# Slots for Swept 'Wings?

There is little doubt the design of swept wings presents a number of challenges. Perhaps one of the greatest challenges is directly related to sweep itself. In previous columns we've discussed the deleterious effects of cross-span flow, and this month we'll do it again.

Cross-span flow occurs any time the wing is swept. For wings which are swept back, the flow tends towards the wing tip, while the flow on swept forward wings tends toward the fuselage. Some designs can take advantage of cross-span flow, as the NASA X-29. Our models, however, do not usually react to cross-span flow in positive ways.

If the air flow runs parallel to the chord line, laminar separation can be controlled either during the airfoil design process or by strategically located "trip strips." There is no way to know, however, where the boundary layer will break away under cross-span flow conditions, but for swept back wings the end panels of the wing will surely be affected. Since the pitch and roll control surfaces are in this area, positive control will be problematic. Additionally, $C_{Lmax}$ will be reduced and large amounts of drag will be created.

The classic method of dealing with cross-span flow is to install a fence parallel to the local wing chord, extending over the leading edge and back well past the quarter chord point. The idea is to create a barrier to the flow, much like the action of a tip plate at the end of a wing. One fence on each wing proved very effective on Akaflieg Braunschweig's SB13 "Arcus." The major problem with fences is their inherent high drag — a sum of their parasitic drag and interfence drag, plus their induced drag, a product of their being at an angle to the oncoming air flow.

We recently received an interesting letter from Mark Nankivil in which he explained a rather unique leading edge slot which he feels will be as effective as a fence and yet present far less drag. While Mark borrowed the idea from high speed aircraft, it should certainly be adaptable to model use.

"I want to make a case for flying wings in the 10 cell F5B event and also in Speed 400 and 7 cell pylon racing. As you probably know, there has been some good success in Europe with wings in electric pylon racing... the Aussie *Electric Flight Newsletter* shows success Down Under, too.

"In flying the F5B event, the one challenge is to minimize the turning radius during the distance portion of the task. In 'Faszination Nurflügel' the F3E (now F5B) model by Urs Leodolter was shown and discussed in one chapter. As I recall, straight line speed was not the problem, it was turning radius and the time wasted in making the turns at each base on the distance task. The flying wing would essentially high speed stall if wrapped into too tight of a turn. My thoughts on this are to eliminate the flow separation on the upper surface in tight turns by using a vortex to keep the flow attached in the tight turns.

"As I see it, two ways of achieving this are to go with a fixed canard or leading edge slots...

"Nothing original on my part, I just looked at full size delta wing and swept wing practices on the better operational fighters. Deltas (F-102, F-106, Mirage, etc.) have a high instantaneous turn rate but immediately run into high drag growth which inhibits sustained turn rate. The Israelis got around most of this problem by going to a fixed canard on their Kfir that improved the sustained turn rate dramatically. I think this will work in model form. However, the angle of attack of the canard would be difficult to optimize and drag gain elsewhere in the flight envelope would be likely without a lot of effort being spent on canard location and its angle of attack.

"The more enticing method would be to go with leading edge slots as used on the Sukhoi Su-15 Flagon or Saab Viggen. This lot is a vertical cut in the leading edge that forms a vortex over the top of the wing when the angle of attack increases. When the nose is down and the model is going for speed, the slot has very low drag, much better than a fence, and should have minimal effect on airframe drag. It also has the advantage that it can be placed where it is needed along the span of the wing...

"The slots will be tested later this Spring on a two meter EH flying wing for use in the 10 cell F5B class. More on this as it comes to pass..."

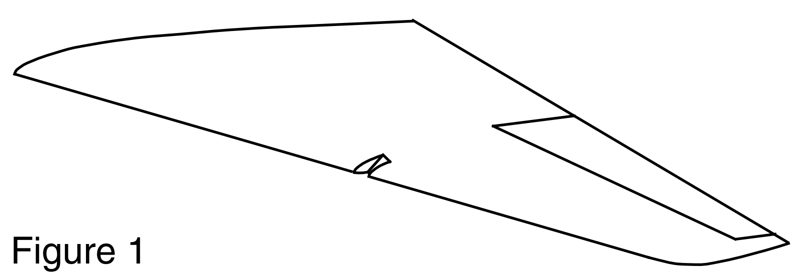


Figure 1

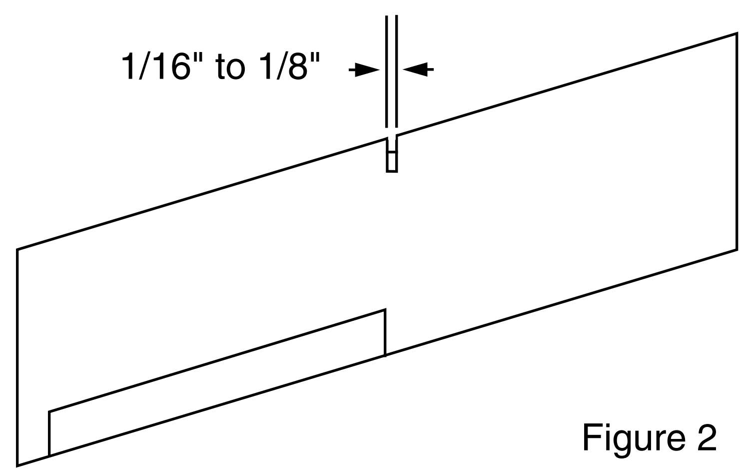



Figure 2

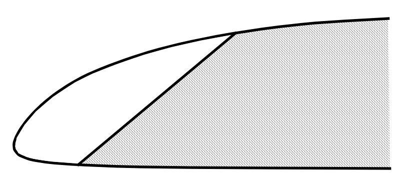
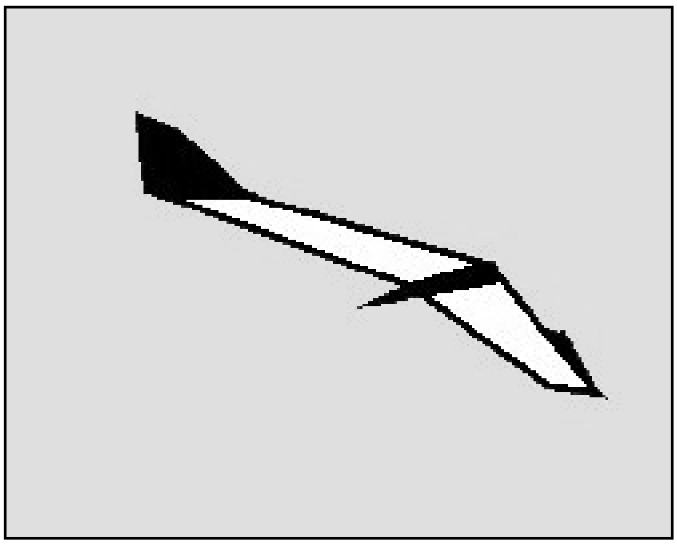


Figure 3

The slot, shown in various views in Figures 1, 2, and 3, creates a small vortex which turbulates the flow in the region behind the slot. This vortex mixes the stagnant boundary layer with air molecules having higher energy. The action of the slot is similar to that of a variable orientation trip strip. It will not stop the cross-span flow, but will inhibit the laminar separation which can be so detrimental to consistent pitch and roll control. There should be an increase in effectiveness as the $C_L$ increases.

We encourage Mark to experiment with leading edge slots and share his findings with *RC Soaring Digest* readers.

Mark concluded his letter, "If I can solve the turn rate/drag increase problem, then I think there can be a quantum leap in competitiveness for flying wings in F5B and F3B. I'm excited about the possibilities!"



Andrew MacDonald's web page icon.
<http://www.cs.net.au/~andy/>