Jim Keller's "Zephyrus"

The cheapest form of instant (well nearly instant) self gratification

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This month's column is written by Jim Keller of Diamond Bar, California.

Here's my story on the development of the flying wing I wrote about in RCSE and received so much mail about (approximately 20 requests for more info, specs, setup, etc.), and call the Zephyrus.

I've always been an airplane nut, starting my model building career in about 1949. I have been interested more than just mildly in flying wings for years. An early recollection during my childhood right after WW II was seeing a Northrop wing flying near the Lockheed Burbank facility.

The last few years, I have taken to designing and scratch building planes. Last year I got hooked on slope soaring, and I find every excuse in the book to leave work on time to get in some evening soaring. This is in addition to my daily jaunt to a local park near work to fly a HLG or 2m ship during lunchtime. I also leave early for work sometimes and fly a small electric planes from a park near home. Did someone say I was obsessed?

Enough digression. Recently, a regular flier at the slope showed up with a Zagi-LE. I was astonished at two aspects of the plane: it handled light lift with ease, and when the rest of us were sitting, waiting for the wind to pick up, he was flying; it also was very agile, regardless of the wind speed. That did it. All of the studying, reading and calculations for my own design had to be accelerated.

About this time, I was also doing a lot of business travel. I would sketch a wing and then make a card stock model and fly around the hotel room in the evenings I was away from home. This prepared me for the practical side of things and taught me what worked, and what didn't. I experimented with planforms, sweep angles, tip twist, elevon configurations, stability and control. It seemed the best flyers were the ones with a 23 degree sweep and full span elevons. I was performing these little experiments at fairly low airspeeds, where stall recovery could be evaluated.

The resulting planform that I present here is the best compromise of all:

Jim's daughter Colleen with the Zephyrus

- 48" wing, approximately 10% thick RG 15 airfoil, 4 degree washout at the tips
- 23 degree sweep, each wing half
- 12" root chord, 7" tip chord
- white foam cores, covered with 80# Kraft paper using 3M 77 spray adhesive, then covered with 2" clear plastic packing tape
- partial span top spar made from $^{3}/_{16}$" dowel placed in slot cut on top of wing, then filled flush with fiberglass package tape. The next version will be composite or at least partially EPP foam. The paper and tape covered foam is durable, but deforms somewhat after repeated crashes, which are inevitable for slopers. My downfall is what I call blowovers, which occur when you get the plane high, right above you at the edge of the slope and you try to turn back into the wind. The plane just blows over your head and then back into the rotor. Bummer — no control!
- full length (except for about 1.25 inches each elevon root) 1½" elevons made from T.E. stock, then shaved to match airfoil and hinged with packing tape
- center of gravity so far is best at 18% M.A.C., which translates to about 6 $^{5}/_{8}$" from root L.E. for this planform. Obviously, you either need a separate mixer in the plane for the elevons, or have a computer radio programmed for elevons (which I have). Each elevon is moved by a separate Hitec HS 80 servo. You can use full size servos, but they won't be flush in the wing. You can move them a bit inboard, but unless the elevon balsa is real stiff, you'll have flexing at speed.

- for launching, I taped a small strake under the wing near the C.G. to hold when I toss it off the slope.
- all up weight for this configuration is 14.7 ounces
- wing area is 451.5 sq. ins.
- pockets cut into the foam for the receiver and 150 mAH battery in the center of the wing, and two pockets for the servos, each mounted about 10" from root line. Servos mounted from the top, pushrods on top to protect from landing damage. I laid the radio components on the covered wing and moved them around to try to achieve good balance without adding weight. This, as I now realize, wasn't necessary, since more weight will be better in 10 m.p.h. wind.
- tiplets made from $^{1}/_{16}$" ply, roughly triangular with rounded corners, 7" long and 5" high. Securely tape to tips. Make sure these are parallel with the center line of the wing, else you'll have a yaw bias for sure, which you'll need elevon trim to correct, which means you've built in some needless drag — aspects I have identified so far.

I call the plane the Zephyrus, after the Greek god of the West wind; so named since the slope I fly on faces west, into the prevailing wind.

Design Objectives

The initial full size RC plane was built with four objectives, or requirements in mind:

1. It had to be cheap, constructed of readily obtained and inexpensive materials.
2. It had to be durable and/or light enough to resist damage.
3. It had to be built simple and fast — I get antsy to try out something new, plus my building time has become precious lately.
4. It had to look different from the current genre of 'wings, but have a conventional (for a 'wing) planform so I wasn't outside of the range of current thinking.

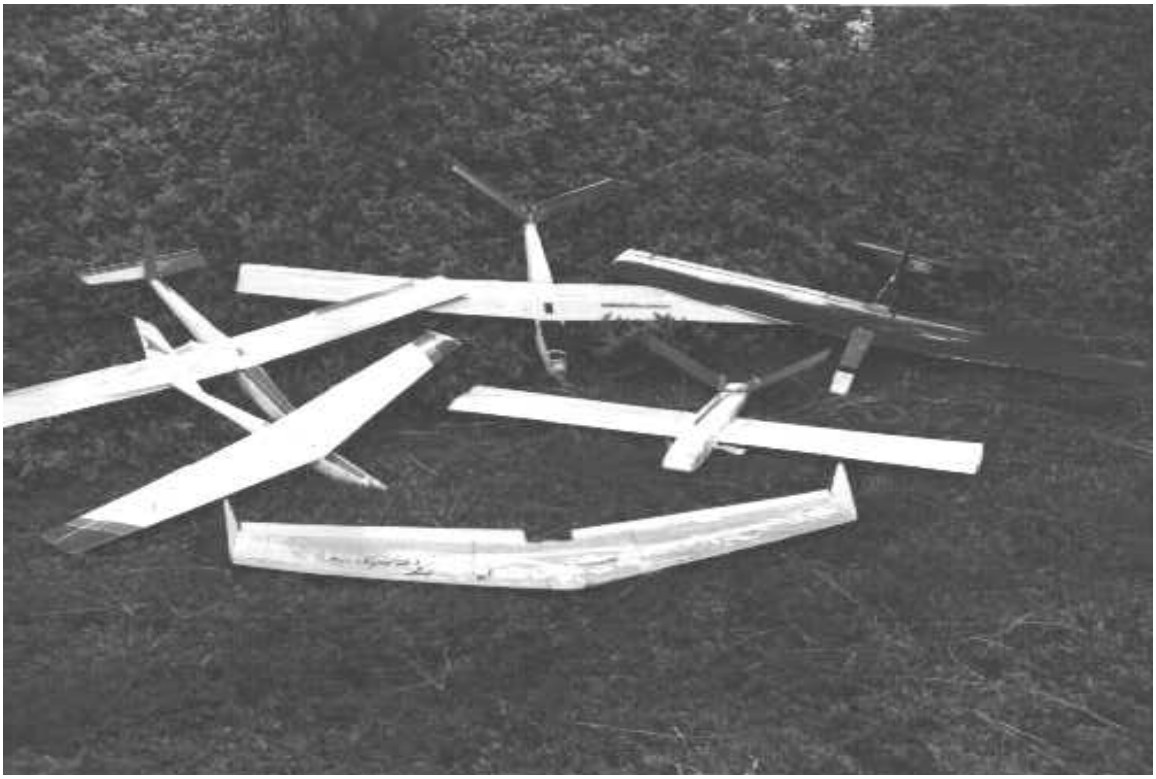
To satisfy all of these requirements, I decided that brown paper and packing tape over expanded bead polystyrene (white) foam would be the cheapest and fastest approach. It would be light for a sloper, which meant that it would resist a nominal number of crashes before it became landfill fodder. Remember, this was to be a "proof of concept" model.

Construction

I cut the templates to an RG 15 airfoil, but thinned the leading edge back about an inch to allow for the extra tape I would put on the leading edge of the wing. This would allow extra reinforcement and minimize the amount of

ballast up front. My next version will at least have a hardwood dowel at the L.E. to take more abuse, since the white foam deforms pretty easy. After cutting the cores, I prepared the blanks. It's important that the root and tip of each wing half be square with the transverse axis of the wing and parallel to each other to have the airfoil be true. I use 3M 77 adhesive spray to adhere the templates. The tip template was attached at a 4 degree washout position and the cores were hot wired.

After hot wiring the cores, they were glued together, making sure they were each flat and true with each other — no dihedral is built into the wing. At this point, I wrapped the wing top and bottom spanwise with one or two layers of $^{3}/_{4}$" fiberglass packaging tape. After wrapping the wing halves, I sprayed 3M 77 adhesive spray on the brown paper and the wing. I use the heavy 80# package wrapping paper you can get at most discount stationary stores like OfficeMax, OfficeDepot and Staples. After covering with the paper, I covered the paper with 2" clear plastic package tape. At this point, you're probably only 2 hours into the project, and your equivalent outlay is only about 3 - 4 bucks. At this point (actually, it should be done before covering), I sliced a $^{3}/_{16}$" deep groove into the top of the wing and about 15" long for a top spar made from a $^{3}/_{16}$" hardwood dowel. I covered the dowel and its slot with fiberglass package tape.



Jim Keller's stable, with the Zephyrus is in the front.
Half of the 'ships shown are original designs.

I used 1½" trailing edge stock for the elevons, and took a razor plane and matched the contour of the airfoil. You can easily carve the elevons from $^{3}/_{16}$" medium sheet balsa. Use your favorite method of tape hinging to attach the elevons, and the wing is essentially done, except for radio installation and balancing. Mount the elevon control horns on the top of the elevons at the point where the pushrods will attach.

The tip plates are made from $^{1}/_{16}$" birch plywood, although you could use balsa, covered with packing tape. Before mounting the tiplets, make absolutely sure that the ends of the wing tips are parallel with the centerline of the root of the wing, so as not to induce a yaw component.

Radio Installation

Radio installation is simple. Cut pockets for the receiver, battery and servos by using a sharp X-Acto knife. Cut these with care so that the components fir snugly, especially the servos, to minimize slop. Cut their location as far forward as possible, but no closer than about $^{3}/_{4}$" from the leading edge to allow for some crush space after crashes. Insert the components into the pockets and then tape over them. You can leave an inch or so of battery lead hanging out to turn off the radio, or you can use a short servo extension as an on/off switch. The pushrods for the elevons are made with Z-bends at the servo, and adjustable clevises at the elevons. If you don't have a computer radio, add a mixer and cut a pocket for it, also. When mounting the servos, angle the servo arms rearward about 30 - 40 degrees to induce differential. Tape the servo leads flat with package tape. I tape the antenna straight back and then just let the remaining 30" or so flop in the breeze.

Balancing

The balance point, if you built in strict adherence to the specs is 6.4 - 6.6 inches back from the leading edge at the root. This corresponds to about 18% M.A.C. for those aerodynamically endowed. I had to add about 2 ounces of lead to achieve this. Correct balance, of course, can be determined by hand tossing. I found that a triangular skeg made of $^{1}/_{8}$" balsa, taped along the underside of the center of the wing was very handy for hand tosses. The glide should be flat, as with a conventional plane.

Flying

This plane is intended to be a sloper, so the following is strictly for that mode. Toss the plane ahead, directly into the wind, just a tad of nose down attitude. I usually give it a little down elevon initially to gather some speed and get free of the ridge turbulence. After that, it will climb fast and then you're in for some fun. Please be advised that a characteristic of 'wings is that they will "kite" if you get a significant angle of attack. In strong wind,

you need to be very quick to catch this and give it some down elevator to recover. Until I learned this, I had a number of "blowovers" where I turned into the wind close to the ridge and then had the plane blown over my head into the rotor. Play with the elevon movement to fly docile or to fly fanatically. I've found about ½" up and $^{3}/_{16}$" down for turns and a little less for equivalent elevator control is a happy compromise, but for the first couple of flights, set these at about half that throw.

Into the Future

With enough air time now under my belt with this plane, my next version will be fiberglass covered foam with an adjustable C.G. to experiment with stability. I will increase the weight to fall into the seven, or so, ounce per sq. ft. loading category. As the summer progresses, the wind speed increases at our slope, and the additional weight will be needed. Combat is making it's way onto our hill, but Zephyrus, for now, is a peaceable soul, content with a combination of lazy, relaxing flight mixed with some exuberant aerobatics. We'll leave combat for the DAWs, Foaminators, PSSs and Zagis.

Earlier, I indicated the four requirements for building this plane. If you build one too, I think you'll see that these objectives were met, and that the fun-per-dollar ratio is pretty hard to beat. Enjoy!

Mr. Keller is an Electrical Engineer, specializing in Systems Engineering for Lockheed Martin. He has been a model builder since the 1950's. He has built flown all forms of models from indoor to control line combat to electric flight, including the infamous Galloping Ghost RC control of the late '60's and early '70's, but now concentrates on R/C sailplanes and electrics.