NASA's super wing gives new lift to small planes

Supercritical-airfoil program spins off benefits for slower craft

By BEN KOCIVAR

For years we've been treated to NASA's wondrous exploits in supersonic airplanes and space travel. Now, for a change, an exciting new NASA project may dramatically improve small-plane performance and safety: It's a low-speed spin-off of the supercritical-wing research program ['NASA's New Mach 1 Airliner,' PS, Apr. '72] originally designed to make airliners go faster and farther with the same engine power.

To my knowledge, POPULAR SCIENCE was the first publication allowed to see the low-speed wing. I got a look at the research plane recently at Lakeland, Fla., where Piper had a NASA contract to fabricate the new wing on a popular production fuselage.

I was ushered past restricted-area signs by an engineer authorized to work in Piper's top-secret hangar. At first, what I saw looked like a fairly conventional twin-engine six-passenger plane. It was a Piper Seneca I, selected for the project because it can easily carry the several hundred pounds of test instruments that will be needed for the exhaustive flight testing now beginning. But the new wing will be useful on even the smallest two-place craft—not just twins with six-figure price tags.

The wing on the Seneca was different from rectangular production models. It was unpainted aluminum with numerous wind tufts for airflow studies. The wing was also tapered. In itself, that's not too unusual. But closer examination revealed the wing's uniqueness.

Spoilers, flaps, and shape

- There were no ailerons. Instead, there were top-of-the-wing spoilers. (You can see these clearly on the wings of big jet airliners when they are triggered up in landings to kill lift after touchdown.) On some high-performance jets, spoilers are used instead of ailerons for banking in turns.

This is how they're used in the new research Seneca. For right turns, the right spoiler is raised to kill lift on the right wing—making it bank down and help the plane in a smooth turn. The same would apply on the left side when a left turn is made.

Modified twin-engine Piper Seneca undergoes test flight to check performance of new wing design. New airfoil promises improved lift and less drag for fuel savings. Better performance can aid small-plane safety.

- The flaps were different, too. These were Fowler flaps that extended the entire length of the trailing edge. They are designed to slide back and down, which increases the lifting area of the wing by about a third. Ordinary flaps on small planes simply tilt down slightly to provide increased lift by changing the airfoil section. They tilt down more to create drag, slow down a plane and keep it from building up too much speed while making a steep descent.

- The third feature was more subtle but the most exciting. Look-
Airfoil shape is variation of supercritical-wing design for lowering drag on subsonic jets. Diagram, right, contrasts supercritical, conventional, and GAW-1 wing designs. Latter is used for the Seneca (above).

Looking at the wing from the side, I could see that the airfoil shape was quite different from conventional designs. This was the new and promising GAW-1 wing section designed by Richard Whitcomb, NASA’s outstanding wind-tunnel researcher at Langley Research Center, Hampton, Va.

GAW-1 stands for General Aviation-Whitcomb. This airfoil promises to be the most important single aerodynamic breakthrough for small-plane performance in many years.

It was designed by computer, tested in wind tunnels in model form, and for a year it is being flown in the small, heavily instrumented Seneca to prove its performance. The three major U.S. small-plane manufacturers are keeping close watch. They’ve already announced research projects that include its use. I’ve discussed the new wing shape in Florida and Kansas with research engineers at Piper, Beech, and Cessna. All are reluctant to disclose what they consider proprietary information.

But let’s look at what can be learned about the shape of the new wing. Whitcomb designed his original supercritical airfoil to reduce drag and increase the speed of subsonic jet airplanes. With it they could fly closer to the speed of sound: about 700 mph instead of the present 600 mph, and do it without any increase in power required. Thus, for the same amount of fuel, a 707 with the new wing would fly faster and farther.

New wing shape

Using the same basic computer program developed for the supercritical wing, Whitcomb applied the computer to developing a low-speed airfoil for light aircraft. The resulting shape is an interesting new form.

First, the leading edge looks much thicker than normal. Instead of the smooth, relatively flat lower surface of conventional light-plane airfoils, the new shape has an unusual bulge curve. To many pilots, it looks almost as though the wing had been turned upside down.

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Spoilers open on top of wing, are used instead of ailerons. For right or left turns, the spoiler is raised on the wing in the turn direction, eliminating the tendency of ailerons to generate opposite yaw.

What does this do to airflow? Lift on an airfoil is developed by speeding up the air velocity over the upper wing surface. This reduces air pressure above it and in turn supports the wing in the airstream.

For a conventional wing, the air velocity is accelerated rapidly so that a high peak exists close to the leading edge.

For the new supercritical airfoil, the air velocity on top is increased more gradually. It does not peak at the leading edge, but spreads back over the rest of the wing. Thus, lift is distributed over much more of the wing chord.

Since drag is proportional to the square of the velocity, by reducing the size of the peak you also reduce drag. Yet, since the lift is distributed farther, you increase lift.

This combination of reducing drag and increasing lift works out so that you can get by with a smaller wing. This in turn means a saving in both weight and drag. And this means you can fly faster and farther for the same or less fuel.

Smother ride

Another benefit: The smaller wing means heavier wing loading per square inch. This leads to a more comfortable ride because less area is subject to gusts.

Mal Harned, executive vice-president of Cessna, told me, "We're very interested and are researching the airfoil to make full use of it." The other manufacturers are doing the same. Piper, I heard, put it on a new secret two-seat trainer, and Beech tried it on a Musketeer wing. But no one is eager to talk about the findings.

What will the new wing do for performance? The promise is that there will be a 30-percent increase in maximum lift over present wings, and that the lift-to-drag ratio will be increased about 50 percent. Result: The same airplane with the same engine power will be able to fly about 10 percent faster and farther. Also, because of the reduced drag, a 10-percent saving in fuel may be possible flying at the same speed but with less power.

There is another even more significant application for safety. Twin-engine planes have a critical time at takeoff: The failure of one engine can lead to emergencies. The plane may not climb fast enough—if at all—on single-engine power. The exact speeds vary, of course, with the specific plane, the altitude, outside temperature, and weight. Pilot skill and technique are obviously also important factors.

For comparison, a small, conventional twin-engine plane might climb 200 feet a minute on one engine. With the new wing it could climb at 350 feet per minute. This is a major improvement, well over 50 percent. And since more than half of small-plane accidents take place in takeoff or landing situations, the new wing promises to be a major contribution to safety.

Similar advantages exist for single-engine planes. Obviously, with a wing that gives more lift, a single-engine plane can climb faster. Thus, even in the case of an engine failure shortly after takeoff, a single-engine plane would probably have attained more altitude and be able to glide safely to an emergency landing.

The new NASA research plane is designated ATLIT (Advanced Technology Light Twin). It is one result of a three-year design effort by several organizations working under a grant of $800,000 from NASA's Research Center.

The program's general management is under Professor David Kohlman at the University of Kansas. He also directed the program that developed the Redhawk. It too has wing-top spoilers and Fowler flaps [PS, Sept. '74].

Piper builds wing

The wing was designed by Robertson Aircraft Corp., of Renton, Wash., well known for STOL conversions of Cessna and Piper airplanes by adding high-lift devices to the wings. The actual construction of the wing was done by Piper Aircraft Co. at its Lakeland, Fla, plant, where I first saw the plane. It was test-flown there for a few hours and then delivered for instrumentation and exhaustive testing at Langley.

The exact numbers on performance will not be available for several months. But preliminary flight results are promising. Dr. Kohlman told me the spoilers gave improved roll rates compared with the Seneca with conventional ailerons. This is similar to what I experienced flying the Redhawk last year with a similar installation. I also found that the adverse yaw of conventional ailerons was eliminated. For example, if you simply bank right using only ailerons, the nose of the plane swings to the left; this needs to be corrected by using right rudder.

Engine-out control

In the research plane, stall speeds are reduced below that of the standard Seneca because of the increased wing area provided by the Fowler flaps. The pilot also reported improvement in the engine-out minimum-control speed. A dangerous situation often develops at low speeds with one engine out. Using flight controls to counteract the off-center pull of one engine can create so much drag that flying speed is lost.

The new wing sounds promising, but I also heard some less enthusiastic, though not critical, reaction.

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Super Wing

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example, has greater effect on the flight path of a plane landing at 40 mph than on one touching down at 50 mph or more. Thus, STOL-type planes require bigger control surfaces and control inputs to make safe landings at very slow speeds than are required at higher speeds.

This greatly increases the task for the pilot. While it is possible for slower-landing planes to land in smaller fields it also requires greater skill.

Simply changing the thickness of the wing by using the new airfoil with the same wing area might increase lift at low speeds, but it would also reduce the cruising speed.

"The way the benefits work out is that you reduce the wing area and wind up with a smaller wing that goes faster at cruise, but still has the desired amount of lift for safe takeoffs and landings by adding the big high-lift Fowler flaps," says Winblade.

The new wing section also saves weight internally, Winblade explained. "Since it is thicker, the GAW wing has space for a thicker and lighter wing spar, which is structurally more efficient. The thicker wing also provides more room for fuel."

Costly changes

Making changes in airplanes takes lots of money. With the tremendous tooling investment plane makers already have in existing designs, it's understandable that drastic changes don't come abruptly.

Yet, the promise of the new wing shape is substantial, and judging from the interest I've already observed at our big plants, I would not be surprised to see the new wing appear on production planes within the next two years.

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