the vortex flap was custom built and then attached.