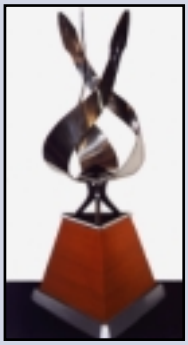
TRIAVIATHON TROPHY

CHALLENGE TROPHY



CAFE FOUNDATION

AIRCRAFT RESEARCH REPORT

Sponsored and Funded by the Experimental Aircraft

Local Flow Control III

BY BRIEN SEELEY AND THE CAFE BOARD

INTRODUCTION

This report presents CAFE flight test results on wing root flow guides as a modification to the Globe Swift.

Bruce Seguin is an expert in aircraft sheet metal fabrication and one of the foremost authorities on modifying the Globe Swift. His beautifully polished Swift, N84NS is based at Concord, California's Buchanan Field Airport. Bruce has so thoroughly rebuilt and redesigned this aircraft that it became reclassified as an amateur-built experimental aircraft.

Working with the late Lyle Powell, Bruce designed and installed the wing root flow guides tested here. When he discovered that they produced a noticeable improvement in low speed handling of his Swift and seemed to give a significant reduction in stall speed, it prompted many to suggest that these devices should be tested by the CAFE Foundation.

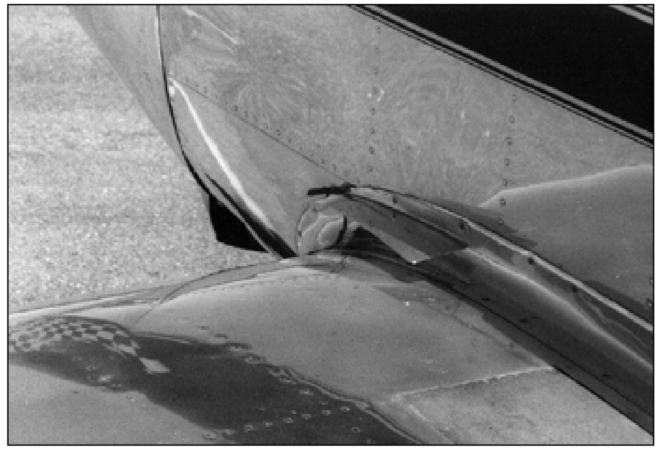
STALL SPEED TESTING

CAFE Barograph #3 was mounted on the wingtip of the Swift with fiberglass wing cuff attachments that Bruce built for the purpose. Two data flights were made. One flight with the flow guides installed and the other without them. A third flight was made to obtain tuft photographs.

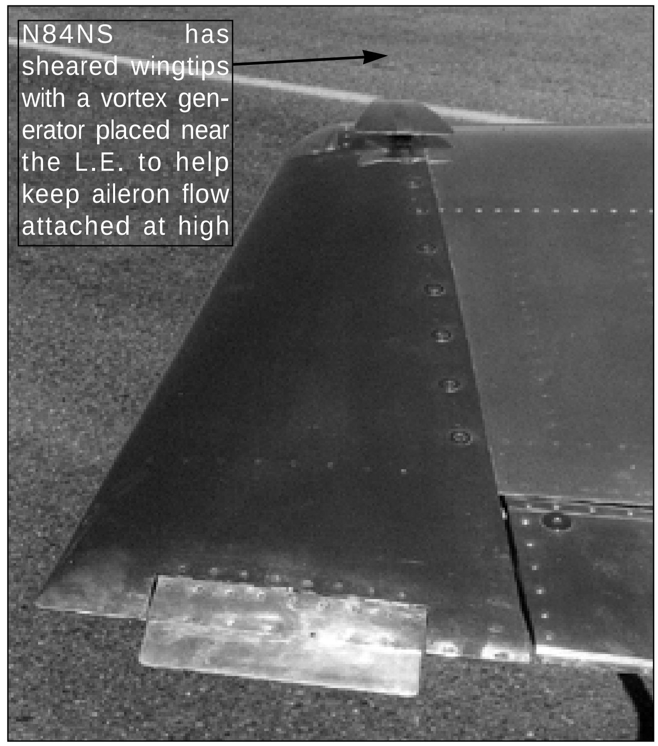
The aircraft weight and c.g. were carefully set at the same value on both flights . The test pilot, C.J. Stephens, performed power off stalls while seeking to maintain level flight and a less than 1.0 knot per second deceleration rate.

The results are shown in table **A**. There was a 2.1mph reduction in stall speed with the flow guides. This is a substantial increment for such a small, simple and lightweight device. It indicates a large increase in the overall maximum lift coefficient (Clmax) for the aircraft. At a weight of 2070 lb, the reduction in stall from 57.6 to 55.5

The flow guides attach with 4 screws each and weight just a few



The wing root flow guide installed on the side of the fuse-



N84NS has sheared wingtips with a vortex generator placed near the L.E. to help keep aileron flow attached at high

mph equates to an increase in maximum lift coefficient from 1.85 to 1.99. To place this 2.1 mph stall speed improvement in perspective, the flow guides acts as if they had added 10 square feet to the wing area of the Swift while being no more than 0.3 square feet in area themselves. Put another way, the wing root flow guides allow this Swift to carry 159 pounds more weight and maintain the same 57.6 mph stall speed recorded without the guides. The flow guides increase this aircraft's CAFE Triaviathon score from 85 to 95.6, further emphasizing the nifty way that they enhance lift.

The flow guides cause the wing root's upper surface airflow to remain attached when it otherwise would separate at stall angle of attack. The Swift's high taper ratio and relatively large wing root chord exaggerate this effect compared to what would occur on aircraft with non-tapered wings of shorter chord.

Many aircraft are purposely designed to have their wing root stall first so that the outer wing panel's ailerons will re-

Swift builder/owner Bruce Seguin, left, and CAFE Foundation President Brien Seeley share a light moment during the flight testing.

main effective for recovery during the stall. If using a wing root flow guide allowed an aircraft to stall at a higher angle of attack, one at which the ailerons were no longer effective, a stall recovery problem could be the result. Therefore, *caution* should be exercised in applying such wing root flow guides. Some concomitant trick to enhance aileron effectiveness throughout the stall may be necessary to the use of wing root flow guides.

In the case of Bruce's very special Swift, the wing tips *were* modified to help preclude such a problem. Bruce eliminated the outboard wing panels' leading edge slots when he rebuilt the wings. Then, he added a sheared wingtip of his own design and placed leading edge upper surface vortex generators just outboard of the aileron's tip. These VG's are of a design very similar to those used on the Glastar.

The result is an ability to maintain roll control during the stall, even during the deeper stalls allowed by the wing root flow guides. Thus, the overall design integrates one small change with another.

Extensive add-on flow devices may add to the drag of an aircraft and reduce its top speed. Our attempt to measure this was hampered by an ignition system problem that occured on the 'guides-off' Vmax test flight and we were unable to obtain meaningful data. However, it may be of interest to note that the Vmax at 6500' for guides-on with wing cuff drag was 196.65 mph TAS. (The ignition problem limited Vmax to 188.89 mph guides-off.) Maximum rate of climb at 97.5 mph CAS from 2500' to 3500' at 2070 pounds was 1093 fpm with the guides on.

Table A.

Swift N84NS at 2070 lb. Stall progression power off with full flaps and gear down. (~132 square feet wing area.)

Data clock	Pressure alt.	Sink, fps	CAS, mph
With flow guides			
14:11:34	7463	1.3	58.48
14:11:35	7463.7	0.7	57.46
14:11:36	7461	-2.7	57.03
14:11:37	7454.9	-6.1	56.18
14:11:38	7452.9	-2	55.89
14:11:39	7444.8	-8.1	55.93
14:11:40	7437.3	-7.5	**55.5**
14:11:41	7429.9	-7.4	56.46
14:11:42	7420.4	-9.5	58.48
14:11:43	7404.2	-16.2	61.01
14:11:44	7382.7	-21.5	63.61
No flow guides			
09:04:10	7431.2	-1.4	60.16
09:04:11	7431.2	0	59.94
09:04:12	7427.9	-3.3	59.62
09:04:13	7424.5	-3.4	59.26
09:04:14	7424.5	0	59.08
09:04:15	7423.8	-0.7	58.94
09:04:16	7420.4	-3.4	58.71
09:04:17	7417.7	-2.7	58.53
09:04:18	7409.6	-8.1	58.25
09:04:19	7406.9	-2.7	58.11
09:04:20	7400.9	-6	**57.6**
09:04:21	7392.8	-8.1	58.34
09:04:22	7382	-10.8	61.14
09:04:23	7366.5	-15.5	63.82

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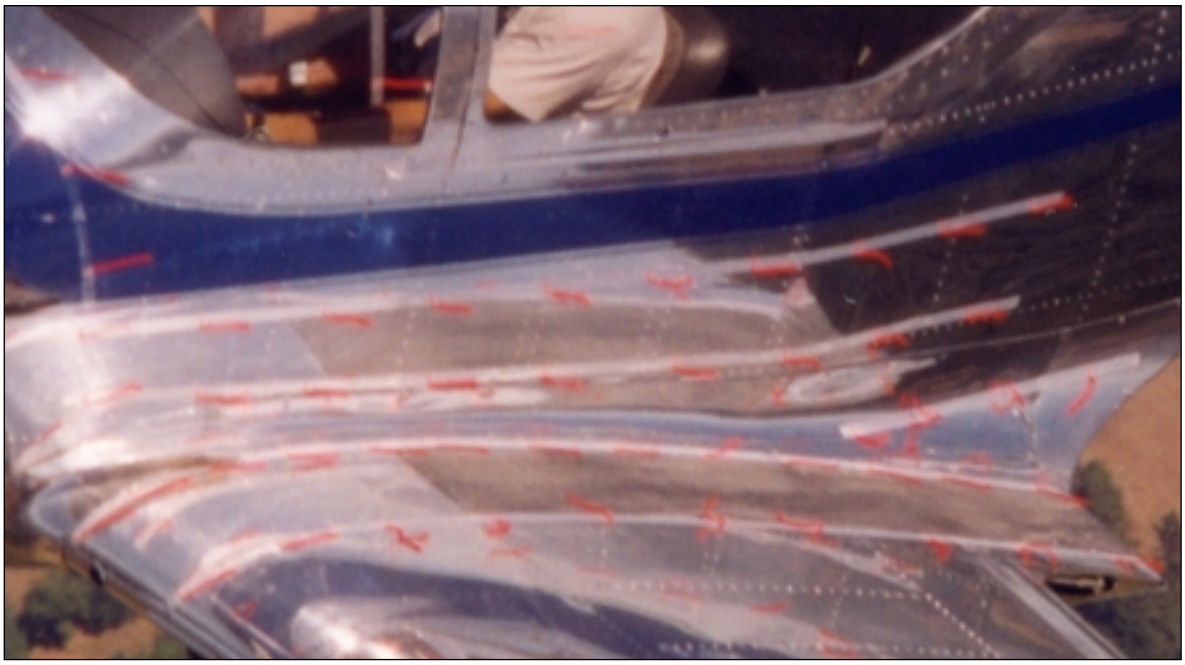

ANALYZING TUFT BEHAVIOR

Red yarn tufts were applied to the Swift to observe the local flow patterns at stall. It was very difficult to see the tufts because of the mirror-like finish on N84NS. C.J. Stephens high level of skill as a formation flyer allowed him to position the Swift in close formation to the photo plane just as he coaxed it into a deep stall. Larry Ford, whose excellent photographs appear in nearly every CAFE report, captured a tuft photo at exactly at the moment of the stall. It is helpful to view this at higher magnification.

Looking closely, we can see that the row of red yarn tufts about 12” outboard of the wing root flow guide are showing the chaotic flow reversal typical of the stalled condition. They are disoriented and pulled into distorted shapes as far forward the 20% of chord location. However, the tufts directly aft of the flow guide are still lying down fairly flat back to about 65% of chord, where one tuft is seen to be standing up off the surface.

The wingtip VG had been removed in this stall photo. The 3 wingtip tufts at 20% of chord and the tuft just forward of the aileron hinge point are all showing separation or reversal. The left aileron is deflected downward, increasing the angle of attack of that left wingtip. The tufts along the top of the outer edge of the sheared wingtip are kicked up high due to the wingtip vortex that spirals out from under the wing. The large downward angle of the Barograph’s brass pitot static probe shows the high angle of attack at stall. The tufts on the side of the fuselage graphically emphasize the influence of the top of the wing on local flow direction.

CONCLUSION

The big story from these results are the remarkably *large* effect from the fairly small and lightweight wing root flow guides. Hopefully, careful application of such devices can similarly improve the slow flight behavior of other homebuilt aircraft.