Al Clark's mysterion

by Al Clark

BUILD YOUR OWN INEXPENSIVE AEROBAT

The Mysterion was designed in response to a request from my brother, Rod, who has flown several of my lightweight park flyer designs. Rod has access to a large, well-manicured grass field and wanted a slightly larger model that would excel at aerobatics and be able to handle the wind.

When designing the Mysterion, I spent much time trying to come up with the best combination of weight, size, aerodynamics, and equipment. I believe the result hits the sweet spot.

I incorporated everything I've learned from my previous designs into the Mysterion. The motor, wing, and stabilizer are all on the thrustline as well as the vertical CG. The model balances perfectly on the spinner if it is positioned vertically on its nose.

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The finished Mysterion is ready to go for another fun aerobatic flight. The sunburst color scheme is great for visibility and orientation. With no landing gear and a folding propeller, it is perfect for flying from grass.

The fuselage is thin, has ample side area, and the canopy is placed well forward. This provides good knife-edge flight and good tracking in maneuvers. The wing uses the marvelous Eppler 168 symmetrical airfoil section, which has a wide speed range, is well behaved at slow speeds, and refuses to tip stall while performing excellent snap rolls and spins.

The wing has no dihedral—making inside and outside maneuvers similar. The rudder area is large, providing good control in knife-edge flight and making hammerhead stalls easy.

I incorporated some other features into the design to make flying the model more convenient. The wings are attached using a carbon-fiber tube, music wire pin, and two 10-32 nylon thumbscrews. Easy wing removal makes the Mysterion convenient to transport in any small vehicle.

The propeller is a folding Aeronaut—allowing for grass landings without the worry of breaking expensive propellers. It also has the bonus of cutting the drag when the motor is off, improving the glide.

The BB Model Turbo spinner unit does a great job of introducing cooling air to the motor and battery.

The fuselage top—from the rear edge of the canopy all the way forward to the motor cowling—is removable. It is held on with magnets for easy battery and radio access.

The power system uses reliable and readily available components. The E-flite 480 Brushless 1,020 Kv outrunner motor, Castle Creations Thunderbird 36-amp ESC, Thunder Power 3S 2,700 mAh Pro Lite 25C battery, and Aeronaut 10 x 6 folding propeller are a good match to the Mysterion's airframe and provide excellent performance.

JR DS290G digital servos are used on the ailerons and the Hitec HS-5065MG digital servos are used on the rudder and elevator. Short aileron pushrods and stiff carbon-fiber rudder and elevator pushrods result in precise control inputs. A Spektrum AR 6200 receiver provides a solid radio frequency link.

The finished model weighs 36.7 ounces. When using a Thunder Power 3S 2,700 mAh battery, the flight duration is approximately 8 minutes at generally full throttle.

When it comes to aerobatics, the Mysterion performs better and more precise aerobatics than any of my previous designs. It does exactly what I tell it to do—no more and no less. It rolls as if on a string.

Outside maneuvers look as good and are as easy to perform as inside maneuvers. Snaps and spins, both inside and outside, immediately stop when the sticks are released. Vertical performance is excellent, requiring the throttle to be reduced to perform hammerhead stalls. Knife-edge flight requires only a small amount of down-elevator mix (no more than 5%).

Slow-flight performance is amazing with the Eppler E168 airfoil section. If you didn't know better, you'd swear the model had a semisymmetrical airfoil when slowly flying. It happily flies around with complete control and refuses to tip stall.

With the power off, the Mysterion has a flat glide because it is clean. It is fun to give it a little altitude, shut off the motor, and perform dead-stick aerobatics.

The Mysterion is a great all-around model. It is relatively inexpensive to build, small enough to fit in nearly any vehicle, large enough to be visible in the sky and handle some wind, and has excellent flight performance. In my more than 40 years of model designing, it is my best effort!

Construction

It is very important to pay attention to the balsa wood densities specified, especially in the tail. The Mysterion has a long tail moment and any extra weight in the tail or aft fuselage will require nose weight to be added, reducing flight performance accordingly.

Study the plans to make sure you understand how all the bits go together. The fuselage is slightly more complex than the usual four-sided type, and the wings are more like glider wings than the usual powered model. All gluing is done using CA (thin) unless otherwise specified.

Tail Section

The tail is made from $^3/_{16}$ balsa with a little $^3/_{16}$ x $^1/_4$ spruce (sanded down from $^1/_4$ square spruce stock). Use medium density for the elevator and rudder and medium-hard for the stabilizer and fin.

Use CA glue if you can make good-fitting joints, otherwise use Zap CA+. Draw a centerline on the front edge of the finished elevator and rudder to assist in making straight hinge slots with a #11 hobby knife, then bevel the front edges as shown on the plans. Make matching hinge slots in the stabilizer and fin. Cut some Sig EZ Hinges, or similar hinge material, in half and temporarily hinge the rudder and elevator (no glue), then round off all of the outer edges of the tail.

Control horns are made from two layers of $^1/_{32}$ plywood glued together with CA+. Laminate the wood, apply templates with rubber cement, drill the $^1/_{16}$-inch holes, then cut the horns out and sand to final shape.

Saturate the $^1/_{16}$-inch holes with CA and then run the drill through them again after the CA cures. It's also a good idea to coat the entire horn with a thin coat of CA, wipe it off, then lightly sand it smooth—this gives protection from moisture.

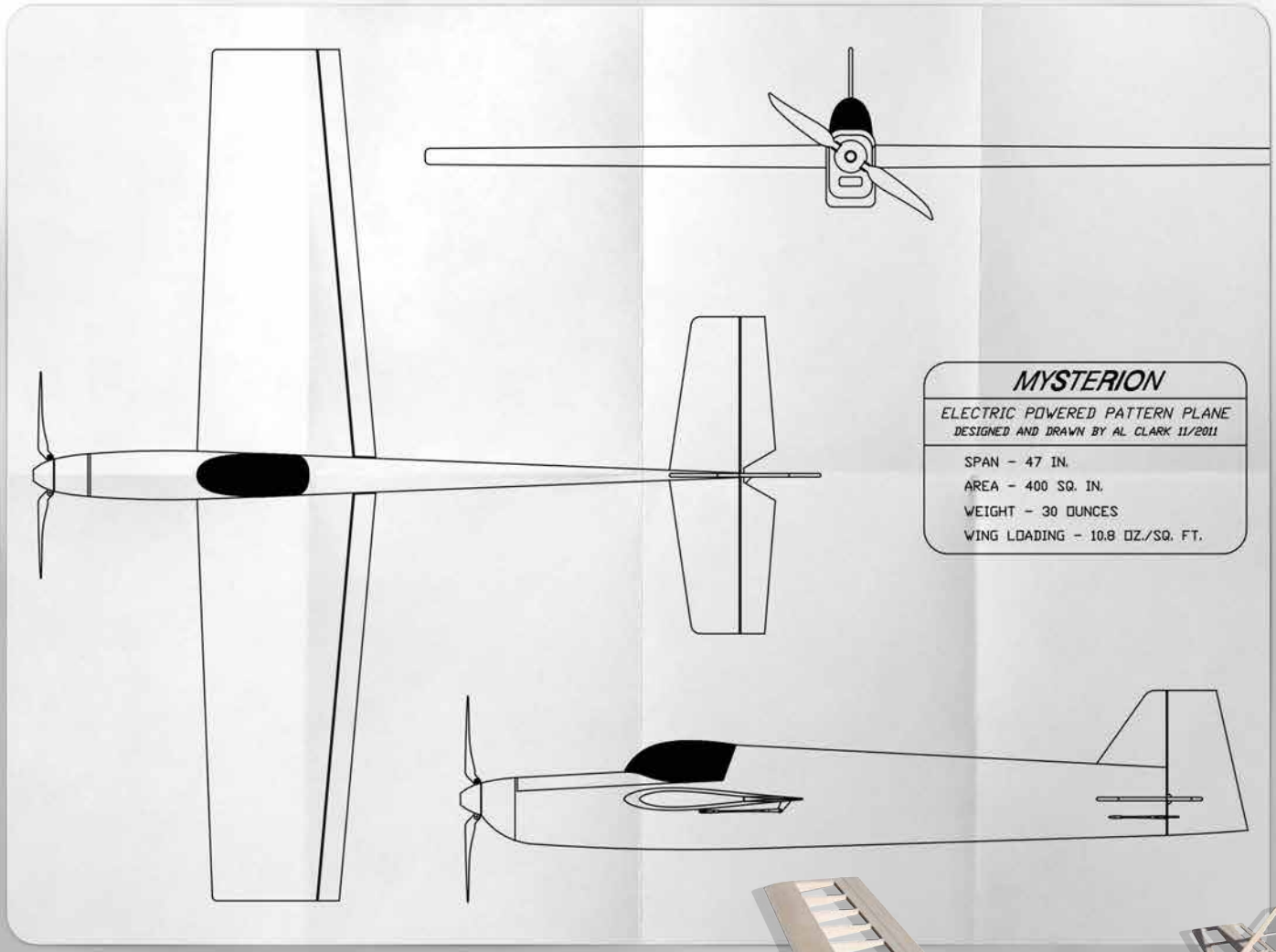
After the horns are completed, glue them into the rudder and elevator. Then put a small scrap of balsa into the slot at the front of the horn and sand it off to match the bevel on the rudder. That avoids having a small dip in the covering at that spot.

On the prototype, the fin and rudder with hinges and control horn weighed .3 ounces. The horizontal stabilizer and elevator with hinges and control horn weighed .84 ounces. If you have paid attention to your balsa density, you should be close to these weights.

Fuselage

The fuselage sides should be cut from medium-density matched sheets if possible. This will ensure both sides bend the same in the forward area. Carefully cut the stabilizer and pushrod slots. It is good to use the finished stabilizer as a guide for the stabilizer slot size, ensuring a good fit.

Note that the $^1/_{16}$ balsa fuselage doubler pieces have two



The finished airframe is sanded and ready to be covered. The canopy will be glued on after covering.

mysterion

SPECIFICATIONS

Type: Electric sport model

Wingspan: 47 inches

Wing area: 400 square inches

Weight: 36.7 ounces

Wing loading: 13.2 ounces per square foot

Power system: 200- to 300-watt brushless motor; 36-amp ESC

Propeller: 10 x 6 folding

Battery: Three-cell 2,700 mAh LiPo

Radio: Four-channel four micro servos

Construction: Balsa and plywood

An E-flite 480 1,020 Kv brushless motor is mounted to F1 using 1/4-inch diameter x 9/16-inch long 4-40 threaded circuit board standoffs. Other types of standoffs will work as long as the length is kept at 9/16 inch. At the top of F1 are the ends of the two 1/16-inch music wire hatch pins.

This shows the aft end of the right fuselage side. The stabilizer doubler and balsa filler are clearly visible. The aft portion of the stabilizer doubler and the filler were sanded to a taper so the left side would fit, and they were notched to accommodate the rudder hinges.

different grain directions. The forward section of the doubler is made from 3-inch wide sheets edge-glued together. Glue the forward and aft doubler pieces together, then cut out the balsa and glue in the square 1/16 plywood piece. Cut the slots for the servo rails but do not make any holes yet.

Make the master rib #1 template from 1/32 plywood. Be careful to make this accurately because it locates all the holes for the wing rods and sets the angle of incidence. Glue the doublers to the inside of the left and right fuselage sides (I use CA+ but you can use whatever you are comfortable with), making sure they are spaced aft of the front edge by the thickness of the firewall F1.

Now pin or tape the fuselage sides to each other with the doublers on the outside. Lay the sides down over something firm such as a piece of pine. Use the paper doubler template to properly position the master rib #1 template and pin it in place. Make holes using sharpened brass tubes in the sizes indicated. The #9 hole will have to be made using a drill bit.

Cut out the lightening holes, glue on the 1/16-inch stabilizer and rudder hinge doublers, the 1/8-inch square longerons, and the vertical 1/8 x 1/4 pieces. Carefully cut slots in the stabilizer doublers to match those already in the fuselage sides. Referring to the top view, taper the stabilizer and rudder hinge doublers, and lower longerons so the fuselage sides will meet properly at the tail.

Referring to the side view, taper two pieces of 1/2-inch triangular stock down to 1/8-inch triangular (use a razor plane or coarse sandpaper) and glue them to the lower edge of the fuselage doublers. Then cut nearly all the way through the triangular stock every 1/2 inch with a razor saw to later facilitate bending. Be careful not to cut into the doublers.

Pin the turtledeck floor down to the building board over waxed paper and glue each fuselage side to it. (The fuselage sides are inverted for this step). Before gluing, make sure the sides are perpendicular to the building surface and tight against the sides of the turtledeck floor.

Put the servo rails into their slots and then glue F3 into place with the tail end of the fuselage sides held together temporarily. Use the servos to check the servo rail spacing, then glue into place. Use a square to make sure the ends of the fuselage sides are perpendicular to the building board and glue them together.

Glue F2 into position on the battery shelf using CA+. Make sure F2 is perpendicular. Dry-fit F1 and the battery floor with F2, sanding the edges, if necessary, to get a good fit. Put the battery shelf and F1 back in place, clamp or tape the sides to F1 and check the alignment over the plans top view.

Check to make sure there is no twist on F1 and F2 compared with F3. Make sure there is no left or right thrust in F1. When satisfied with the alignment, glue F1, F2, and the battery shelf to the fuselage sides. If the joints at F1 are not a tight fit, go back over the joints with CA+.

F2 has been glued to the bottom of the battery floor. The battery floor with F2 and the firewall F1 are dry-fitted and held into position with clamps at F1. After checking the fuselage to make sure it is not twisted, the battery floor and F1 are properly positioned, glue all the joints using CA. Make sure F1 has no up/down or left/right thrust before gluing.

Sand the edges of the fuselage bottom as necessary to make sure everything is flush. Install the two lower motor standoffs now while the screws are easy to access. Edge-glue pieces of 1/16 balsa together and cut to match the fuselage bottom shape from F1 back to the center of the edge of F3.

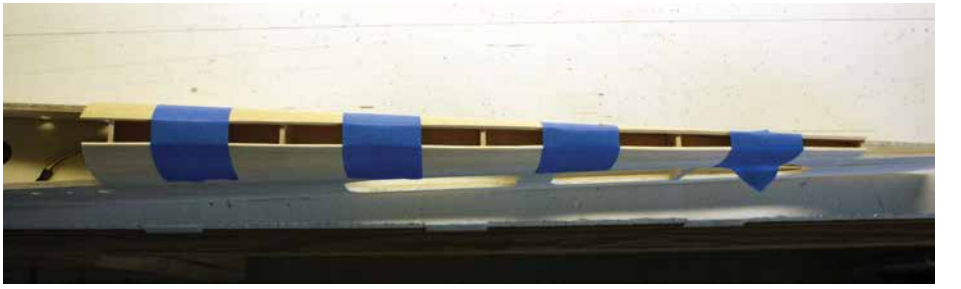
Where the ESC will be mounted, spread a thin layer of five-minute epoxy and let cure; then attach a strip of sticky-back Velcro. Now glue the 1/16-inch cross-grained bottom from F1 to the middle of the edge of F3. Sand the joints in the bottom sheeting smooth. Cut a piece of 1/32 plywood to size (grain fore and aft) and laminate it onto the 1/16 balsa bottom sheeting using CA+.

Install turtledeck formers T1 through T5, made from lightweight balsa, using the angle gauge to ensure the proper angle on T1. Make sure these formers are all centered; it's best to draw a centerline down the turtledeck floor and mark the center of each former to help guide their placement.

The bottom edge of the right side turtledeck sheeting has been glued to the fuselage side with CA. Next, the outside of the turtledeck sheeting will be dampened with water so the sheeting will better conform to the turtledeck formers, and the sheeting will be glued to the formers with CA.

Cut out the turtledeck sides from fairly light 1/32 balsa leaving roughly 1/16- to 3/32-inch extra all around (you can just roll the fuselage onto the sheet of balsa to see where the top of the sheeting is. It works well at T1 where there is substantial curve.

Make sure the bottom edge of each side is straight. Glue the bottom edge to the fuselage side (I tack-glue it at each T former first to make sure it is tight to the formers). Dampen the upper half of the outside of the balsa sheet with water and let sit for 2 or 3 minutes, then glue the sheet to each T former starting at T5 and working forward.



A-grain 3/32-inch balsa sheeting is lightly dampened with water on the outside and glued to the turtledeck formers. The top edges are pulled in slightly and held with painter's tape so the sheets will dry straight. After drying, the top edges are sanded level with the turtledeck formers.

After you attach both sides, put a piece of 2-inch painter's tape across the sides between all of the formers to pull the sides in. You can pull them in slightly past straight. Let them dry for an hour or two, then sand the top edges down to the tops of the T formers.

Check with a straightedge as you get close. Cut out a piece of 3/16 balsa to fit the top, leave some extra width, and glue it on. Use the rear canopy former and the plans section C-C as a guide to sand the top of the turtledeck to shape.

The sides will get sanded slightly as well and that is okay. If you like, you can delay shaping the turtledeck until after making and installing the pushrods so you don't ding the top of the turtledeck while the fuselage is upside down installing the pushrods.

Make up the rudder and elevator pushrods to exactly match the plans. The carbon is .125 x .065 inside diameter and the ends are 1/16-inch music wire. One inch of the music wire is scuffed well with 100-grit sandpaper and then epoxied into carbon tube. The forward end of the pushrods use Du-Bro #112 solder Kwik Links (soldered on) and the aft end uses Du-Bro #111 threaded couplers (soldered on) and Du-Bro #109 Kwik Links.

The #112 solder links are a loose fit so they will need to be held straight while you are soldering them to the music wire. Install the rudder and elevator servos and cut off the servo arms so you have one arm with the holes matching the radius as shown on the plans. Make sure to use the second hole for the rudder and the first hole for the elevator when attaching the solder links.

To install the pushrods, you will need to cut out a thin section of fuselage directly behind each pushrod slot, from the aft edge of the pushrod slot almost to the tail end of the fuselage. Cut this with a fresh razor blade.

Install the pushrods, then carefully glue the thin sections of fuselage back into place. Cut the fuselage bottom to size from 3/32 balsa with the grain running fore and aft. Cut out the servo access/cooling hole, and CA into place.

Glue the fin on making sure it is vertically aligned with the fuselage. Slide a 12-inch long 11/32 outside-diameter (OD) brass tube through the fuselage wing tube hole to check for square with the tail. If the aft end of the fuselage was perpendicular when you glued the sides together at the tail, the brass tube should be square with the vertical tail.

If necessary, lower one side of the tube slightly to get it square. Check the brass tube's alignment in the top view and check to make sure it has the same angle on each side of the fuselage. Adjust as needed.

Servo mounts are made from 1/8 x 1/4-inch and 1/8 x 3/8-inch spruce for the Hitec 5065MG rudder and elevator servos. Pushrods will be attached to these servos before the fuselage bottom is glued on.

Cut a piece of $^{11}/_{32}$ OD brass tube the correct length to match the fuselage width, scuff the ends with sandpaper, and slide it through the fuselage. Now slide the carbon wing tube through the brass tube. Check the alignment of the carbon wing tube against the vertical tail and the top view. Use balsa shims in the fuselage holes if necessary to properly position it. When everything appears correct, tack-glue the brass tube with CA+. Pull the carbon rod out and finish gluing using CA and CA+.

Cut a piece of $^{1}/_{8}$ OD brass tube the correct length to match the fuselage width at the rear wing pin position, scuff the ends with sandpaper, and slide through the fuselage. Now slide a 10- or 12-inch length of straight music wire through the brass tube.

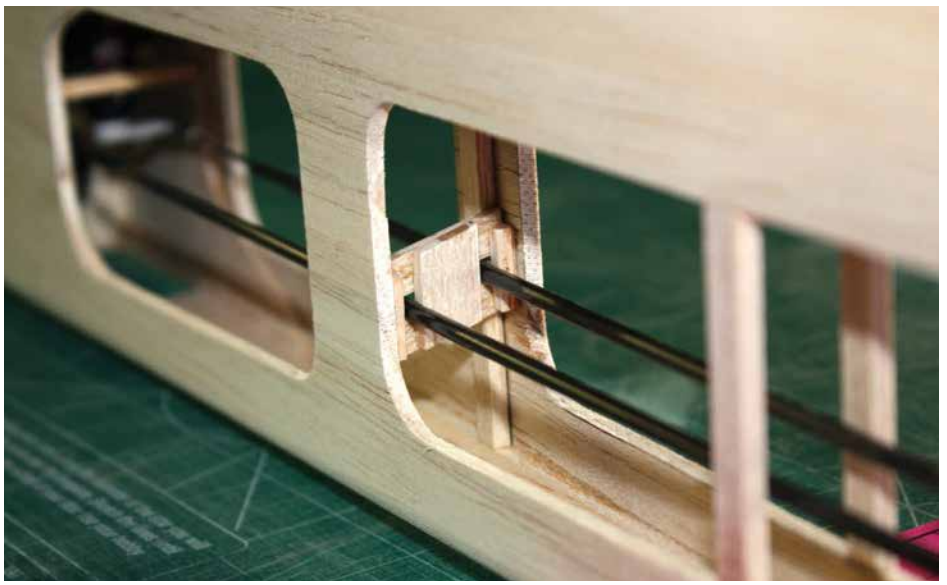
Check in the front view and in the top view to make sure the music wire is parallel to the carbon wing tube. Make any adjustments and then tack-glue the brass tube with CA+. Pull out the music wire and finish gluing with CA and CA+. Sand the ends of the brass tubes flush with the fuselage sides.

Make the balsa fairing blocks at the base of the fin from lightweight balsa. Try to sand them as close to final shape as possible, then glue them onto the fuselage and fin and finish shaping them. You can put some masking tape on the fins on each side for protection while sanding.

Make a center mark on the back edge of the stabilizer and slide it into the stabilizer slot on the fuselage, centering it and holding it in place at the back edge with a small T pin. Measuring from the aft stabilizer tips to a mark on the top center of F1, align the stabilizer and put a small piece of masking tape on each side of stabilizer against the fuselage to keep it in place. Use a square to make sure the stabilizer is perpendicular to the vertical tail. Adjust the slot if necessary, then glue (use CA+ if there is any gap).

Temporarily install the Sig EZ Hinges into the tail section (do not glue) and add the elevator and rudder. Hook up the pushrods to the tail control horns. Make sure the servo arms are at neutral, and adjust the Kwik Links to put the elevator and rudder at neutral.

Now install the pushrods guides, made from scraps of $^{1}/_{8}$-inch hard balsa. Refer to the plans top and side views to see where the guides go. Use small pieces of printer paper as spacers on one side of the carbon pushrods when installing the guides to ensure that the balsa guides are as close as possible to the pushrods, but not in contact with the pushrods.



After the pushrods have been connected to the tail surfaces and their length adjusted for neutral rudder and elevator, scrap balsa supports are added to the 1/8 x 1/4 hard balsa vertical stiffeners. These supports should be positioned for a slight clearance around the pushrods. These supports prevent the pushrods from bowing under high G loads.

Hatch

The hatch sides are cut from two pieces of $^{5}/_{8}$-inch thick balsa and the top is cut from $^{1}/_{8}$ sheet balsa. You will likely have to thin down some $^{3}/_{4}$- or 1-inch thick balsa stock to get the $^{5}/_{8}$-inch thickness. For accuracy,

create a template of the actual fuselage side curvature using manila folder stock. Do this for both sides.

Your templates should look like the ones shown on the plan for the hatch sides. Use the templates you just made to draw lines on the 5/8-inch balsa and cut out the left and right hatch sides. These will be made into triangular stock in the next step.

Make the canopy former from 1/8 light plywood. The edge of the canopy former needs to be smaller than the turtledeck former T1 by the thickness of the canopy. Rest the canopy former against T1 and use a sanding block on the ends of the hatch sides to achieve a good fit between F1 and the canopy former on each side of the fuselage. Make sure the outer edges are flush with the outside of the fuselage.

Now draw a line on the bottom of each hatch side that is 3/16-inch in from the outer edge (use the templates as a guide to draw this line). Remove the excess balsa on each hatch side with razor plane and sanding block so that you end up with a triangular cross-section that has a 3/16-inch wide flat area on the bottom. Refer to the hatch front view on the plans to understand what this looks like. The 3/16-inch wide flat area rests on the fuselage sides.

Place the canopy former back into position centered against T1, position the two hatch sides on the fuselage so their tops are level, make sure the outer edges are flush with the fuselage outer edge, and glue them to the canopy former. Use pieces of tape on the hatch sides to position them flush with the outer fuselage edges, then glue the 1/8 balsa top onto the hatch sides.

Glue F1A into the hatch with CA+. Add the 1/4-inch thick balsa piece to the inside bottom rear of the hatch. This should fit tight against the top, sides, and canopy former. Sand the bottom edge of this piece flush with the bottom of the hatch sides.

Cut the 1/8 x 3/8 and 1/8 x 1/2 medium-density balsa magnet holder pieces to length. Refer to the fuselage side view and hatch views. These should fit snugly between the fuselage sides.

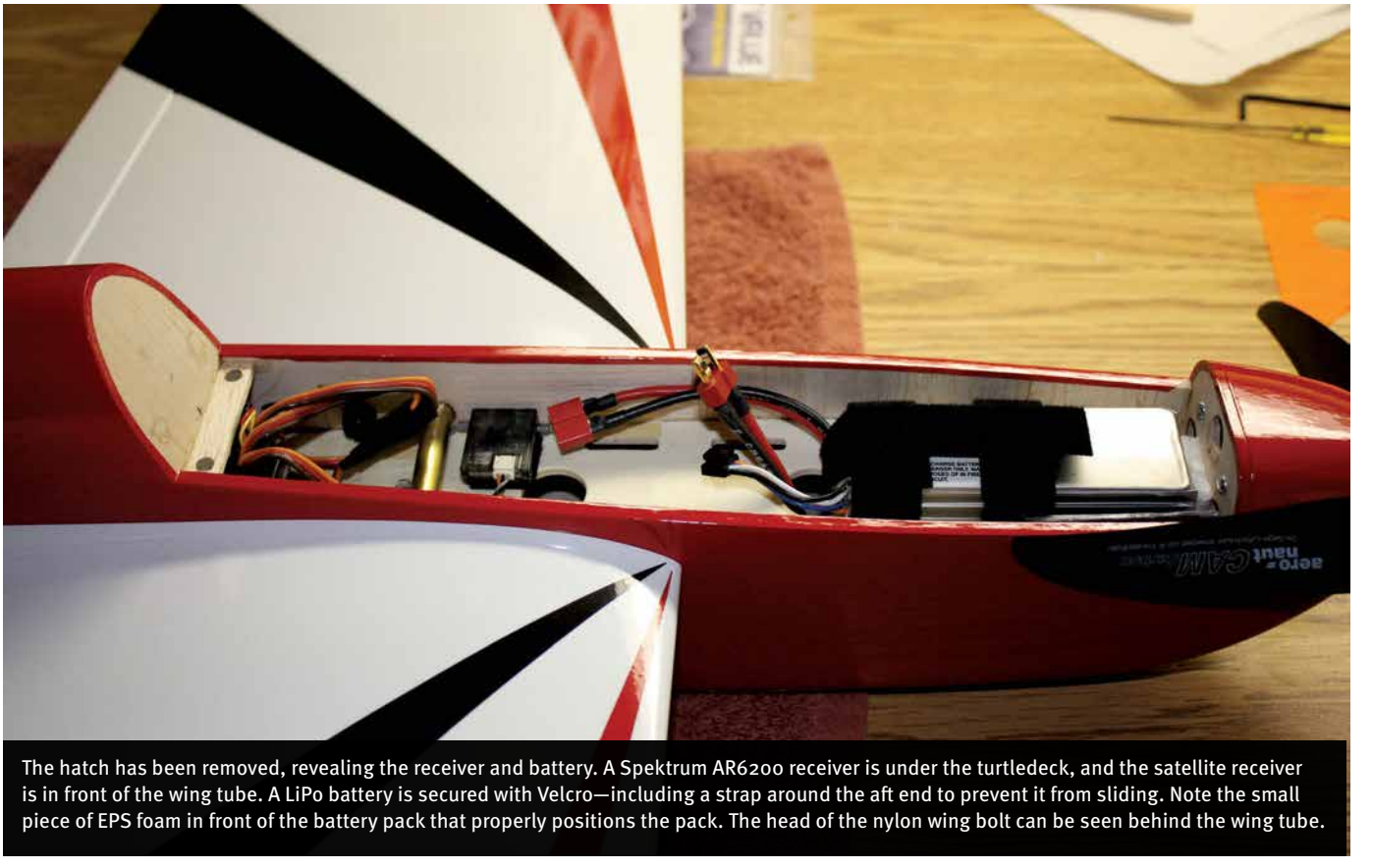
The holes for the magnets will be made next using a sharpened 3/16 OD brass tube. Put the holes into the 3/8-inch piece first. Align the front edges of the 3/8-inch and 1/2-inch pieces and put holes through the 1/2-inch piece using the 3/8-inch piece as a drill guide.

Before installing the magnets, put some Sharpie marks on them to indicate the proper orientation. You don't want to end up having one or more pairs repelling each other! Put the magnets into the holes flush with the interfacing surface of the 3/8-inch and 1/2-inch pieces and secure with CA (balsa magnet holder pieces should be apart before gluing the magnets). Then add some CA+ to the back side of the magnets.

Place the 1/2-inch magnet piece into the fuselage, with the aft 1/8 inch of it up under the bottom of turtledeck sheet, aligning it using the 3/8-inch hatch magnet piece. Check to see that the top of the 3/8-inch piece is flush with the top of the fuselage sides. You might have to slightly bevel the aft 1/8 inch of the 1/2-inch wide piece to achieve this.

When satisfied, put a small amount of glue onto the sides of the 1/2-inch piece (be careful not to get any on the 3/8-inch

Photos by the author



The hatch has been removed, revealing the receiver and battery. A Spektrum AR6200 receiver is under the turtledeck, and the satellite receiver is in front of the wing tube. A LiPo battery is secured with Velcro—including a strap around the aft end to prevent it from sliding. Note the small piece of EPS foam in front of the battery pack that properly positions the pack. The head of the nylon wing bolt can be seen behind the wing tube.

piece); then remove the 3/8-inch piece and finish applying glue to the 1/2-inch piece. After the CA has cured, put the 3/8-inch magnet back onto the 1/2-inch magnet and make sure the top of it is flush with the top of the fuselage sides. Sand it if necessary.

Glue this to the bottom of the hatch by putting some CA+ on the 3/8-inch magnet piece and setting the hatch down onto it, making sure the hatch is aligned side-to-side as you place it on the magnet. Don't get the CA+ too near the outer edges because you don't want to glue it to the fuselage.

Center the front of the hatch on the fuselage and drill 1/16-inch holes through the F1 former into F1A. Make the two 1/16-inch music wire hatch pins and glue into F1A with CA, adding some extra CA+ on the inside of the hatch and hitting it with kicker. It's good to scuff the gluing area of the pins with sandpaper before gluing. Plane and sand the top edges of the hatch assembly to round them off as shown in cross-section B-B on the plan.

Canopy

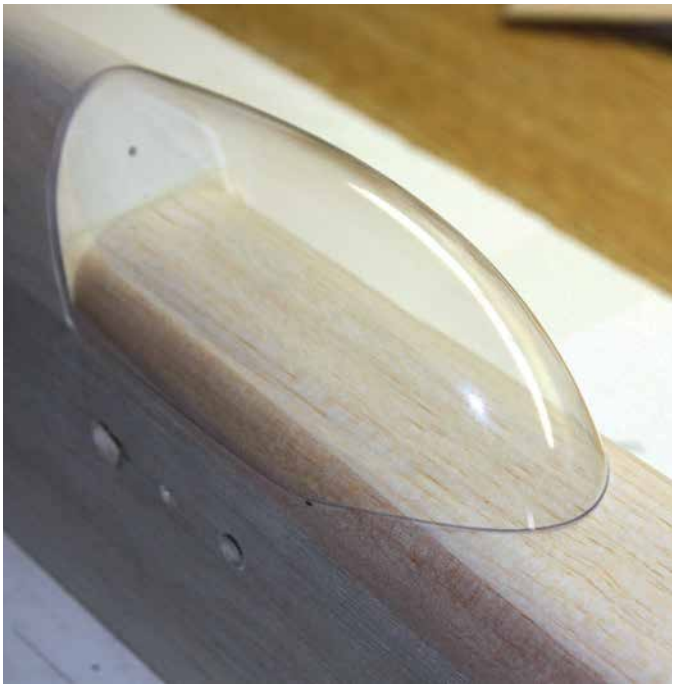
Add small balsa fill-ins at the base of the canopy former on each side of the hatch. This will prevent there being a gap after the canopy is installed later. Cut the canopy from the SIG 11-inch bubble canopy to the shape shown on the plan; leave it a bit oversize to start with and trim and check a bit at a time until you get a good fit to the hatch.

The canopy is painted on the inside with black Pactra RC car paint. Although expensive, it adheres well to the canopy which is necessary for gluing the canopy on. Cover the hatch first, and then attach the canopy to the hatch covering using a little 15 minute epoxy. That will give you enough time to clean any excess epoxy off with alcohol. After the epoxy cures, apply a 5/32-inch strip of UltraCote all around the canopy-to-hatch joint using a trim iron set on low heat. Don't dwell on the canopy material and it will work fine.

Cowling

The cowling template pieces are sized to allow the proper angles to be sanded into the edges. After the pieces are cut, refer to the cowling portion of the plans to understand how all of the pieces fit together. Because the sides all angle in at the front, there are some tricky angles on the edges. Work a little at a time and you should be able to get a good fit. Glue the four pieces together (use CA+ if the fit isn't quite perfect), making sure they look square from the front and rear.

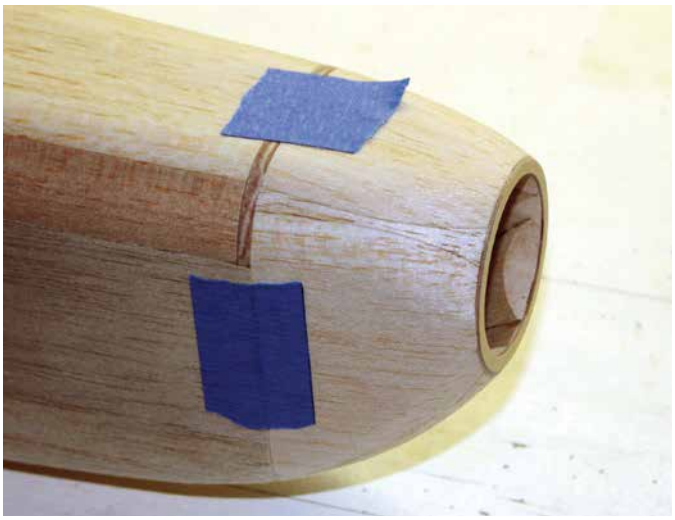
Because of the angles on the inside of the cowling, the corners of the triangular pieces will not be 90°. They will have to be sanded to fit. Get or make some short pieces of 3/4-inch triangular stock and sand them to fit properly into the corners of the cowl. Starting at 3/4 inch will allow room for some material to be removed when fitting them into the corners.



The canopy is cut from a Sig Manufacturing 11-inch bubble canopy. Cut it slightly large, then sand the edges until a good fit is achieved. The canopy is spray painted on the inside with black Pactra RC car paint and glued to the hatch after covering.

Mark each one at the proper position and taper them according to the plans. They will all be 5/8-inch size at the front. When satisfied with the fit, glue all four pieces in place. Sand the front and rear of the cowling flat, being careful not to sand off any one side more than the others. The front face should be parallel to the rear face and both should be perpendicular to the fuselage thrustline.

Temporarily mount the motor, slide on the cowling (you will have to trim the triangular stock at the front of the cowling for motor clearance), slide the spinner onto the motor shaft, and check the clearance between the spinner and cowling. You want 1/16 inch all around. Sand the front of the cowling as



The finished cowling is taped to the fuselage and a pencil is used the mark the inside edges at the sides and bottom. The cowling is then removed and the three spruce mounting blocks are tack-glued into place with small amounts of ZAP CA+. Check the cowling for proper fit, and when satisfied, glue the three blocks using CA.

necessary (or add some balsa if the clearance is too large) to get the proper clearance.

Cut out the 1/32 plywood spinner ring slightly oversized on the outside and leave the paper template on the ring for now. You will use it to aid in alignment. Center the cowling left to right and top to bottom over F1 and tack-glue it in the middle of each side onto F1. Set the spinner ring on, add the spinner, and use the spinner to accurately locate the spinner ring. Then glue the ring to the front of the cowling and remove the spinner.

File, carve, and sand the corners of the fuselage and cowling to achieve the cross-sections shown on the plans. Note that the bottom corner radius decreases as you go from the front to the back of the fuselage.

Sand the aft sides of the cowling to make them fair smoothly into the fuselage sides. When sanding at the front of the cowling to the spinner ring, don't go quite all the way. When you get close, check by putting the spinner on, then remove the spinner and do some more shaping where needed with 220-grit paper. After checking with the spinner a few times you should have a good match.

Make the three spruce mounting blocks for the cowling per the plans, paying attention to the angles. Pop the cowling loose with a razor blade and touch up the spots with sandpaper where it was tack-glued. Tack-glue the three mounting blocks carefully to the inside of the cowling in their proper positions. Put a drop of CA+ on the rear of each of the three mounting blocks—not too much you don't want to glue the cowling to the firewall—and put the cowling into position on the firewall, making sure the edges of the cowl are flush with the fuselage. After the CA+ is dry, pop the cowling loose and go back over the spruce mounting block to the firewall joints with some more CA.

Reposition the cowling, make marks on the outside over the center of each mounting block, and remove the cowling. Using a sharpened 1/4 OD brass tube, make a hole through the cowling centered over each of the marks you just made. Glue a short piece of 1/4-inch dowel into each of the three holes.

Carefully sand the dowel pieces flush with the inside and outside of the cowling. Reposition the cowling on the fuselage, tape it into place, and drill a 1/16-inch diameter hole through each of the dowel pieces and through the spruce mounting blocks.

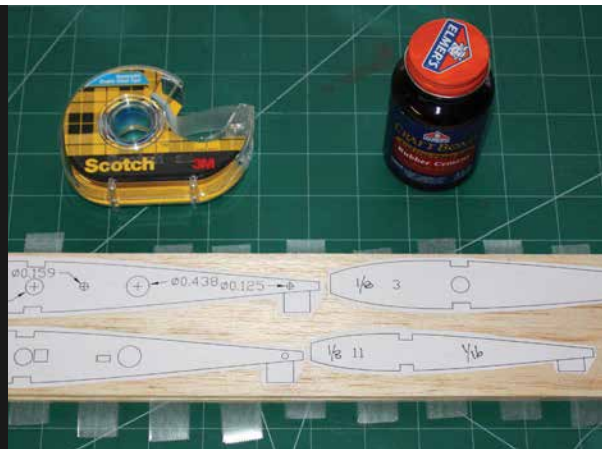
Remove the cowling and drill out the 1/16-inch holes on the cowling to 3/32-inch diameter. Put the cowling back on and install the three #2 button-head screws. Rub some soap onto four or five of the threads on the end of each screw before installing them and they will go in easily. If all looks good, remove the screws, pull off the cowling, and set it aside.

Wing

The wings are made as two separate panels. The tabs on the ribs ensure that the panels are built with no twist. When cutting the 1/8-inch thick ribs, it's easiest to stick two 1/8-inch sheets of balsa together with Scotch removable double-stick tape. Apply templates with rubber cement, and cut out the ribs out using a scroll saw.

After cutting, sand the edges to the line with a disc sander to ensure square edges. With the templates still on ribs #1, #2, and #3, use the master rib #1 template as a guide to cut the wing-tube holes with a sharpened brass tube. This will ensure the wing-tube hole spacing in the ribs exactly matches the fuselage tube spacing.

After the wing-tube holes are cut, check their spacing against the brass tubes that are already installed into the fuselage. Make the servo-mount holes and spar-cap notches in all of the 1/8-inch ribs while the two balsa sheets are still stuck together. After all the holes are made, pull the balsa pieces apart from the double-stick tape, peel off the paper templates, rub off the rubber cement, and draw lines across the tabs so you'll have a sanding guide when you remove the tabs.



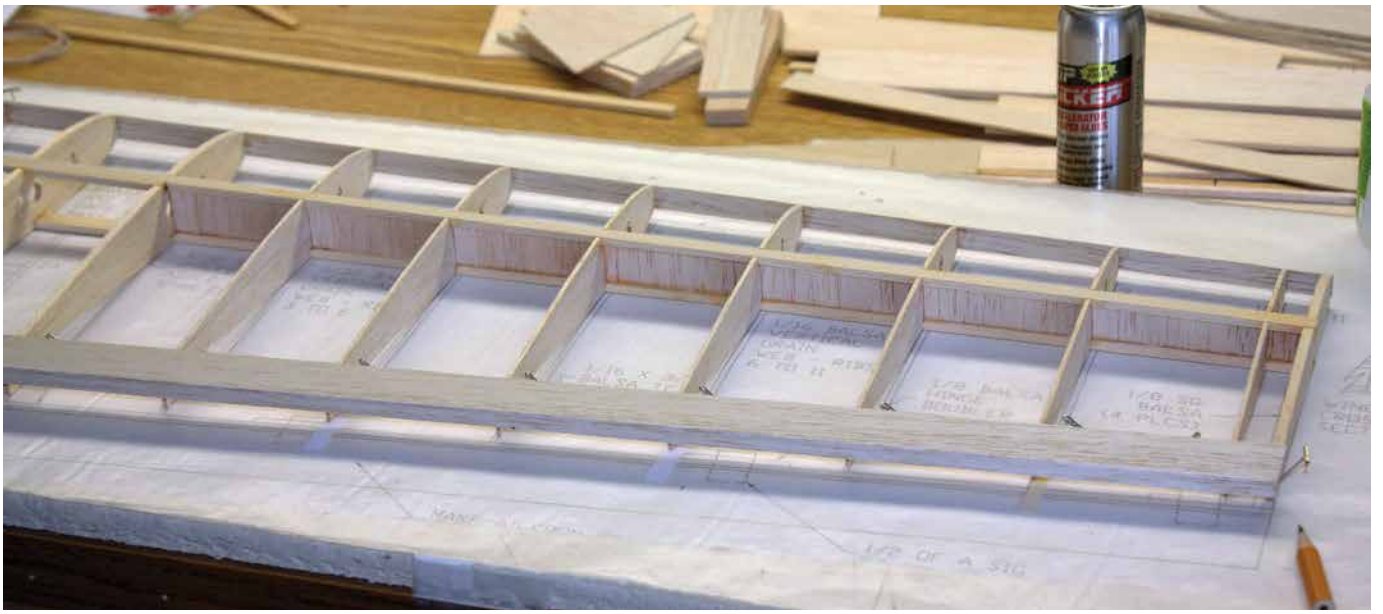
Cutting out the 1/8-inch thick balsa ribs is shown. Two sheets of 1/8-inch balsa have been temporarily stuck together using removable double-sided tape. Slightly oversize templates have been adhered to the top sheet with rubber cement, and then the ribs were cut slightly outside of the lines using a scroll saw. After cutting, a sanding block was used to bring the balsa down to the template lines.

Glue 3/32 x 1/8 spruce pieces to the aft edge of the spar caps from the root end to the outer edge of rib #3 using CA+. You can make 3/32 spruce by just sanding down some 1/8 square stock.

What follows is for one panel. If your building board is large enough you can build both panels simultaneously. Pin the lower spar cap in place over the plans—don't pin through the cap—and glue all of the ribs to it. Make sure to use the rib #1 angle template from plans sheet 3 on rib #1. The other ribs should be perpendicular to the building board.

Lay a straightedge along the top of all the ribs at the aft ends. If there are any gaps, put some paper shims under the rib tabs to bring any low ribs up to level. Bevel the top edge of the 1/8 hard balsa trailing edge (TE) to match the angle shown in the wing cross-section views. Then glue the TE to the ribs making sure the top edge is flush with the top of the ribs. Glue on the top TE sheet.

Install the top spar cap, making sure that the 3/32 x 1/8 piece you added earlier is on the aft side between ribs #1 and #3. Bevel the top of the 1/16 sub LE to match the angle shown in the wing cross-section views, then glue it to the front of the ribs making sure the top edge is flush with the top of the ribs.



All of the spar webs have been installed except for the first two rib bays where the wing tube resides. The top trailing edge sheet and the sub-leading edge have been glued on.

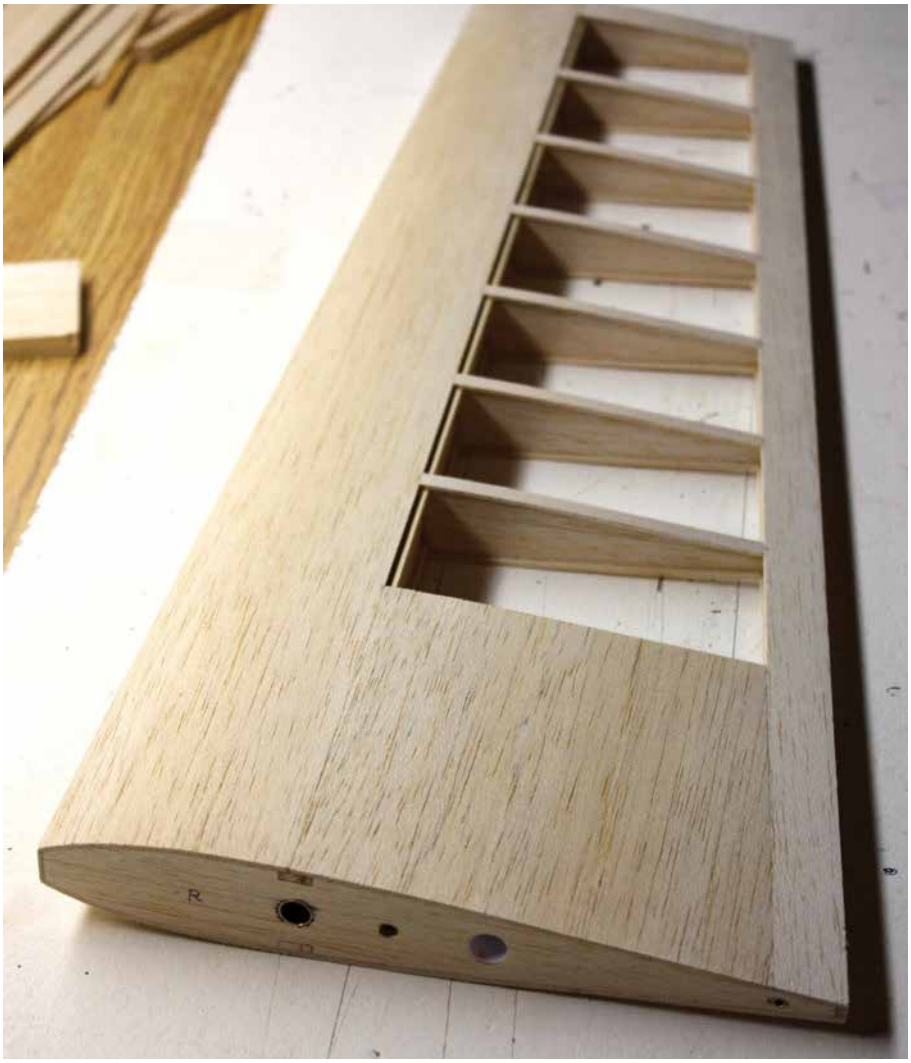
Install all of the spar webs outside of rib #3, making sure the grain is vertical. Cut a piece of $^{11}/_{32}$ OD brass tube to fit, scuff the outside with sandpaper, and glue it to ribs #1 through #3. Install the hard balsa fill-ins above and below the brass tube using CA+.

Remove the wing panel from the building board. Add the $^{1}/_{32}$ plywood webs between ribs #1 and #3. Sand the bottom edge of the sub LE to the proper angle flush with the edges of the ribs (protect the ribs with masking tape while sanding). Glue the $^{1}/_{8}$ square balsa pieces to inside edges of rib #11 on the top and bottom. Glue the bottom $^{1}/_{16}$ D-tube sheet on. The sheet only goes back to the center of the bottom spar cap, not the aft edge.

Put the wing back onto the building board with scrap $^{1}/_{16}$ balsa shims under each rib tab. Pin the ribs at each tab and use pin clamps or something similar to hold the wing down along the lower spar cap. Cut and fit the top $^{1}/_{16}$ D-tube sheet so there is roughly $^{1}/_{16}$ inch of overhang at the sub LE, and make sure it is straight along the spar. Again, the sheet only goes back to the center of the top spar cap, not the aft edge.

Mark the center of the top spar cap at each end. Now glue on the top D-tube sheet using the following process.

Apply aliphatic resin glue (Titebond, Sig Bond, or other) along the top of



The right wing panel is completed except for the LE and plywood root cap. The small hole behind the wing spar tube will be tapped for a 10-32 nylon screw.

ribs #2 through #10 between the sub LE and spar cap. Align the top D-tube sheet on the spar using the center marks and CA all along the spar cap. Now, beginning at rib #6, pull the D-tube sheet down over the front of rib #6 and tack it to the sub LE at rib #6 with some CA. Continue to do this at each rib, alternating sides (rib #5 and #7, rib #4 and #8, etc.).

When you have tack-glued the D-tube sheet at every rib, apply CA to the sheet all along the edge of rib #1 and rib #11. Remove the wing panel from the building board and finish gluing the D-tube sheet all along the sub LE.

Carefully cut off all rib tabs and sand if necessary to get down to the line you previously drew at each rib tab. Glue the five 1/8 balsa hinge doublers into place. Cut the rear brass tube to length and glue a small plug of scrap 1/16 balsa into the outer end. Scuff the tube with sandpaper, and glue to ribs #1 and #2. Sand the bottom of the TE to the proper angle flush with the bottom of the ribs (protect the ribs with masking tape) and glue on the lower TE sheet. Fit and glue in some scrap balsa strips above and below the rear brass tube.

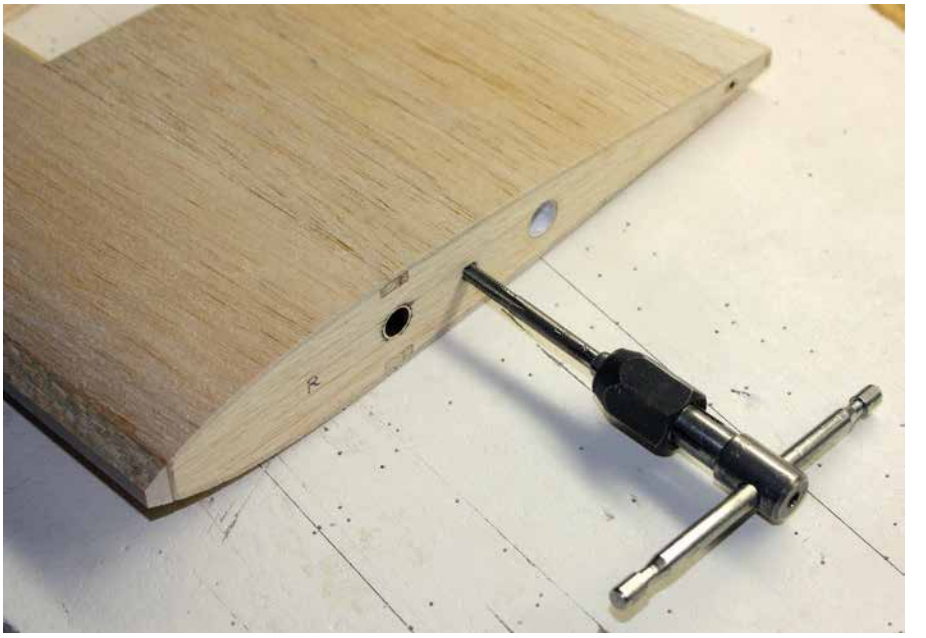
Glue the 1/4 square spruce and 1/8 x 1/4 spruce servo mounts, and rib #2A into place. Glue in the plywood wing screw doubler with CA+ and glue in the rolled paper tube (made from a couple layers of printer paper or something similar).

Sheet the top and bottom of the wing from rib #1 to #3. Note the sheeting overhangs rib #3 by 1/16 inch. Remember to cut out the bottom sheeting to allow the aileron servo mounting access. Add all of the cap strips to the ribs and the sheeting from rib #10 to #11 on the top and bottom. Sand the D-tube sheeting flush with the sub LE and glue on the hard 1/4 x 1/2 LE piece. Sand the LE and wingtips to shape.

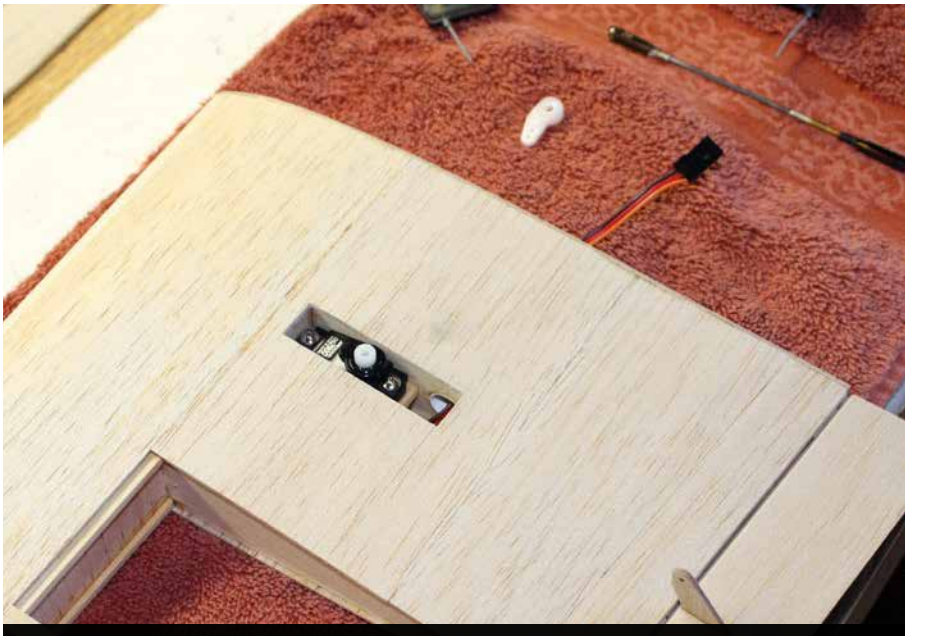
Sand the wing root so everything is flush. At this point you can use the carbon wing tube and music wire rear pin and slide the wing onto the fuselage to check the fit of the wing root. Remove the wing and make any corrections with a sanding block. Cut out the 1/32 plywood wing root cap slightly oversize. Cut the four holes into the cap referring to the plans and using the master rib #1 template. Glue the cap onto the wing root, then carefully sand the edges flush with the wing sheeting.

Make the ailerons from medium-density 3/8 balsa. You only need to remove balsa from one side to get the final shape. Use a razor plane to shave one side close and finish with a sanding block. Square the TE (in the end view of the aileron) with the sanding block. Draw a centerline down the front of the aileron and cut the hinge slots with a #11 hobby knife.

Bevel the front of the aileron per the wing cross-section shown on the plans. Locate and cut the slot for the aileron horn, ensuring that the slot will allow the horn to be perpendicular to the aileron. Make the aileron horn in the



Tapping the wing hold-on screw hole with a 10-32 tap. After tapping, the threads are saturated with CA to harden the balsa. The LE has been added and beveled, ready to be rounded off to the proper shape.



Finished right wing panel has the servo installed and the aileron hinges dry-fitted. The 1/32 plywood root cap can be seen. The aileron control horn is laminated from two layers of 1/32 plywood.

same manner as was done for the tail section, and glue the horn into the aileron.

Tap the wing-screw hole in the wing root with a 10-32 tap, saturate the threads with CA, let cure, and re-tap. Cut the aileron hinge slots into the wing TE with a #11 hobby knife. Check the fit of the aileron by dry-fitting all of the hinges, and sand the outer end to fair into the wing tip.

Repeat for the other wing panel.

Finishing

Check the entire airframe and touch up any areas that need it with 220-grit sandpaper. Then go over everything with 400-grit paper. Vacuum and use a tack rag, and you are ready for covering. I prefer UltraCote because it tends to wrinkle less over time. When you cover the wings, leave the servo pocket uncovered, then come back with a separate piece of covering, made to fit over the opening, that has a hole in it for the servo shaft.

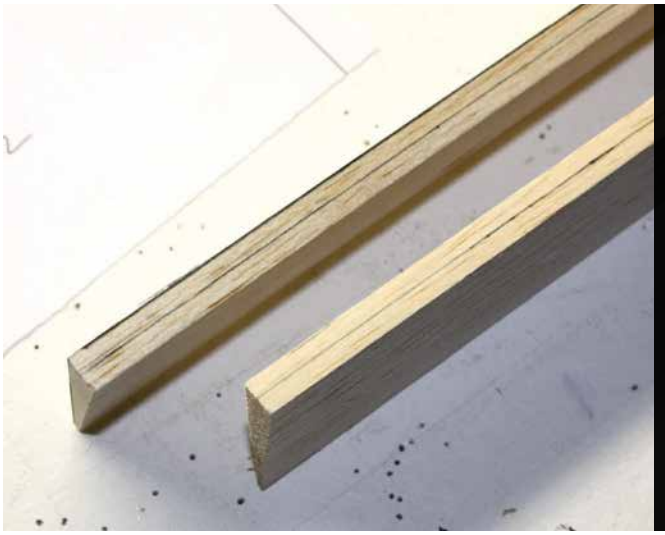
After covering, attach the ailerons, elevator, and rudder using CA on the Sig EZ hinges. Remember to attach the elevator before the rudder! I like to use small pieces of .015-thick vinyl as spacers to ensure even gaps everywhere before hitting the hinges with CA. Be sure to clean up any excess CA immediately.

Install the motor and ESC. *Do not install the spinner and propeller yet!* The motor wires go through the elongated slot on F1. The ESC is dropped through the slot on the battery shelf and stuck to the Velcro you previously installed. You will need to add an extension to the ESC receiver wire to reach the receiver. Route the power lead and receiver leads up through the appropriate holes in the battery shelf.

Install the aileron servos, routing the servo leads through the paper tubes and out the wing roots. Cut the servo arms to match the wing plans sheet. Make up the aileron pushrods as shown. Center the servo arms and attach the pushrods.

Plug the rudder and elevator servo leads into the receiver, and plug in two short extension cables for the left and right aileron. Plug the ESC extension lead into the receiver. Mount the receiver and its satellite using Velcro at the positions shown on the plans. It helps to first apply a thin coating of five-minute epoxy where the Velcro goes. Let the epoxy cure and then stick the Velcro down.

Set the 3S 2,700 mAh LiPo battery in place on the battery floor (my battery was nearly all the way forward). Cut two pieces of Velcro strap to size and install them around the battery using the slots in the battery floor. Cut a piece



Ailerons are made from 3/8 balsa. Draw a reference line on the TE side so you achieve the correct TE thickness, then use a razor plane to bevel the balsa. It is only necessary to plane one side. Finish with a sanding block to get a smooth surface. Next draw a centerline on the front of each aileron to use as a reference when beveling the front edges and making the hinge slots.

Photos by the author

A JR DS290G servo and aileron linkage consisting of a Du-Bro solder Kwik Link, threaded coupler, and Kwik Link on 1/16-inch music wire. The aileron is dry fitted here.

BONUS CONTENT

The Mysterion has an excellent glide thanks to a folding propeller and lack of landing gear. Landings are easy with the power off.

of Velcro to go around the aft end of the battery (this strap is at 90° to the aft strap and attaches to it above and beneath the battery shelf) to prevent it from sliding aft.

Plug the battery connector into the ESC power connector, bind the receiver, and set up your radio programming to the throws and exponential settings noted on the plans. Check the motor direction and swap the motor leads to correct it if required. Turn off the radio and disconnect the battery from the ESC power lead. Now install the spinner and folding propeller.

Move the battery pack fore or aft as required to balance the center of gravity (CG). The prototype balanced with no nose weight required. Add some nose weight if needed to achieve the CG shown on the plans. After the CG is achieved, glue a small piece of EPP foam or balsa on the battery floor between F1 and the front of the battery to prevent the battery from sliding forward against F1A.

Check the lateral balance by resting the aft end of the fuselage on a hard surface and supporting the front by holding onto the spinner. If needed, add some lead to a wingtip by removing a small piece of covering material and balsa from the bottom wingtip sheeting and glue in a small piece of lead, then replace the balsa and covering piece.

Flying

Before you head out to test-fly the aircraft, double-check the balance point, control directions, and look for any warps caused by covering. It's easier to correct these in the shop than at the field.

The control throws shown on the plans result in a fairly responsive aircraft. If you like controls that are softer, or offer a slower response, you might want to set up dual rates and start with somewhat reduced throws.

I think you'll find the Mysterion a pleasant model to fly. It is capable of any pattern maneuver as well as sport aerobatics, upright or inverted. Because the power-off glide is excellent, you may need to get accustomed to making your turn to final approach farther out, or lower than you are used to.

I hope you enjoy flying your Mysterion. It is compact enough to keep handy in your car and rates high on the "fun-per-buck" scale.

—Al Clark
hotdogx@knology.net

SOURCES:

AMA Plans Service
(800) 435-9262, ext. 507
www.modelaircraft.org/plans.aspx

Mysterion Materials List

By Rod and Al Clark

Wood

First an explanation of the grades or densities of balsa wood is in order:

Grade	Ultra Light	Light	Light Medium	Medium	Medium Hard	Hard
Density in lb/cu.ft	4 - 5.4	5.5 - 6.0	6.1 - 7.5	7.6 - 9.5	9.6 - 12	14 +
	"Contest" grade balsa					

To determine balsa sheet weight for the various density ranges shown above, see the end of this list for two handy balsa wood sheet size and density nomographs which were also developed by my brother, Rod Clark. Take a small postage scale (the kind with a weight and clip, not an electronic one) to the hobby shop with you and weigh the balsa sheets; then look at the nomograph to determine the density of the particular sheet you are looking at.

Next is an explanation of balsa grains:

Notice that the C-grain balsa sheet has a mottled appearance and distinct checkerboard pattern. It is very stiff across the sheet and splits easily. Used for sheet balsa wings and tails, flat fuselage sides, wing ribs, formers, and trailing edges. C-grain is usually hard to find in local hobby shops. I mainly use it for sheet tail surfaces.

B-grain grain lines are shorter than A-grain and it is stiffer across the sheet than A-grain. If you look at the narrow edge of the balsa sheet, B-grain will look the same as it does on the wide, flat side. Used for flat fuselage sides, wing ribs, formers, planking gradual curves, and wing leading edge sheeting.

A-grain has long fibers that show up as long grain lines. If you look at the narrow edge of the balsa sheet, A-grain will have a checkerboard appearance. Used for sheet covering rounded fuselages and wing leading edges, planking fuselages, forming tubes, strong flexible spars, and hand launch glider fuselages.

The following list of wood required was developed by my brother, Rod Clark, who is building a Mysterion.
Note: balsa grain can be either A or B grain unless otherwise called out below.

Dimensions	Density	Grain	Qty	Item	Amount of sheet or stick used

Balsa sheet:

1/16" x 3" x 36"	Medium		1	Fuse doublers - vert grain	14"
				Fuse bottom - cross grain	13" (5 pieces)
			1	Wing ribs 4-10	(33 x 1" + 11 x 1") x 2 wings
	Medium	A	4	Wing D-tube sheeting	22.3" x 2.7" x 2 (top & bottom) x 2 wings
				Wing root sheeting	5.1" x 5" x 2 (top & bottom) x 2 wings
	Medium+		2	Wing TE sheeting	22.5" x 0.75" x 2 (top & bottom) x 2 wings
				Rib cap strips	22.3" x 0.25" x 2 (top & bottom) x 2 wings
				Sub-leading Edge	22.2 x 0.4" x 2 wings
				End rib sheeting	3" x 0.75" x 2 (top & bottom) x 2 wings
	Medium/Hard		1	Spar webbing (ribs 6-11)	2.35" x 1" x 4 places x 2 wings
1/16" x 4" x 36"	Medium		1	2 Fuse doublers - horiz grain	28"
				2 Stab doublers	5.25"
3/32" x 3" x 36"	Med, Med-	A	1	Turtle Deck sides	24.5"
3/32" x 3" x 36"	Medium+		1	Fuse bottom	21.5" (2" wide X 0.2" wide)
				Spar webbing (ribs 3-6)	2.35" x 1" x 3 places x 2 wings
1/8" x 3" x 36"	Light/Med-		1	Turtle Deck floor	25" (only 2" wide at one end)
				Turtle Deck formers T1-T5	4"
	Med+/Hard		1	Hatch top	11.5" x 2.7"
	Med+/Hard			Hatch locators	1.9" x 1/2" + 1.9" x 3/8"
	Medium		1	Wing ribs 1,2,2A,3,11	31" x 1.1" x 2 wings
1/8" x 4" x 36"	Medium	B	2	2 Fuse sides	36"
3/16" x 4" x 36"	Med, Med+		1	Turtle Deck top	20" x 0.8"
	Med, Med+			Cowl top and sides	3.2 x 5.7"
3/16" x 3" x 36"	Light/Med		1	Rudder bottom piece	3" x 0.75"
	Light/Med			Vert Stab bottom piece	3.4" x 1.25"
	Light			Fin fairings	3.9" x 1.9"
3/16" x 3" x 36"	Medium/Hard		1	Horiz Stab	35.2" x 0.8" + 10.6" x 0.8" + 2.4" x 1.25"
3/8" x 3" x 36"	Med/Med-		1	Ailerons	23" x 1.25" x 2 wings
				Cowl bottom	2.5" x 2.5" (sanded 3/8" wood)
3/4" x 3" x 36"	Medium+		1	Hatch sides	11.5" x 2.2"
				Cowl corner pieces	

Balsa Sticks:

1/8" sq. x 36"	Hard	2	Fuse rear bottom longerons	21.5"
1/8" x 1/4"	Hard	1	Fuse vertical stiffeners	10" (cut from Hatch top sheet?)
1/8" x 3/16"	Hard	2	Trailing edge	22.6" x 2 wings
3/16" sq. x 36"	Light	1	Vert Stab & Rudder	9"

	medium/medium			
			Horiz Stab & Elevator	11.5"
3/16" x 1/2" x 36"	Light	1	TE of rudder	10" (can come from light sheet)
	Medium	2	Horiz Stab & Elev, V Stab, Rud	1" + 17" + 19"
1/4" x 1/2" x 36"	Hard	2	Wing leading edge	22.2" x 2 wings
			Wing tube spacers	4.6" x 2 per wing x 2 wings
1/2" x 36" triangular	Medium	1	Fuse front bottom longerons	29"
Spruce Sticks:				
1/8" x 1/4" x 36"		4	Wing spar caps	22.3" x 2 per wing x 2 wings
			Servo rails - fuse	6.6"
			Adder to spar caps	4.6" x 2 per wing x 2 wings
3/16" x 1/4"		1	Horiz Stab joiner & horn slot	5" (can use 1/4" sq and sand down, or glue 2 1/8x1/4)
Birch Plywood:				
1/32" x 12" X 24"		1	Fuse bottom	15" x 2.7"
			Control horns	1" x 6" (3 horns, doubled plywood)
			Wing root rib cap	8.6" x 1.1"
1/16" x 6" x 12"		1	Wing bolt insets	1" sq.
1/8" x 6" x 12"		1	F1 former	3.4" x 2.2"
			Wing retainer screw doubler	1.1" x 1.5" x 2
Lite-Ply Plywood:				
1/8" 12" x 24"		1	F2, F3 formers	2.3 sq. ; 3.5" x 1.6"
			Battery shelf	14.4" x 2.3"
			F1A hatch end	2" x 5/8"
			Canopy former	2.1" x 2.2"

Hardware

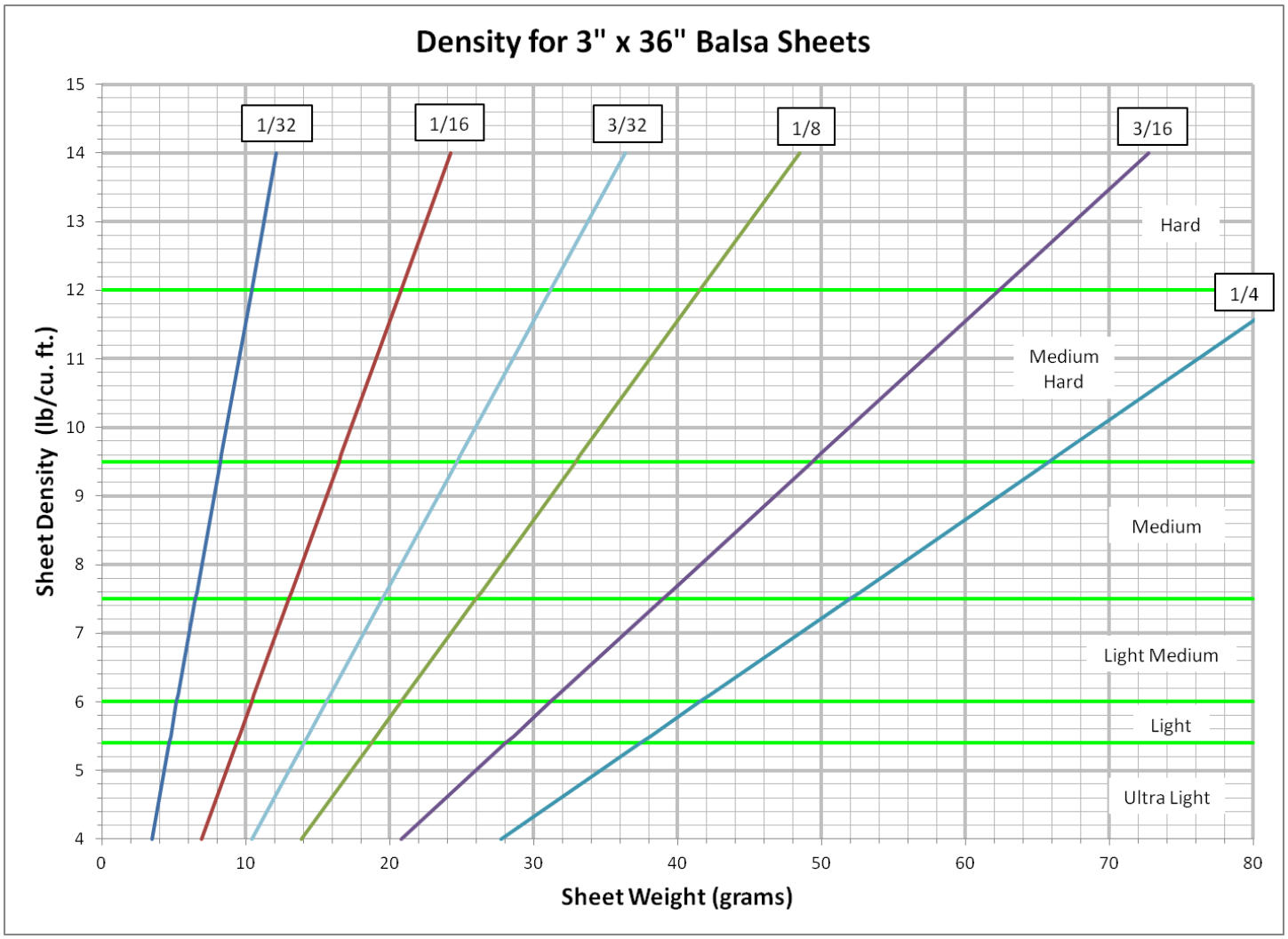
1	E-Flite 480 BL 1020 Kv brushless outrunner motor
1	BB Model Aluminum Turbo Spinner 45/4/8 for 4mm motor shaft (source Esprit Models www.espritmodel.com)
1	Aeronaut CAM 10X6 folding prop (source Esprit Models www.espritmodel.com)
4	.25 dia X 5/8 long circuit board standoffs, tapped 4-40 (note these are shortened to 9/16 long for the model) Check your local electronics store, or here are two from MSC that will work. The ones with flats might actually be best as you can tighten the screws into them easier. http://www.mscdirect.com/product/details/67732040 and http://www.mscdirect.com/product/details/67724724
3	#2 X 1/2 button head sheet metal screws (one source is Micro Fasteners http://www.microfasteners.com)
1	Sig 11" bubble canopy SIGCS011
2 pkg	Radio Shack rare earth super magnets, 2 per package Model: 64-1895 Catalog #: 6401895
2	11/32 O.D. X 12" long brass tube
1	1/8 O.D. X 12" long brass tube
2	10-32 nylon thumb screws (McMaster-Carr p/n 94320A345 or similar)
27"	1/8 O.D. X 1/6 I.D. carbon tube

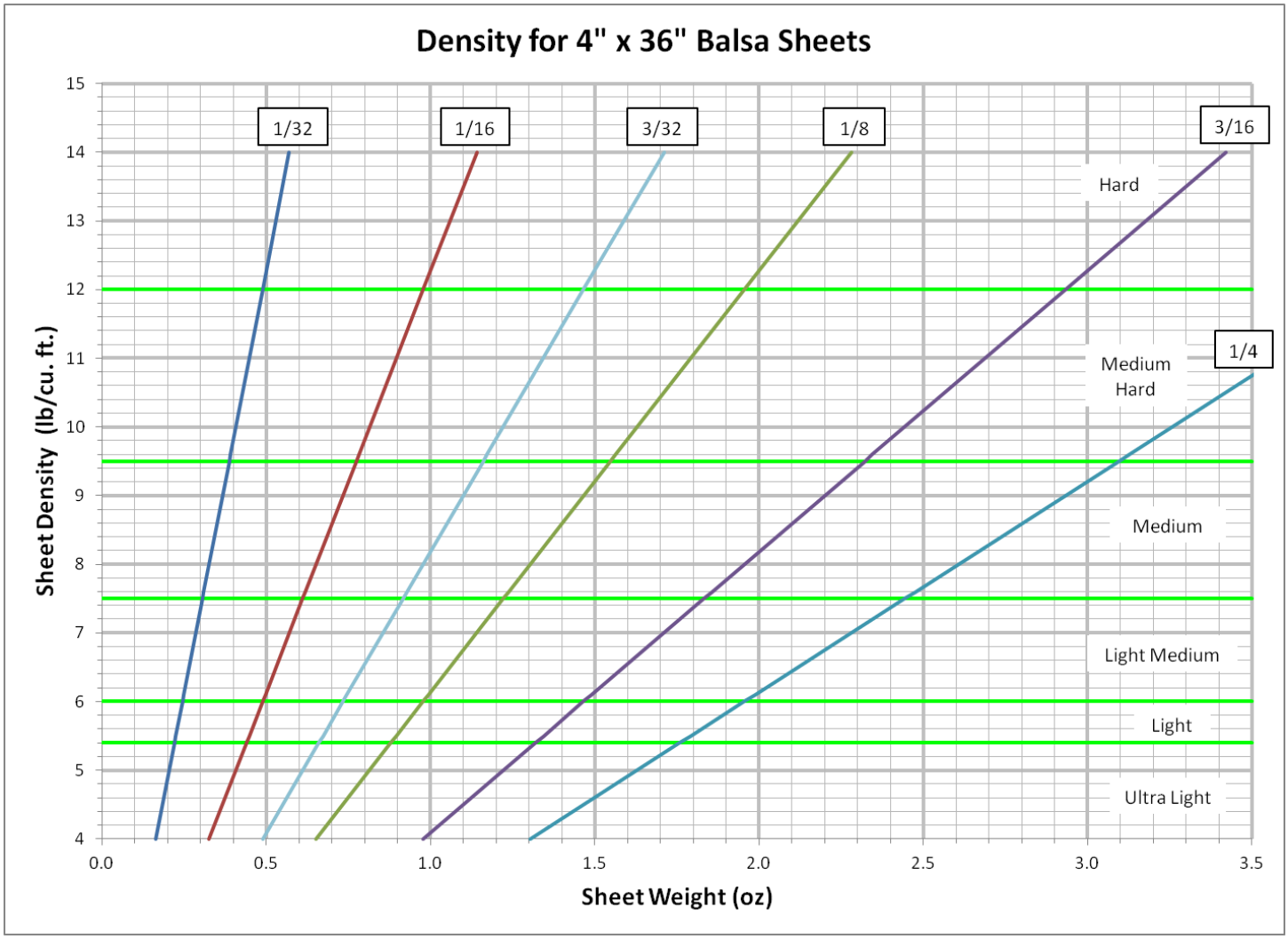
22” 1/16 dia. music wire
4 Du-Bro 2-56 Solder Kwik-Links
4 Du-Bro 2-56 Spring Steel Kwik-Link Clevis
4 Du-Bro 2-56 threaded couplers
6” Sticky-backed Velcro
18” One Wrap Velcro

Radio and Electric Gear

1 Thunder Power 3S 2700 mah 25C LiPo battery
1 Deans Ultra Plug, male/female set
1 Castle Creations Thunderbird 36 ESC
1 Spektrum AR 6210 receiver
2 Hitec HS-5065MG servos
2 JR DS290G servos

Balsa density nomographs (by Rod Clark)




Density for 4" x 36" Balsa Sheets
Sheet Density (lb/cu. ft.)
Sheet Weight (oz)
15
14
13
12
11
10
9
8
7
6
5
4
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
1/32
1/16
3/32
1/8
3/16
1/4
Hard
Medium Hard
Medium
Light Medium
Light
Ultra Light