The D-Light Boost-Glider

How to build a competition free-flight glider

by Trip Barber, NAR 4322

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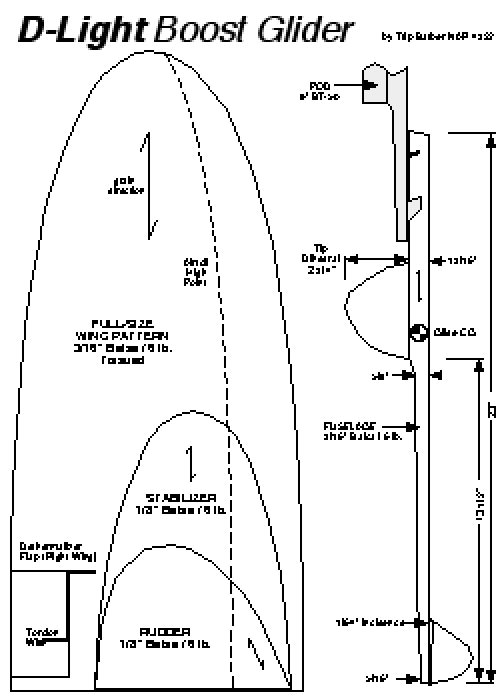
Radio-control gliders have taken over the higher power classes of both boost-glide and rocket glide in recent years, but they take too long to build and then you have to spend dozens of flights learning how to fly them before you can compete! When the events for NARAM-39 were announced to include D B/G (multiround), I was determined to demonstrate that the simpler free-flight gliders could still hold their own against high-tech. This is the design that I did it with.



I designed this model almost 10 years ago and published the plans in the NOVAAR Free Press section newsletter, so it's well-known; QCR's kit for D B/G is a close replica of it. Consequently there were lots of models that looked a lot like the D-Light at NARAM-39; in fact both Ducky Klouser and Jonathan Rains built this design and beat me flying it there, with all of us flying Estes D12-3 motors; I was fourth. That's three of four, so you ask...what won? A radio-control design, doggone it! But only one person (Alex Seltsikas of England, a veteran World Championships flier) had the talent and experience to beat the simple approach by using the ability of an R/C model to fly a controlled boost with a high-impulse composite D motor and then to hunt for thermals and steer into them.

This article will tell you how to build one particular glider, but I'm going to also take the opportunity as we go along to explain a little bit about some design and building techniques that are applicable to virtually any boost-glider or rocket-glider. Even if you don't need a D boost-glider, I hope you will find these other discussions useful anyway.

Balsa selection

The first step in building a good glider is to use good materials. This is an all-balsa glider, and the balsa you pick will determine how light and strong your glider becomes. You can take good balsa and make a bad glider out of it if you aren't careful with your craftsmanship, but you can't take bad balsa and make anything other than a bad glider out of it.

Generally speaking, light balsa is good balsa and good balsa is rare. Some specialty companies (Sig Manufacturing being the biggest of these) sell weight-graded balsa, but most hobby shops carry mass-market balsa lines like Midwest. Even Midwest accidentally includes the occasional good piece in the bulk packs of generic balsa they send stores, so every hobby store I go to, I sort through every piece of balsa sheet stock they have, looking for the one "perfect" piece. What is the "perfect" piece? Well, for glider work it is light-density C-grain.

Balsa wood grows in different densities, but generally is available in densities ranging from 6 pounds per cubic foot to about 20. Most hobby store balsa is in the 10 to 18 pound range, which is fine for boats and for model airplane structural members (and model rocket glider fuselage booms like the D-Light), but when used on wings it makes for heavy boost-gliders that glide poorly.

"Contest" grade balsa is 5-8 pound density, and for model rocket glider wings and stabilizers or rudders 5-7 pound stock is the ideal. Unfortunately, to measure balsa density exactly you need a scale, which is kind of obvious and not always welcome when you walk into a hobby store! You may just have to buy the lightest piece you can find, hope for the best, and weigh it when you get home.

For the D-Light wing (which is made from 3/16-inch thick, 4-inch width balsa), if your 36-inch-length balsa sheet weighs 50 grams or less (7 pound density), you have picked well. For the rudder and stabilizer, which are 1/8-inch balsa, if your 3x36 inch balsa sheet weighs 25 grams or less (7 pound density), it's good. The fuselage should be 12-16 pound density hard balsa, which I find to be stiffer and lighter than the spruce that others use for booms.

There is one other factor to consider for your balsa besides density, and that is strength. Heavy balsa is usually strong, but lightweight balsa can be too weak for use on wings if it was cut the wrong way from the balsa tree. "C grain" balsa sheets are the strongest and most rigid for a given density and should be what you use for the D-Light wing and tail; these sheets are cut in a radial direction from the balsa tree trunk, perpendicular to the age rings. The surface of C-grain wood has a distinctive mottled, almost shiny fish-scale like appearance. Experienced modelers picking through balsa displays have been known to come to blows over the right to buy a rare sheet of light C-grain!

Building a Wing

The wing makes or breaks a glider's performance. It needs to be the right size to provide enough lifting surface for the glider's weight and visibility for timers, the right strength to withstand boost, the right shape to provide stability in glide, light enough to ensure low wing loading and good glide ratio, and the right airfoil and surface finish to ensure low drag and high lift coefficients. Wing design and construction is a trade off among all these factors.

The D-Light wing is about 60 square inches of area with a 17.5 inch span and an aspect ratio of 5.6. It uses a standard low-camber asymmetric airfoil with the high point at 25 percent of the wing's chord. This is fairly small and low-aspect-ratio for a D boost glider; this bird is designed for high-altitude, high-speed boosts on an Estes D12 motor.

The D-Light wing is made from 3/16-inch thick, 4-inch width, 6 pound density C-grain balsa. (If you do not plan to tissue the wing, use 1/4-inch thick balsa of the same quality instead).

Use the half-wing template in the plan and lay out a complete two-sided wing on the balsa, then cut out the whole wing as a single piece. Do all of the sanding, surface preparation, and tissuing to the wing as a single flat piece, then cut it in half at the very end for installation on the glider.

Step one for making any wing is to sand in the airfoil. Doing this is a multi-step process, as shown in Figure 1.

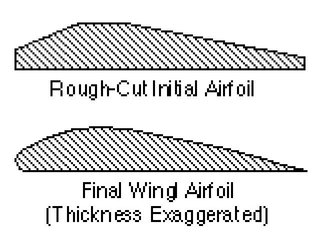


Figure 1. Shaping the Airfoil

First, put a felt-tip pen line across the wing at the point 25 percent of the way back from the leading edge toward the trailing edge. This is where the highest point in the airfoil will be at the end of your sanding, and is the only place where the finished wing will remain the full thickness of the original balsa.

When you are done sanding, this line should still
be there, at least at the center part of the wing.

Next, use a balsa planer or a sanding block with coarse paper (I use 60 grit cut from a belt-sander belt and placed in a hand sanding block) to rough-cut the airfoil shape as shown in Figure 1. Also, taper the wing's thickness somewhat out toward the tips so that the airfoil's thickness is constant as a percentage of the wing chord at each point along the span.

Finally, use progressively finer sandpaper (ending with 400 grit) in a sanding block to bring the wing to the shape of the airfoil. I sight down the length of the wing frequently during this process, to ensure that I am doing the sanding evenly along the whole span, and at the end I hold the wing up to the light to ensure that the same amount of light passes through at each point along the trailing edge, indicating that it is thin enough and evenly thin all along the wing.

If you are going to tissue your wing, this is the point in wing construction where you do that. More about this later. If you do not tissue the wing, at least put one coat of clear dope on it to improve its resistance to moisture and warpage, and to make its surface finish smoother and less draggy.

Once the tissuing or doping is done, it's time to cut the wing. The D-Light uses simple dihedral (two-piece wing); other designs may use a three-panel or four-panel polyhedral. Regardless, the wing cannot stay flat or it will have no capability to provide corrective stability and bring the glider back to level flight in the event of gusts or other disturbances in glide. Normally, the wingtips are each raised about 1/8 of the total wing span by use of either dihedral or polyhedral. For the D-Light, this is 2 1/2 inches per wingtip.

Cut the wing along the line where the two half-wing patterns met. (It's OK to stop here for a minute and admire the cross- section view you just created of the airfoil you worked so hard to sand in.)

Now you need to bevel an angle into this fresh-cut edge of each of the two wing halves. Place each wing half with this edge lined up along the edge of your workbench, with the wingtip propped up by a 2 1/2-inch block on the bench. Use a sanding block along the edge of the bench to put in a bevelled root edge so that when the two halves are joined with the wingtips raised, the beveled edge on each half will be in 100% contact with the other for strength.

Once the bevels are done, use the "double gluing" technique to attach the two wing halves: put a thin layer of aliphatic resin (yellow) glue on each edge, push the two together, then separate and let dry. This ensures complete penetration of the glue into the wood, greatly improving subsequent strength of the bond. Then apply glue again, and push the two halves together. Prop each wingtip up 2 1/2 inches with a block and put a weight on the wing joint to hold it flat on the workbench (with a piece of wax paper under it so it does not get glued to the bench). Let dry overnight, then reinforce the top of the joint with 30-minute or slower epoxy that can soak into the wood before it sets.

Tissuing

Adding a surface finish of model airplane tissue to a balsa wing greatly enhances the stiffness and smoothness of the wing, improves visibility to timers due to its color, and distinguishes the user as one of the true elite of glider people. If you do not use tissue on the D-Light, be sure you use 1/4-inch balsa for the wing rather than 3/16-inch and use Magic Marker or other lightweight pigmentation to make the wings a more visible color than bare wood.

Standard wrapping tissue is not what you use for gliders; use only the strong and light "Japanese" model airplane tissue, imported by Peck Polymers and sold by some hobby shops and model airplane suppliers. My personal preference is black tissue, but red is also a good visible color. Blue is counter-productive, but I've seen people use it!

Applying tissue starts with prepping the balsa surface. The surface needs a 400-grit or finer surface finish, and is then given a single coat of thinned clear dope which is sanded smooth after it dries. I prefer to use the Sig "Litecoat" brand of clear dope for tissuing, because it has a greater fraction of volatiles than most other dopes and dries with a much lighter weight, but any clear dope will work.

Next step is to cut out the tissue pieces that will be applied. Always apply tissue so that its dull side is down in contact with the wood, and always tissue both sides of a wood part to avoid warpage as the tissue dries and shrinks down tight. Cut the tissue pieces to fit the wing using a fresh, very sharp single-edge razor blade, and cut them so there is substantial excess tissue around every edge.

You may wish to make two half-pieces for the top of the wing, leaving a 1/2-inch gap at the center of the wing. This will be the joint for the wing's dihedral, and also the area that the rocket motor's exhaust will toast during boost, so this strip of the wing should be coated with epoxy eventually, which does not stick well to tissue.

Tissue the top of the wing first. Apply clear dope (thinned 50% with thinner) starting at one end of the wing, and lay the tissue (dull side down) on the fresh wet dope progressively as you work across to the other wingtip. When the entire top has been tissue-covered, rub the whole thing down with a small pad of toilet paper soaked in thinner, ensuring that there are no wrinkles.

Once the tissue has dried, trim carefully around the edge of the wing with a sharp blade, leaving a 1/16-inch excess. Wet this with undiluted clear dope and tack it down over the leading and trailing edges onto the bottom side of the wing one section at a time.

After the top and edges are dry, repeat the tissuing process on the underside of the wing. When this side dries, trim or sand all excess tissue from the underside tissue all the way around the edges of the wing. Apply one coat of thinned dope to the entire wing, then sand completely smooth with 400 grit or finer when this dries. The wing is now tissued!

Building the Rest of the Glider

The stabilizer and rudder of the D-Light are very straightforward to build. Simply cut them out of light (6-7 pound C-grain) 1/8-inch balsa and sand in a purely symmetric airfoil (rounded leading edge, sharp trailing edge) just like a fin. They can be tissued if you wish for appearance purposes; the added strength is not required. Like the wing, if you do not tissue then give them one coat of clear dope.

The fuselage of the D-Light is made of 3/16-inch hard, stiff balsa; 12-16 pound density is best. It should be sanded such that any portion that will not have other parts (wing, pod, or stabilizer) attached to it has rounded, smooth edges. The whole thing should be given a 400-grit or better sanded finish and one coat of clear dope. The cutout where the pod's "piece-X" tab fits in should be cut out after the pod is made, by tracing the outline of the pod's tab on the fuselage and cutting out this exact shape. Glue 1/16-inch hard balsa side pieces on both sides of the fuselage over this tab cutout.

When gluing the glider together, first put the stabilizer on the fuselage. Use yellow glue for this joint (reinforced later with epoxy) and use blocks to support the fuselage exactly vertical while the stabilizer glue is setting. If you tissued the stabilizer, use a needle to poke dozens of tiny holes through the tissue along the line where the glue will go.

Put a 1/64-inch thick shim between the leading edge of the stabilizer and the fuselage, so that the stabilizer's aerodynamic force will tend to kick the glider tail downward. While this has to be counteracted for glide trim by adding some nose weight later, it ensures that the glider transitions quickly from boost, without a "death dive" type of failure.

Put the wing on the fuselage next, while the fuselage is being held nicely vertical on your workbench by the already-attached stabilizer. First sand a flat gluing surface in the sharp V edge on the bottom of the wing where the two halves are joined. Glue the wing on once again with yellow glue, followed later by epoxy fillets along the underwing wing-body joint.

Put blocks under each wingtip, but don't make the two wingtips the same height above the workbench unless you want your glider to sail off into the distance in a straight line when you fly it. Make the left tip about an inch higher than the right tip, so the glider will do nice lazy clockwise (right) turns in flight. Reinforce this turn by gluing the rudder to the fuselage very slightly out of straight alignment and toward the right.

Dethermalizer

Once the glider is assembled, you may wish to add a "dethermalizer" or "D/T". This is an aerodynamic control device to limit how long the glider stays up by breaking up its glide at a predetermined time so that it does not fly off into the distance if it catches a thermal; hence the name. It is useful for those competition flights where you absolutely must get a return on the glider (e.g. you flew away your first one already in a contest). If it is well-designed, it adds little performance penalty when it is taped in the not-enabled position during those flights where it is not needed. There are many different designs, but I prefer a the wing flap type shown in the D-Light plans for my larger gliders.

The timing element of a dethermalizer is a length of cotton cord (sold by model airplane suppliers such as Sig Manufacturing as "dethermalizer fuse") that burns at about 1/2 inch per minute. A piece of the appropriate length is cut and installed, ignited just before launch, and at the end of its length it burns through a thread that had been holding down a pop-up aerodynamic surface&emdash;in the D-Light, a wing flap on the wing panel on the right wing (the inboard side of its turn direction.) When the flap pops up, it converts the glider's slow turn into a rapid dive to the ground.

Because of the potential fire hazard, the end of a D/T fuse is always held in a "snuffer tube," an aluminum tube that shields and contains the glowing fuse remnants when the glider lands. And the area along the fuselage that the fuse contacts while it is burning during glide is coated with epoxy to avoid setting the glider on fire.

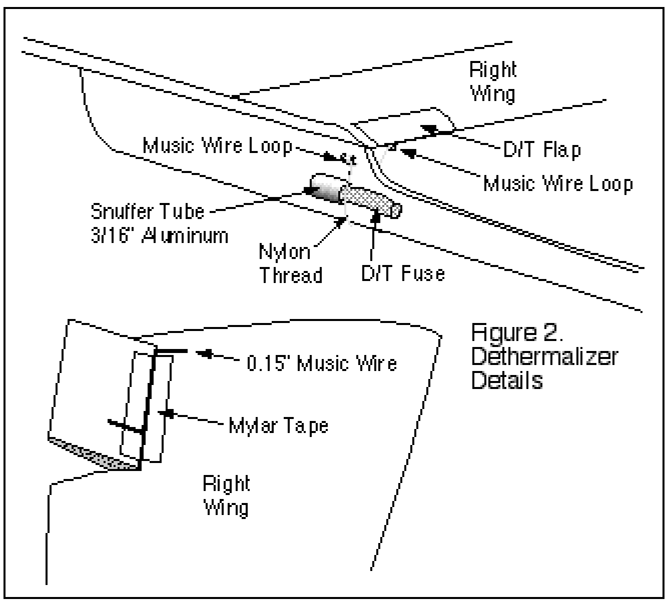


Figure 2. Dethermalizer Details

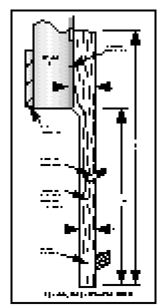
The D-Light's D/T design is shown in Figure 2 above. The flap is cut out after the wing is installed on the glider, then a piece of fine (.015 inch) music wire is bent in a Z-shape, with one of the ends then being glued (with cyanoacrylate glue) to the main wing and the other (which is bent upward by 30 degrees or so) to the wing flap while it is in the raised position. The center part of the Z provides torsion to lift the flap and is not glued at all, but is held in place by a mylar tape hinge that secures the flap to the wing.

As shown in the figure, a thread runs from a music wire loop on the underside of the flap, across the bottom of the fuselage, over the D/T fuse where it enters the snuffer tube on the opposite side of the fuselage from the flap, and to a wire staple just above the snuffer tube. When no D/T action is needed, the flap is just taped in the flush position and no fuse is installed.

Be sure to check the D/T fuse burn rate with a ground test before cutting to the flight length you want. This type fuse generally burns 25% or so faster in glide with air going by than it does in a static ground test.

Building the Pod

The pod is pretty standard in appearance and function, as shown in Figure 3 at right. The standoff is made of a "sandwich" of 3/16-inch hard balsa (as the core) with 1/16-inch hard balsa sides laminated on using yellow glue. The "piece-X," or tab that holds the pod onto the glider, is made from spruce and is placed in a cutout space from the core balsa during assembly of the sandwich. The pod is held straight on the glider with a small piece of .030-inch music wire several inches forward of the "piece-X" that fits into a small hole on the glider fuselage.



Fit of the pod is critical to preventing the dreaded "Red Baron"; when you hold up the glider-pod assembly by the glider in ready-to-fly configuration, if the pod does not fall off, it's too tight and you need to sand the tab!

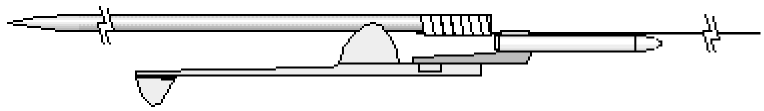
I recommend that you use an external anchor line (as shown in the drawing) to attach the recovery system to the pod, so that the pod does not hang vertically with its balsa standoff downward during recovery and risk breaking off the balsa on landing. I also have had much better success in avoiding Red Baron entanglements between pod and glider when I use a parachute rather than a streamer on the pod.

Flying the Glider

The D-Light should be trimmed carefully before flight. It will need nose weight; start by adding enough to put the glide balance point 3/4 of the wing's chord back from the wing leading edge as shown in the drawing, then work from there.

Toss the glider with a straight-ahead, wings-level "push" throw from shoulder height at first, adding or removing nose weight as required to get a good glide. Once this is working, do some straight-up hard throws to simulate boosts and verify that the glider pulls out of any post-boost dive and transitions to glide with an appropriate turn. Do this in soft ground, so you don't shatter the glider if it does not pull out!

Use a little weight on the right wingtip if the turn is too weak to suit; but do not trim for a turn tighter than about a 100-foot radius.



This glider needs to travel three feet up a 3/16-inch rod to fly well on an Estes D12. If your rod is only three feet long, tape the rod to a tall stake in the ground so that the glider hangs down below the base of the rod and the glider pod has a full three feet of travel. If you're using a D/T, remember to light it just before launch and launch as soon as you light it!

I have flown this glider with great success and a perfectly straight, very high boost on Estes D12-3 motors and on the old Aerotech single-use D7 motors. The Apogee D3 motor does not have enough thrust to provide a glider this big and heavy with a straight boost except in dead calm conditions. The Aerotech D9 reloadable would probably be a good choice once it gets NAR certified.

Build light, fly high, and glide long!

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by Trip Barber NAR 4322