ISSUE 08

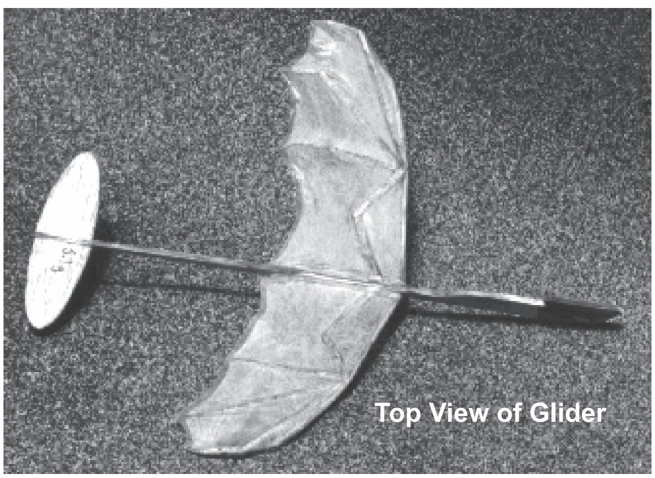
APOGEE PEAK OF FLIGHT NEWSLETTER

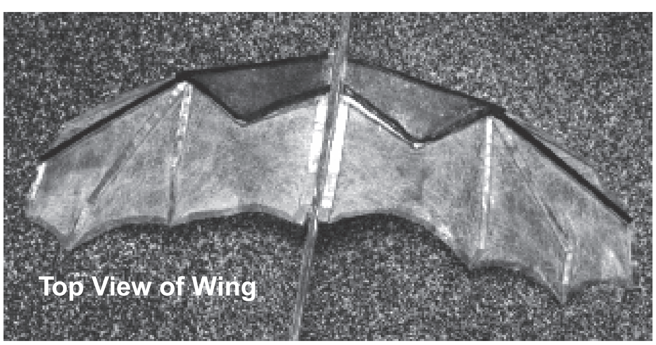
Bat Wing Boost Glider Plans

By Tim Van Milligan

The "Bat Plan" is a small boost glider modeled after the wing planform of the only natural flying mammals on this planet, namely the bat. This wing design, while looking deceptively simple, is very complex structurally, but yet it is only slightly harder to build than a regular solid-core wing.

This designed evolved after my study of bird wings. I came across a section on bat flight in one of the books on vertebrate flight, in which they compared birds versus bats. It turns out that the bird is a better soaring animal than the bat, chiefly because of their habitat, and the way they forage for food. Bat wings are almost never stationary in the outstretched position like soaring birds, so they aren't known to be good soarers. But they do have very efficient wings, and they have a unique ability to change wing camber, which birds can't do very well.


Top View of Glider


Top View of Wing

This ability to change camber, and to change their aspect ratio (by pulling in their wings) allows them to be very efficient over a wide range of speeds - particularly at very low speeds. This ability also allows them to be highly maneuverable, in fact, they far exceed any bird in their ability to perform quick direction changes. Some small species of bats will hunt, catch, and eat their food (insects) while flying at top speed, and staying within the confines of a tree canopy!

The wing of the bat consists of long, thin, lightweight bones that are held together by a skin membrane. Where a birds bones are hollow, a bats bones are solid. It is the membrane that allows the bat to change its wing camber quickly. The membrane has rows of muscles that can be tightened or relaxed, and it is this that keeps the wing in the right shape all the time.

The wing presented in this plan would resemble a fully extended wing optimized for slow speed flight (good for thermal hunting). The wing is extremely light weight by nature because it uses structure only where it is absolutely needed, and then it is covered with tissue paper that handles (by tension forces) the lifting forces developed by the wings. The bending forces are taken up by the stiff wood structure. Because of its light weight, this model is great for competition flying, particularly in the FAI events.

The engineering tradeoff in this design is the high camber wing is not the optimum for high speed flight (during launch). So it will not boost as high as a low camber wing. This is one item one might consider when building this model,

Apogee Components
1130 Elkton Drive, Suite A
Colorado Springs, CO 80907 USA
www.ApogeeRockets.com
orders @ApogeeRockets.com
phone 719-535-9335 fax 719-534-9050

because the shape can be easily controlled during the model construction.

Construction of the model:

The boom, the pop pod, and the tail section are all pretty much standard and comparable to other boost glider designs, so build them accordingly. Just note the dimensions on the drawing.

The wing is the novel item in this plan, so I'll describe how to make it.

The first step is to select the balsa wood for the wing "bones." Since the wings don't contain any single pieces which are "long," you can check your scrap box for 1/8-inch thick contest balsa (the hard stuff that you hate to sand airfoil sections out of).

Step two would be to cut out the members per the plans. Some of the angles on the ends of the members are compound (slope in two directions), so these you will be sanding to fit; so don't worry too much about getting them cut precisely – just cut them slightly longer than the plans show.There are 16 pieces in each wing, so cut two identical sets.

The next step is to lay all the pieces down on the plan and number each one, because they will assemble much easier if they done in the proper order.

Lay a piece of wax paper down over the plans so that you don't glue the pieces to the paper. Note that when assembling the wing, apply just enough glue to hold the joints together. They will be sanded later, and following that, apply extra glue to create stiffening fillets.

Start by gluing pieces 1 and 2 together (the upper arm and the lower arm). These two pieces lie in a flat plane.

Next glue the hand together. Note there are only for digits (fingers) in this plan. Bats actually have five digits, but the thumb is very short and is not attached to the other fingers by a membrane, so it has been deleted from my plan (the thumb is a useful thing for a bat, it helps it secure itself when hanging around, and also helps in catching insects).

This is the sequence I've found best in gluing the hand together: first glue number 6 to #2, then #3, #7, #8. After that it is up to you (meaning the remainder of the pieces can be done in any order. Just remember that the pieces are sanded to shape prior to gluing them into place. The better the fit, the stronger the joint will be.

Wing camber is built into the airfoil by gluing the digits at the proper angle. With the elbow lying flat, the tips of #6 and #8 should be 1/8-inch off the table; #7 should be 1/4-inch up, and #3 should lie in the same plane as the elbow joint. The other knuckles are angled downward to give more camber. Try to keep them less than 10°. Any more than this, and you may sacrifice boost altitude too much.

After everything has been glued together, sand it down all over to blend in the joints so they are nice and smooth, or it may be hard to get the tissue to bond to the wood.

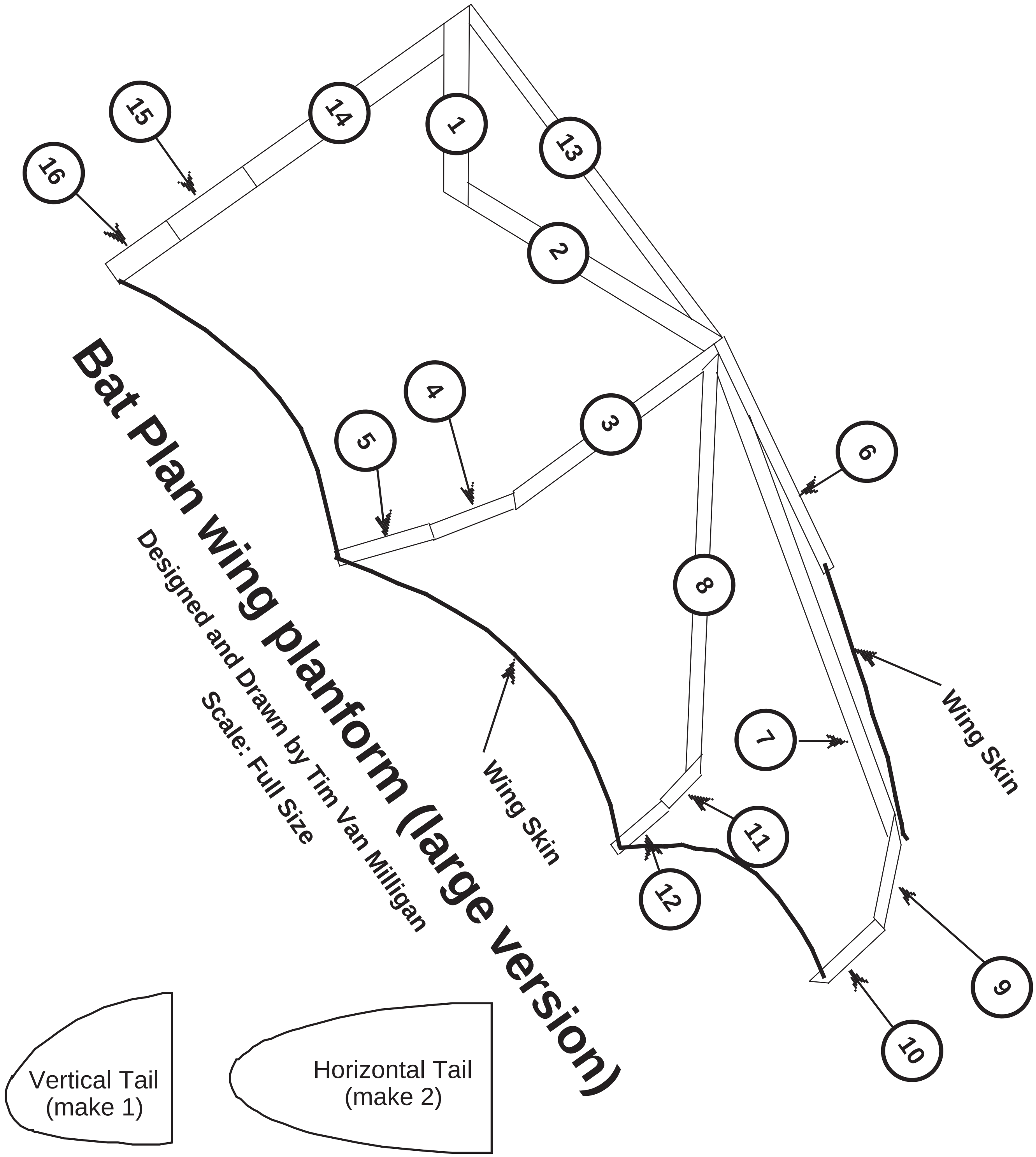
The members #14, #15, and #16 are used to attach the tissue at the root of the wing. These pieces are cut, sanded, and glued into position like the fingers: with the camber built in.

With all the members glued into place and the proper strengthening fillets made, you can cover the wing with Jap tissue. Do this as you would any ordinary built-up wing. Since there is no member at the trailing edge, it will hang free. Cut off the part that is loose (not taught) off the trailing edge - so it resembles a real bat's wing. The skin should be tight over the entire surface of the wing. Remember to dope the entire surface, including the underside to give it strength.

The bottom of the wing isn't tissued (the wood structure will be exposed). So it makes a perfect surface in which to apply graphite fibers to strengthen the wing (without these fibers, I wouldn't fly this bird with any high impulse motors, you can almost be assured that the wing will rip apart).

Graphite fiber tow is a small bundle of loose fibers all arranged in the same direction (it looks like a flat ribbon 1/8 inch wide -- it is available from Aerospace Composite Products -- tel: 510-352-2022). Start the reinforcement of the wing by tacking down one end on the root end of member #1. Run it past the elbow, along member #2, over the wrist joint to the end of member #7. This is the critical bending load path of the wing. Glue it into place with CyA adhesive. Weight can be kept low by using the adhesive sparingly. I also run a piece of graphite along member #13 to help absorb any impact loads that may occur when the glider lands. This is done for both wings.

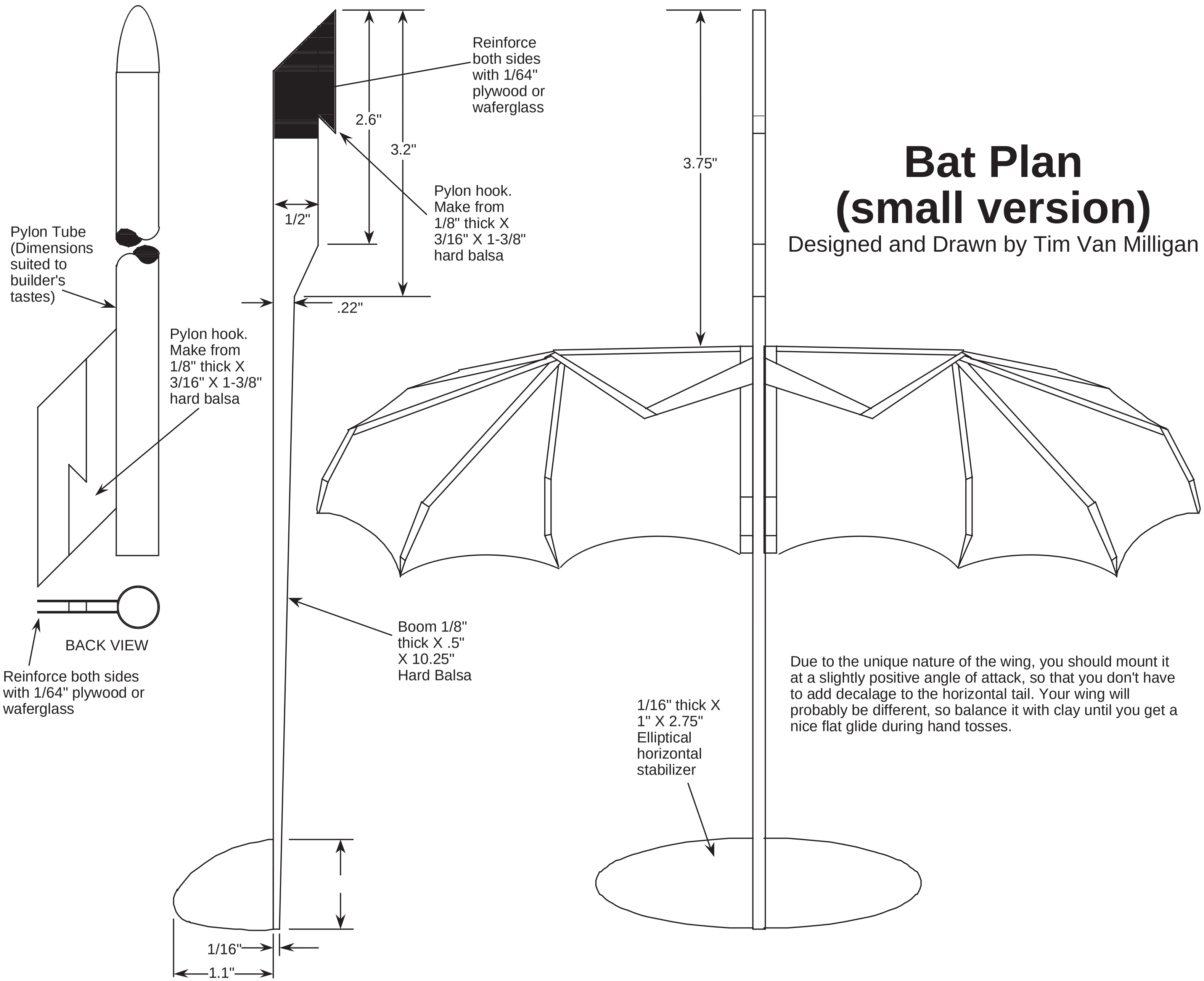
I also like to stiffen the triangle on the underside of the wing formed by members #1, #2, and #13 with a piece of graphite mat (also available from Aerospace Composite Products). It can be attached like a piece of tissue paper with clear dope,



Tail Patterns
(Full Scale)

Bat Plan (small version)

Designed and Drawn by Tim Van Milligan



Due to the unique nature of the wing, you should mount it at a slightly positive angle of attack, so that you don't have to add decalage to the horizontal tail. Your wing will probably be different, so balance it with clay until you get a nice flat glide during hand tosses.

or by carefully applying CyA adhesive.

Dihedral is made by sanding the root edge of the wing prior to gluing it to the fuselage. This is typical of any glider wing, so you shouldn't have much difficulty there.

For other generic tips on building and trimming gliders, refer to the book:"Model Rocket Design and Construction" by Timothy S. Van Milligan.

The model is very light, and because of this, it has very little momentum in a stable glide. So it can easily handle seemingly nasty impacts that almost always occur while trimming the glider for boosted flight. I've flown this model with as high as a B4-2 engine, so it will work great with the Apogee Components micro motors. The model works just fine once it is trimmed properly. Being ultra-light weight, this model also possesses very little inertia, so it can take launch accelerations very well too.

Scaling this plan up or down is very simple, and you should have no problems with it being strong and stable at any reasonable size. I currently have two versions, a smaller size model for "1/2A" and "A" motor class events, and one for "B" and "C" class events.

About the Author:

Tim Van Milligan is the owner of Apogee Components (http://www.apogeerockets.com) and the curator of the rocketry education web site: http://www.apogeerockets.com/education. He is also the author of the books: "*Model Rocket Design and Construction," "69 Simple Science Fair Projects with Model Rockets: Aeronautics"* and publisher of the FREE e-zine newsletter about model rockets. You can subscribe to the e-zine at the Apogee Components web site, or sending an email to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject line of the message.