HAND LAUNCH GLIDER AIRFOILS (Part, two of two parts)

By Curt Stevens

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Bernoulli's Law: We take exception to Bernoulli's Law for hand launch gliders. Bernoulli's Law really does not have much to do with wing sections. He was a 17th century scientist who published a book in which he proved that the sum of static and dynamic pressures over a streamline shape always remain constant.

For years our teachers, none of whom ever read the book and didn't understand the physics, have been teaching their unquestioning students that the air over the top of the wing has to travel further that the air over the bottom of the wing. Therefore the air over the top of the wing has a lower static pressure and produces all the lift we need.

My teachers also injected the little known fact that the air molecules that separated at the leading edge had to really speed up in order to rejoin the same air molecules again at the trailing edge. This is all sort of true under certain conditions. The sad news was that I for one believed them, even when I knew that there was something wrong and things did not add up correctly.

The air molecules that separate at the leading edge of the section never ever meet again at the trailing edge. There are at least 20 good reasons for this but one major reason is the span ward flow of those air molecules on the top of the wing. The very best reason for them not meeting again at the trailing edge is simply that there is no good reason why they should.

Wind tunnel data collected within a confined airflow-type tunnel is almost totally useless. Not totally useless, but almost. Hand launch gliders fly at a very low Reynolds number and at an angle of attack that is unbelievable to the old school of aerodynamics. In the climb portion HLGs operate at near a -1 degree angle and in the glide portion we float along in the range of +12 to +18 degrees.

Wing Platform does matter in that it plays a major role in controlling span ward airflow. The wing platform developed by Don Foote in the late 1930s seems to be about the best. This is the platform used on his old timer gas model, the Westerner and all the Hand Launch Gliders that have ever exceeded 1:20 in dead air. Don Foote claimed that this wing platform resulted in a model that would glide slower and thermal better. I suspect the "thermal better" part came about because he also reduced rudder area about 50% at the same time he went to the new wing platform. Incidentally, that beautiful 1/3 by 2/3 elliptical platform that looks so great on a Spitfire is just about the worst you can choose for any glider type modeL

What I have decided is that the only part of the wing that is really operating up to my expectations is the portion with the trailing edge perpendicular to the intended airflow. The trailing edge must be perpendicular to the airflow to minimize the spanwise flow of the air that must produce the lift we need. Wing platform is another subject altogether and is dependent up on the intended use and required angle of attack.

The section I use is just a flat plate with some curve on top to delay the stall. Figure 1 is the basic section. The top surface is a 6% thick expanding logarithmic spiral curve with a very sharp leading edge. Note there is no Phillips entry and no leading edge radius. The 6X may seem thin but it is a fact of life that as you fly at lower and lower Reynolds numbers you must also reduce wing loading and wing section thickness. No room for the bull.

The section shown in Figure 2 is the actual section I use under most conditions. Over the years I have shifted the high point of the section from 18% to as far aft as 40% of the chord. I think the 25% location is best for most conditions. The true expanding logarithmic spiral has its high point at 30.06%; I fudge this location by treating the distance from the leading edge to the desired high point as the total wing chord. You can do that with this curve and it works out perfectly every time.

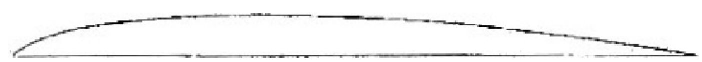

Figure 1

For very light wing loadings you can make a thinner wing by just moving the high point forward. Works well with catapult gliders

Figure 2

Figure 3 (Works well with built-up outdoor models)

Figure 4 (Works well with built-up outdoor models)

Figure 5 (Used on the Swallow RC glider

The most noticeable part of this section is also one of the least important details of the section. From the high point to the trailing edge is a straight line. This has no measurable affect on the glide times when tested with identical gliders at identical weights.

The big reason for doing this is that it eliminates wood from the wing and as a side effect, this section provides a better recovery at the top. We no longer have to waste altitude with the classic HLG Roll Out at the top; we can now use a simple slip out recovery at the very top with no loss of altitude.

The wood that is eliminated from the wing is very substantial, far in excess of the material needed for the entire tail assembly. The model weighs less and flies better.

Figure 3 shows a similar section that does not glide very well. I think the reason is the lack of sufficient curvature right behind the leading edge. This is where many, many would-be glider flyers have gone wrong and ended up with good flying gliders with no hang time and poor flight times. Now indulge me for a moment. Take a sharp pencil and straight edge and draw a line from the leading edge to the high point of the section. Go ahead and do this on figures 2 and 3 and note the differences. Figure 3 does not work, never seems to get up on the step.

That straight line you just drew measures out to be just about a 14 degree angle of attack to the bottom of the wing. When we get the wing to operate at a 14 degree angle of attack we will have a perfectly good airfoil from the leading edge to the high point of our wing section. And, a couple of degrees either way won't hurt much. What happens behind the high point doesn't seem to matter much.

Our only objective is to displace air equal to the weight of the glider and with the least possible drag.

A flat plate at 12 to 18 degrees angle of attack pushes a lot of air downward and creates a lot of drag on the top surface, I think the curvature on the top surface does alleviate the drag problem.

My own totally untested, unproven theory is that low Reynolds number wing sections, all tend to retain most of their laminar flow characteristics until the air is past the trailing edge of the wing. Laminar flow sections sure are beautiful in the wind tunnel.

I am certain that the sharp leading edge starts the turbulation on the top surface of any airfoil at a high angle of attack. On these very low Reynolds number sections I suspect that a burble of air forms on the top surface and has the ability to change size, shape, and location to delay the stall point. To take advantage of this section you also need to keep your wing tips light and thin like a trailing edge, keep your leading edges light and sharp. With any flying model you always must keep the extremities very light to reduce the moment of inertia.

Your HLGs should be made to fly, not to survive a crash. The crashes are you own fault. When a model survives a crash you should reexamine your design. Are you building airplanes or tanks ?

Now that you suspect that I may be a bit of a nut who probably believes the world is also flat, let me say that I have traveled around the world, and I have seen the curvature of the earth from 45,000 feet. The world may not be perfectly round but it's not flat either. There are no sure things and you have no good reason to assume that I'm right about everything.
But let the digital stopwatch be the final judge.

Curt Stevens Model Research Labs 3-1-97, revised 12-9-99