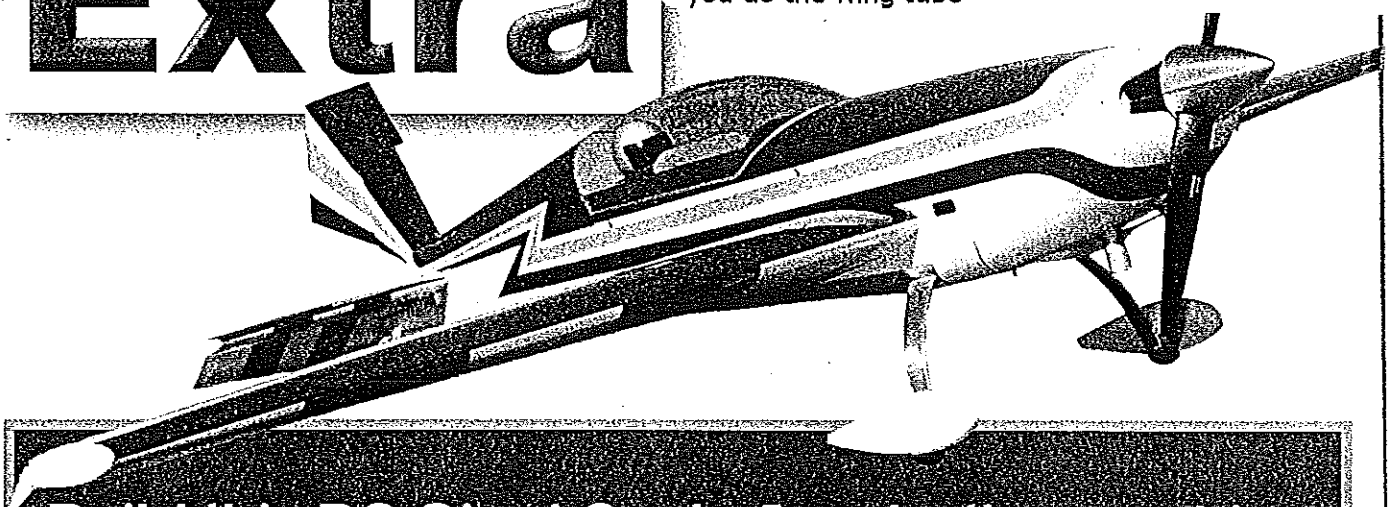
#939 ■ Mike Hurley

Project Extra

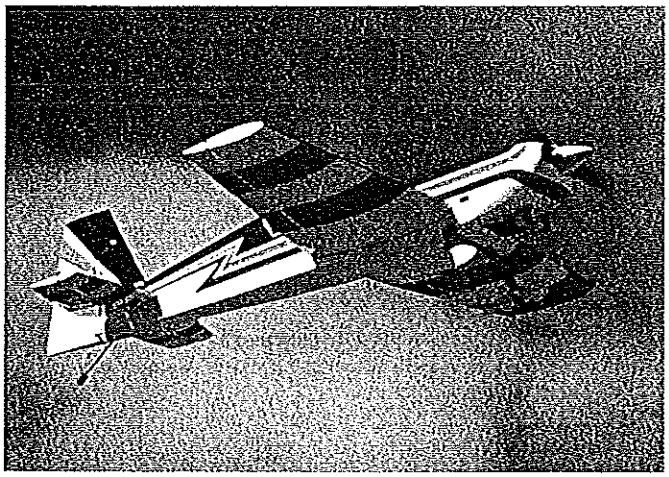
VERY IMPORTANT!
Please note if you build one, you must reinforce the horizontal stab's phenolic tubing in a similar fashion as you do the wing tube



Build this RC Giant Scale Aerobatics machine with magazine and Web-site how-to series

WE ARE ABOUT to embark on an exciting adventure! This is *Model Aviation*'s first Giant Scale construction article, and it will be presented in a "build-along" monthly series. Join us as we discuss frankly products and services, opinions and options, tips and techniques, and discuss the rationale behind many of our component choices. This series will have widespread value for *anyone* building *any* model aircraft. Consider this a set of "how-to" articles using a particular Giant Scale aircraft as the demonstration platform.

Back to Basics: Scale Aerobatics (SA) has been growing steadily in popularity in the last several years. Almost every Radio Control (RC) manufacturer now offers one or more SA models. In addition, the Almost Ready to Fly (ARF) market has grown by leaps and bounds, and many of the ARFs available are International Miniature Aerobatic Club (IMAC)-style SA airplanes. In this series we focus on a segment of the hobby that is gaining popularity (SA) while revisiting a skill set that is losing ground because of today's top-quality ARFs, but is central to our hobby: building your own model.



The completed Extra excels at aerobatic and 3-D Freestyle maneuvers including the Elevator. It's an impressive model!

This six-part series will focus on the construction of an original-design 35% Extra 300LX. A model this size is certainly not for everyone and in the long run can get quite expensive to complete. Even if you're not interested in building this airplane, don't let that stop you from getting some useful information from these articles! These airplanes are state of the art for performance RC, so the info we present should interest most modelers.

We'll cover topics from foam sheeting techniques to computer-radio basics. And if you decide that this is the aircraft you've been waiting for, you can purchase the plans and build along with us. *We'll highlight techniques and tips in the articles and offer a step-by-step instruction manual with detailed photos via the AMA Internet site as a PDF download; go to www.modelaircraft.org, then go to the* Model Aviation *page for directions.*

The Aircraft: The Extra Corporation's naming convention can be somewhat confusing, and some RC manufacturers even get it wrong! To set the record straight, this aircraft is the Extra 300LX. The "300" designates the design lineage and the engine's horsepower. The "L" means it's a low-wing, two-person aircraft. The "X" designates the experimental oversized rudder and elevators.

Extra never produced an aircraft that had the moniker of 330. Two air-show performers put "Extra 330" decals on an airplane, and the name just stuck. You can order a 330-horsepower Lycoming for your Extra 300. The 330-horsepower IO-580 is a fairly common engine in most newer aerobats these days. I recently saw an Edge 540 with one at an IAC (International

Flight photos by Michael Ramsey Construction photos by Mike Hurley Graphic Design by Carla Kunz

Aerobatics Club) meeting, but I didn't hear anybody calling it an Edge 580! Phil Knight has modified the stabilizers and elevators on his aircraft. The tail modifications are not FAA (Federal Aviation Administration)-approved, and therefore cannot be type-rated in the US. The modifications can be ordered from the factory, but the airplane will be designated as experimental. In this case the airplane will be called an Extra 300LX or 300SX (not 330 and not 300XS, as most model manufacturers mistakenly have it). But be assured, officially, that there is no such thing as a 330!

The airplane we'll build is the third version of a design I created four years ago and built with the help of Norm Cassella: renowned IMAC nationals Unlimited champion and early Tournament of Champions competitor. Norm also designed and built one of the first competition-level biplanes: the Pulsar.

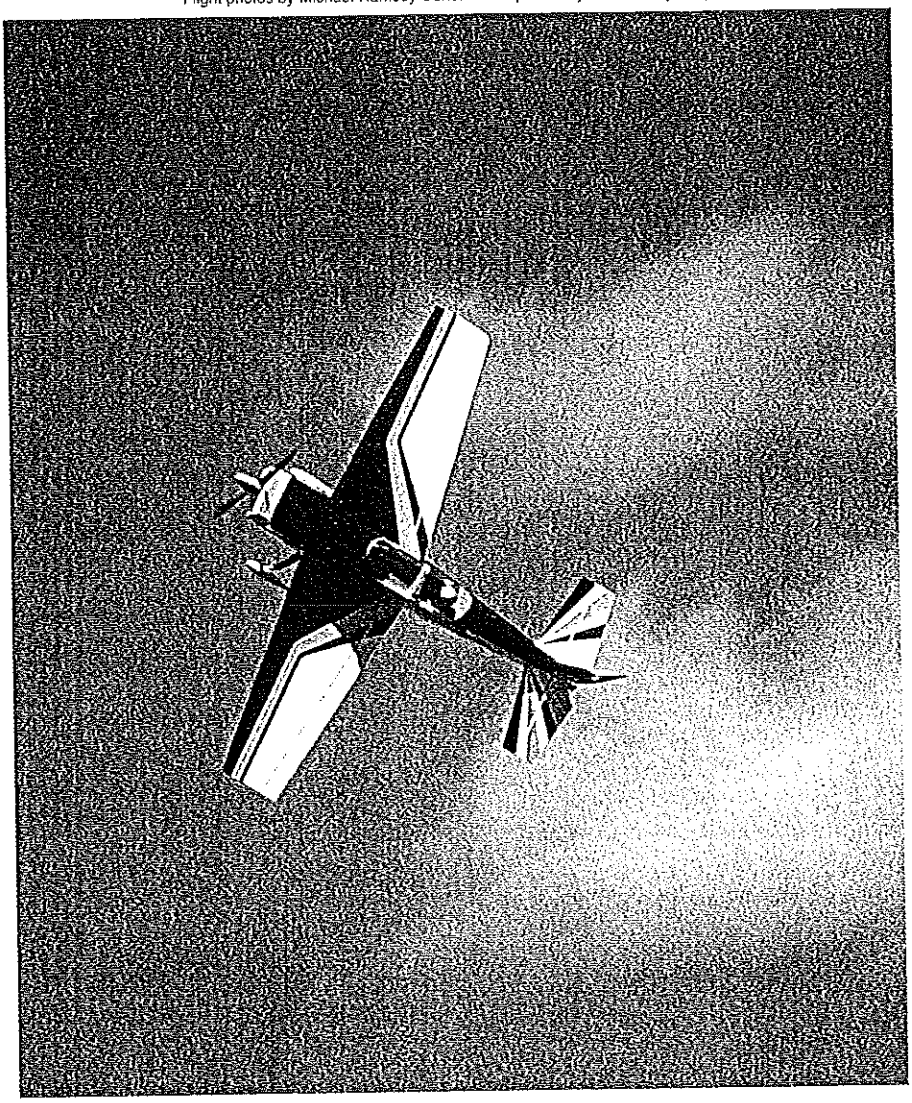
I originally chose to design an Extra because it's one of the most neutral-flying Scale precision airplanes available. By neutral I mean that it reacts with pure motion to the control inputs; rudder imparts only yaw with no tendency to pitch or roll, aileron roll is on axis, and throttle does not affect altitude or heading. I don't know of any Scale models that are perfect, but the Extra in general is as close as it gets.

At the time of my initial research, no manufacturers offered an Extra in the size and with the 3-D capabilities I wanted. Today, however, there are several good choices for an Extra in sizes that are close to this one. Two of the best designs available are the 33% RadioCraft Extra and the 31% and 33% Aeroworks Extras. All excel in 3-D and in precision. Contact information is at the end of this article.

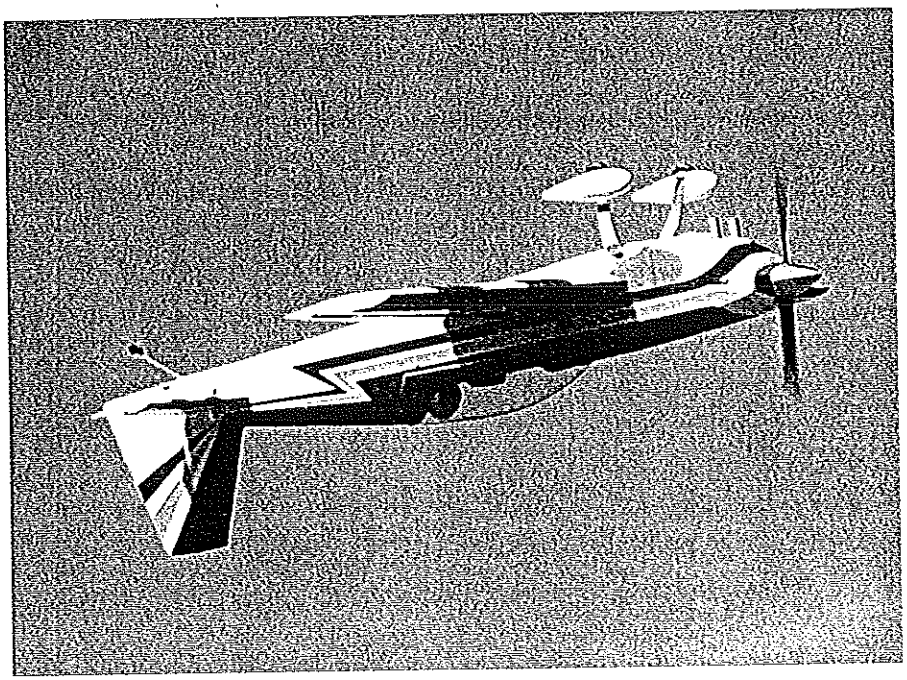
Designed for Precision and 3-D: I chose the two-seat L version over the single-seat S model since it has tested to perform slightly better in knife-edge flight because of its more forward profile canopy. Unfortunately that large canopy gives a weight penalty, but the trade-off is worth it.

Besides being a neutral and forgiving aircraft for precision competition flying, the Extra (when duly modified) is very good at Freestyle 3-D flying, such as torque rolling and harrier flight. This airplane has been specifically designed to take advantage of characteristics that make it suitable for 3-D Freestyle and to keep it as neutral as possible for competition. The stabilizer has been lowered approximately 8% to reduce pitch coupling. The elevator and rudder utilize the "X" experimental design criteria (which were influenced in the full-scale world by successes in the RC arena) for more positive tumbling and 3-D Freestyle maneuvers.

Some of the other design nuances are for strength, longevity, and aesthetics while trying to keep the airplane as light as

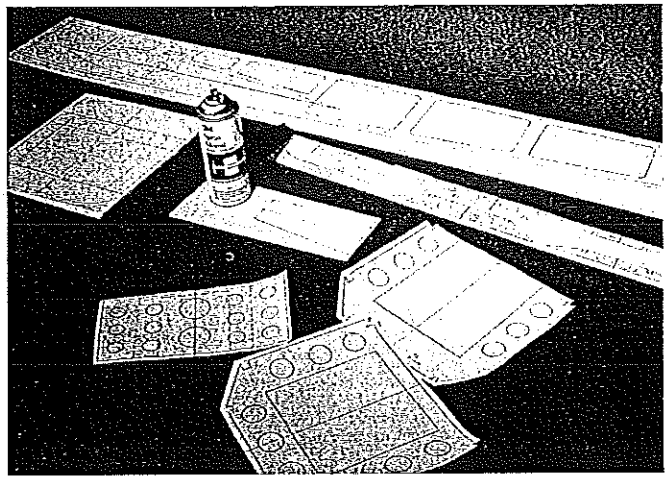


The 35% Extra 300LX, fitted with a Desert Aircraft DA-100 engine, weighs in at just 27 pounds. These large airplanes are easy to see and to fly.

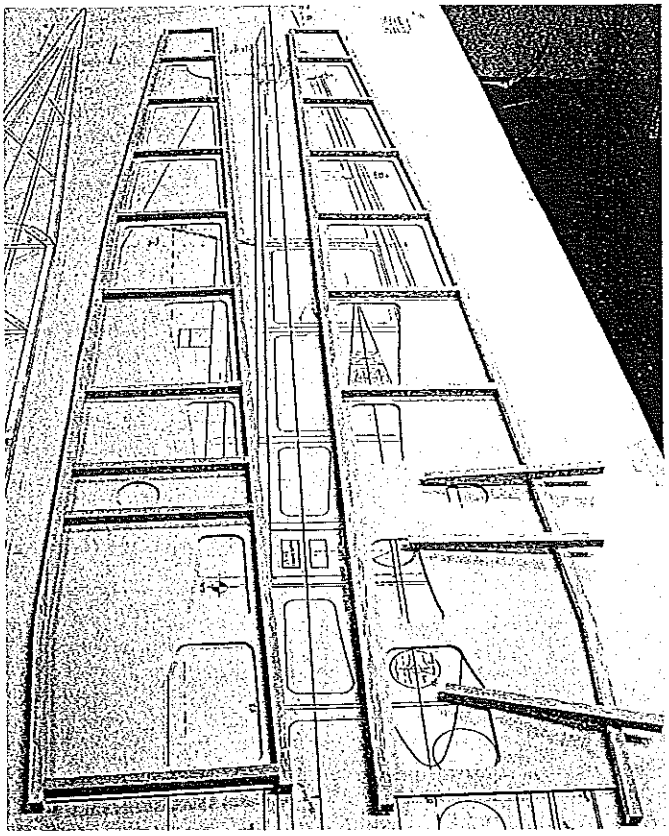


With some practice, your confidence will grow and you should easily be able to perform stable inverted passes. Just remember to always fly safely!

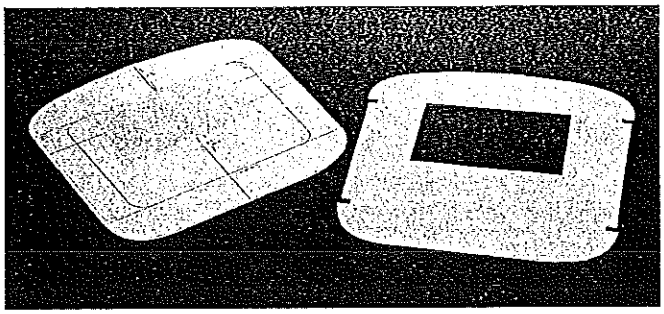
Project Extra



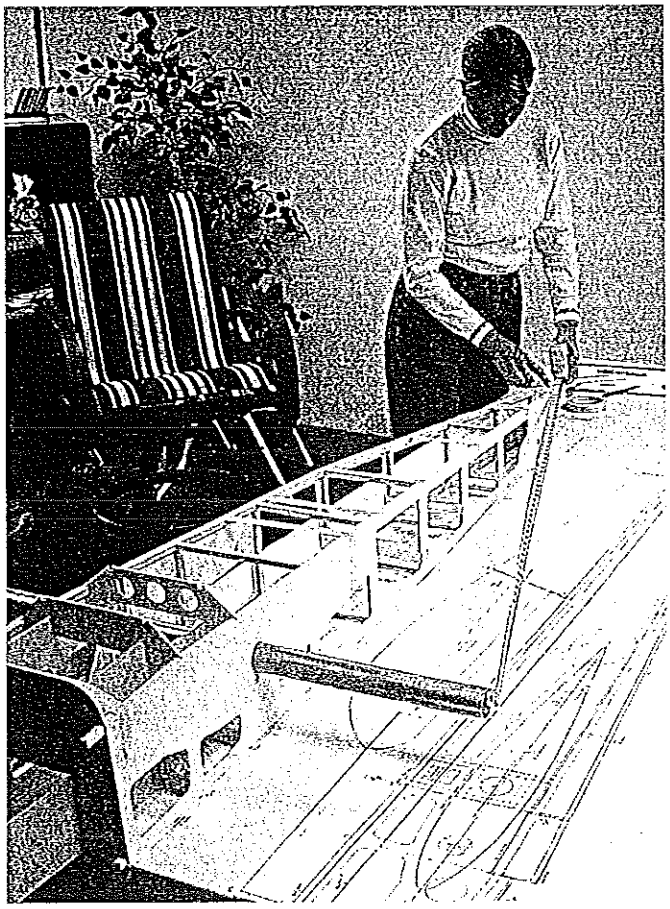
Make a copy of your plans to use as cutting templates. Use 3M artist's spray mount to glue the templates to the wood.



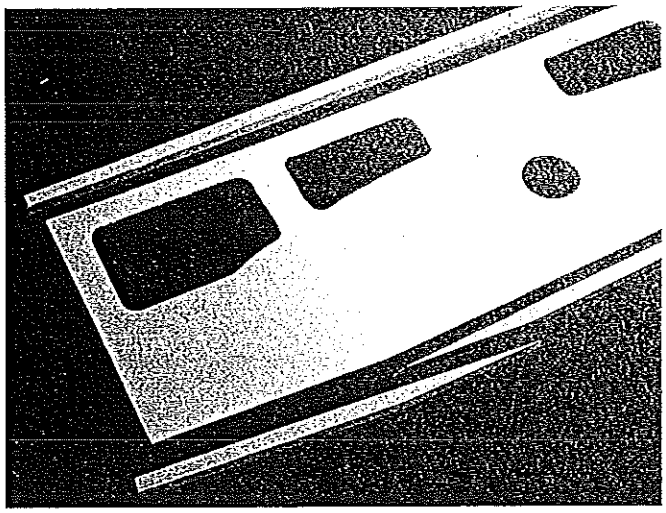
Cut and "build" two sides of the fuselage over the plans and fit (but don't glue in) square-balsa uprights from F3 forward.



Many of the wood pieces are doubled. Glue them together with the 3M spray mount for cutting, then separate for final fitting.

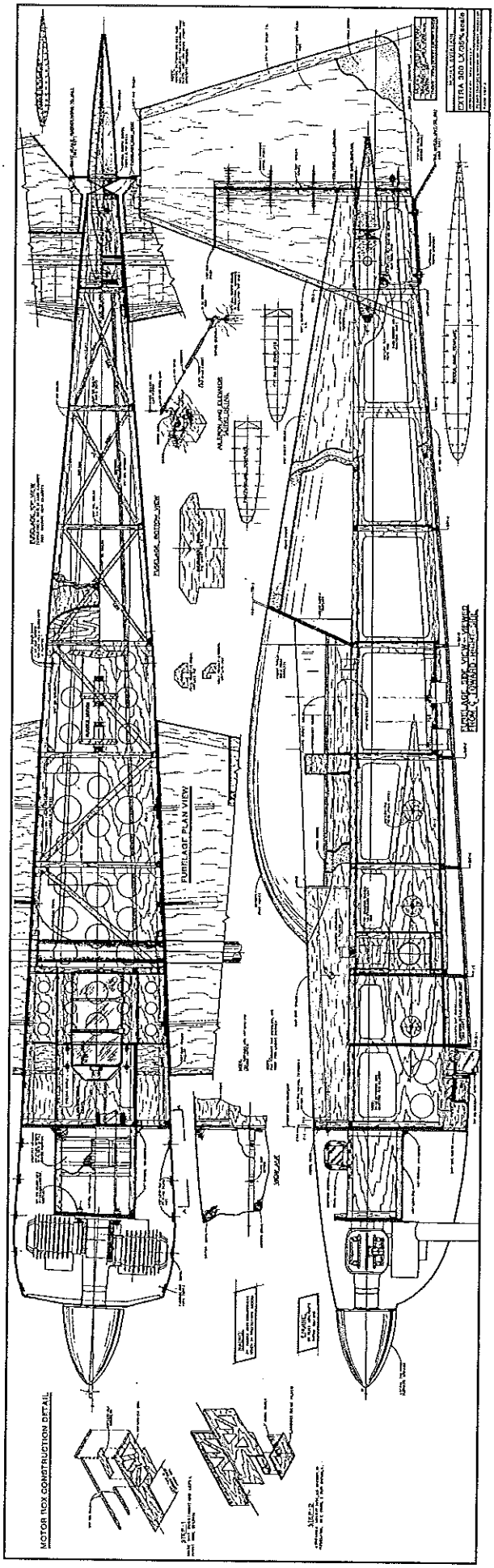


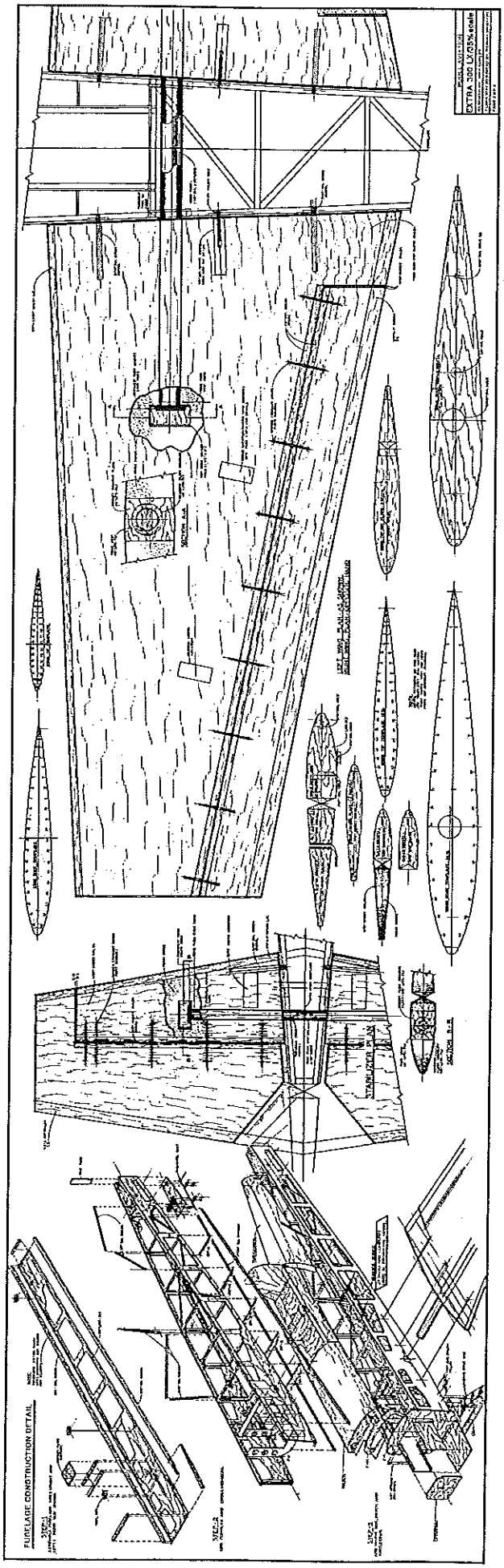
Pin the basic fuselage structure together, then check for squareness before gluing. This is important!

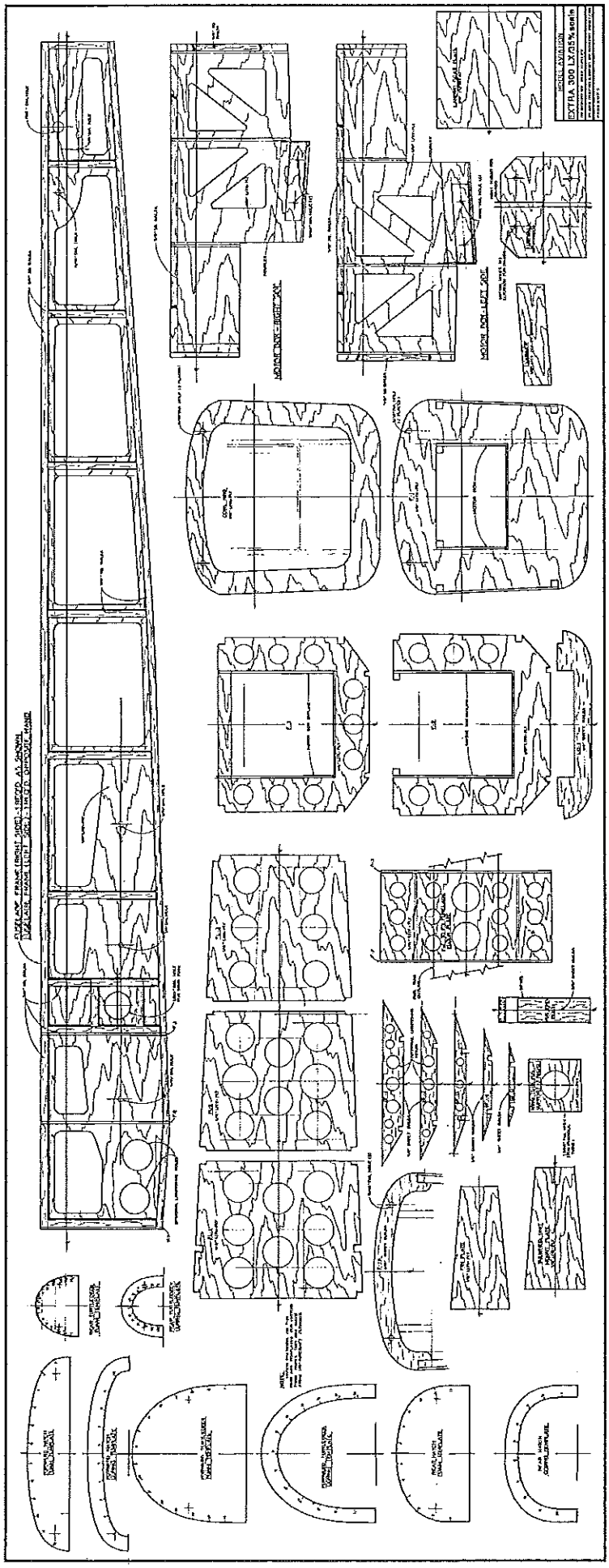


The author used long delta splices where angles were needed and where long, square stringers needed to be spliced together.

Full-Size Plans Available—see page 183







possible. The landing gear has been angled forward to help change the twisting force from landing to a more survivable compression force, and aluminum "L" brackets transfer the load to the motor box, eliminating the need for a heavy plywood plate.

The original prototype was built with a motor box that captured the wing tube. With this design the vibration from the engine was transferred more directly to the wings, wreaking havoc on ailerons, hinges, servos, and linkages. I noticed that designs that did not capture the tube seemed to be much smoother, so in the second design I stopped the motor box short of the wing tube. It worked! The wingtips and ailerons vibrate much less, and the hardware seems to incur less wear and tear.

One of this design's unique qualities is the extensive use of laminating balsa over long expanses of thin, light plywood. The process creates a strength in shear that outweighs the sum of the two materials and makes the structure light while keeping it rigid.

Its shape is also different from other designs. The full-scale Extra is slightly rounded at the front, but for ease of construction and simplicity, most models are designed in a wedge shape utilizing straight lines. Viewed from the top, the fuselage sides form a long triangle from the rear of the cowl to the tail, and the transition to the cowl is often a sore spot. I wanted to do something about that without creating any additional complexity or weight, so slight angles were designed into the airplane to fill it out slightly, getting rid of the "starved horse" look and the strict delta shape. It's not a huge change, but it helps the overall appearance. It also helps to smooth the transition from the cowl to the fuselage.

In IMAC, percentage of full scale is calculated using the wingspan. In this case the full-scale L has a wingspan of 25 feet, 3 inches, giving a 35% span of 106 inches for this model. I kept the wing planform, the root and tip chords, and the overall length at 35% scale but made the width of the fuselage a bit smaller, at 33%. I like the sleeker look of the slightly slimmed, but still scale-shaped, fuselage. Keeping the fuselage smaller may help keep the weight down, increase rigidity, and slightly reduce drag (although in my opinion drag is not a problem in SA models). I did it mostly because I like the way it looks!

The number-two prototype—the finished one seen here—came in at 27.5 pounds ready to fly. A huge wing area of 2,060 square inches gives a very light loading of 30.75 ounces per square foot. Even at our mile-high altitude here in Colorado, the Desert Aircraft DA-100 engine pulls this airplane out of sight with the ability to accelerate out of a Torque Roll. At sea level this combo would be ballistic! In normal flight the airplane floats on the wing like a glider, and for 3-D it's slow and agile.

Not being one to rest on success, this third rendition strives for an even lighter weight. I opened up the fuselage sides, eliminated the formers in the rear, and made a more careful selection of wood, including some contest-grade balsa sheeting for everything except the main wings. I'm hoping to take a pound off the airplane and get it down to 26.5, which would bring the wing loading down into the 20s.

The Design: This airplane's design is rather conventional and compares to other SA aircraft currently being produced. It was specifically designed around Desert Aircraft's twin-cylinder 100cc gas engine. DA engines are light, powerful, and reliable, but best of all the customer service from DA is second to none.

Wings and stabilizers are each two-piece and removable for storage and transport; they slide onto an

aluminum tubing spar. The fuselage sides are of ⅛ light plywood but are almost 70 inches long, so finding the wood will take a little legwork. I found a 4 x 8-foot sheet for roughly $16 from a local plywood specialty distributor, and after a bit of research I was able to find several sources in my area.

The cowl, wheel pants, canopy, and landing-gear cuffs are from Aeroglass. Flying Foam.com offers high-quality CNC-cut foam parts. However, if you want to cut your own foam parts, the plans have templates. The first two airplanes were built with parts that we cut at home, but this model uses foam parts from Flying Foam.com.

The 1.5-inch-diameter x 36-inch .049 wing tube, ⅝-inch-diameter x 16-inch .035 stabilizer tube, and the landing gear are from TnT Landing Gear Products. The tubes come with the phenolic sockets you will need for construction. (A complete list of supplies and suppliers is included at the end of the article.) I'll discuss the components that we chose as we install them. The rest of the airplane is balsa and light plywood with only three pieces of aircraft plywood: the motor-box sides and the landing-gear plate.

Erik Richard, an NOAA physicist, will be constructing this airplane for our demonstration purposes. Erik has spent his lifetime building and designing model aircraft and has been exposed to design since early childhood. His father was an aeronautical engineer with many famous full-scale designs and was also an avid model designer/builder. This design has been an evolving process, and many good changes have come from the results of testing. We are building this third model in as close to real time as possible for conventional publishing.

In a model of this size and power, the equipment and hardware you use needs to be different from what you might use with smaller glow-powered aircraft. We have been very careful about our selections to keep things simple yet strong enough to handle the job. Pay careful attention to the linkages and fasteners we use, and please don't risk off-brand or standard servos or low-quality electronics. It's not just your airplane at risk; it's you and everyone around you. If you're ready, let's start building!

CONSTRUCTION

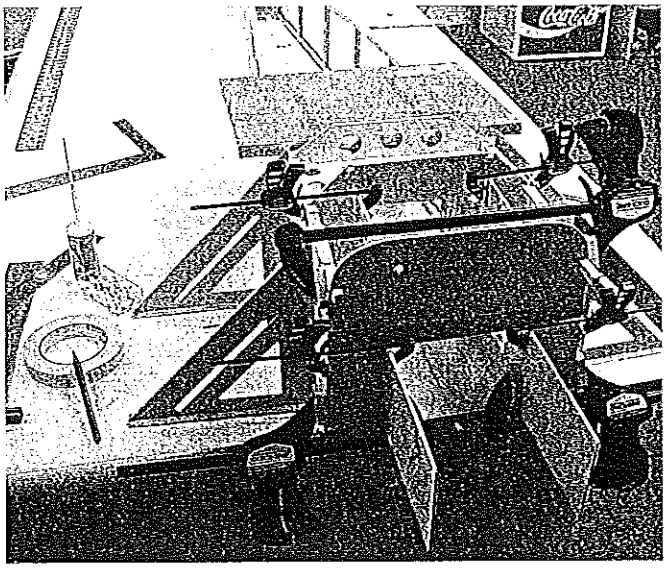
I'd like to make a couple of notes about the plans before we begin. You will notice on sheet three that there are two different hole sizes for the wing tube socket on the fuselage side. This is because we measured several different sockets, and there is almost always a slight variation. The best thing to do is measure your specific socket with a caliper and cut the hole slightly undersized. Gradually sand the opening to obtain a snug fit on the socket. Remember to do this with the two sides taped together so the alignment is exact.

The plans also show the alignment dowels at 90º to the wing root. That's fine for the wing hold-down bolt, but the dowels need to be oriented parallel to the wing tube so they slide into place when installing the wing without binding.

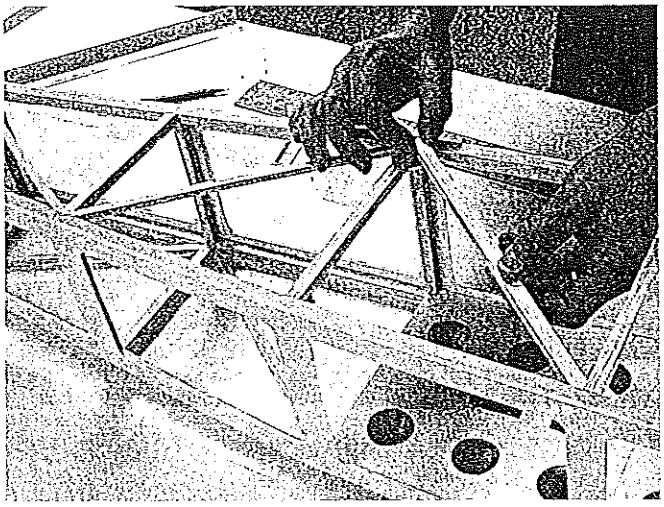
Before you begin, make a copy of your plans to use as a cutting template. With scissors, cut from the plans the formers, fuselage sides, fuselage floors, motor box, LG (landing gear) plate, tail-wheel plate, LG1, cowl formers, and stringer standoffs.

Tape two pieces of ⅛ x 70 x 8-inch light plywood together for the fuselage sides, and two pieces of 12 x 12½-inch for the cowl former and F1. Also tape two pieces of approximately 20 x 9⅛-inch aircraft plywood together for the motor-box sides. We used a light coat of temporary spray glue (listed at the end of the article) to keep the parts together and aligned.

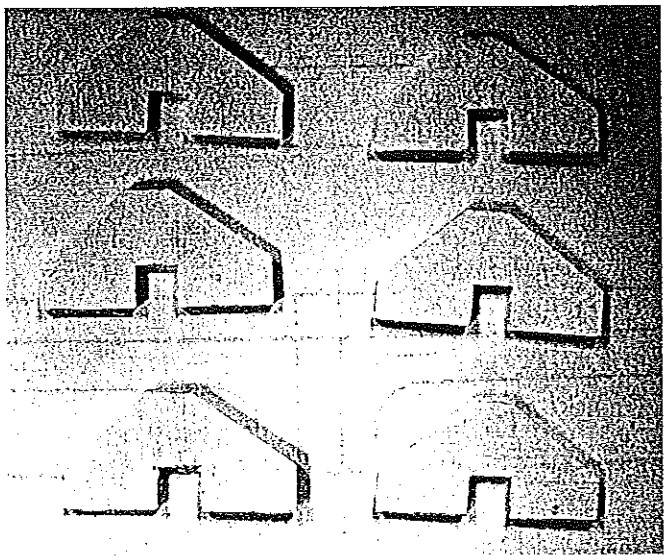
Parts that need to be cut out are: ⅛ light plywood—formers F2, F3, fuselage sides, fuselage floors (FL0, FL1, FL2, FL3), cowl former and F1, and tail-wheel plate; ¼ balsa—LG1 and BF1, 2, 3, 4, and 5, and stringer standoffs; ⅛ aircraft plywood—landing-gear plate and motor-box sides; ¼ aircraft plywood—firewall.



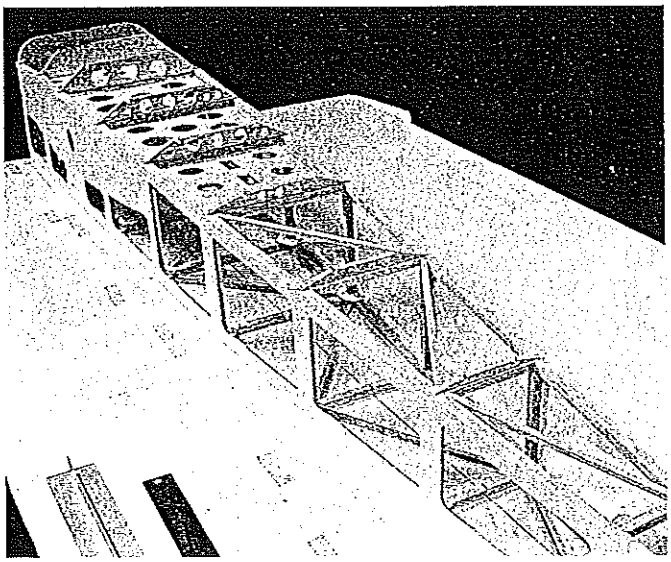
Former F1 and the motor box are glued together at the same time. Clamps are needed to keep everything straight.



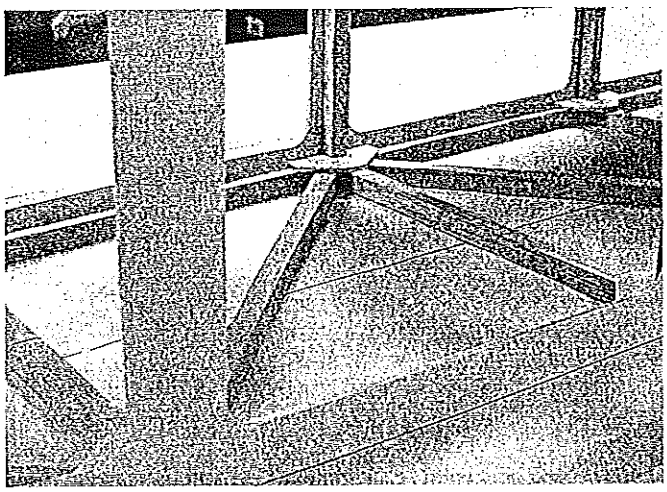
The fuselage behind F3 uses square balsa stock instead of formers. Cut and fit the parallel pieces then the diagonals.



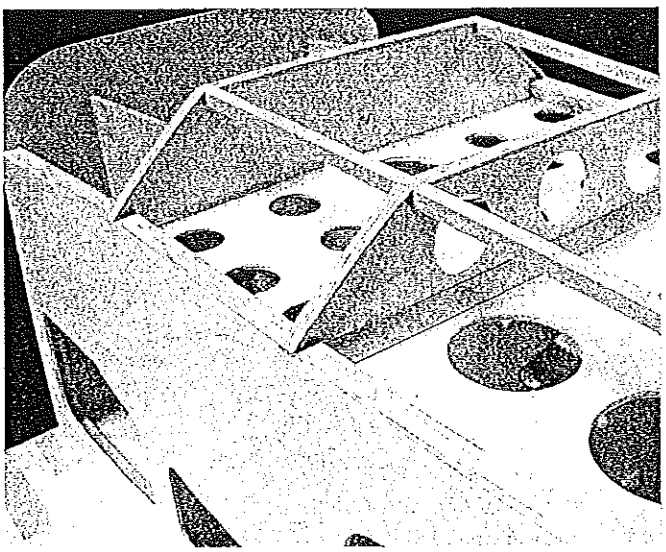
Cut, fit, and glue six gussets at the top of the fuselage stations F4, F5, and F6. These add tremendous strength.



Glue on the ¼ balsa stringer formers BF1, BF2, BF3, BF4, and BF5, centered over the ⅜-inch crosspieces.



You can see the gussets glued in place. Notice how they contact all of the pieces that are adjacent to them.



After the bottom stringers are fitted, capstrip formers F2 and F3. Notice how clean and neat the structure looks.

Use 3M artist's spray mount 6065 to glue the cut plans to your wood. On the fuselage sides, remember to cut to the outside edges. (The landing-gear plate glues in between the motor-box sides.) Also cut the lightening holes. We radiused the lightening-hole corners to 5/8-inch diameter and used an adjustable hole saw to get the wing tube socket diameter just right. Cut and sand the two pieces while still glued together to ensure that they are identical.

As you cut the parts and before you remove the paper template, it's a good idea to mark the centers from the plans onto the edge of the part. After you remove the paper, sand the parts lightly on a flat surface to remove any glue residue, then label the part with a pencil or fine marker and mark the centerline.

The cowl former and F1 can initially be cut and sanded together to the outside line. We used the spray mount to temporarily glue the two pieces of wood together so the parts would be identical. After you're happy with the outline, scribe or draw an alignment line at the top and bottom edges and separate the two parts. Glue the second template to the part without a drawing and line it up on the cowl former using the line you scribed earlier. Proceed with cutting the inside lines on both parts. We'll split the cowl former later.

Fuselage: Splice together four pairs of 36 x 3/8-inch square balsa to form the longerons that will be laminated to the inside of each fuselage side. Use a long delta splice for the bottom front part of the fuselage that angles up. Glue on the longerons, and cut and glue in the 3/8 square upright fuselage structure from F3 back (the forward pieces will be glued in later). Cut and fit the rest of the forward 3/8 upright fuselage structure to be used as former gussets, *but don't glue them in at this time*. Leave a little 3/8 overhang at the front of the fuselage side, which will be cut flush and sanded after the fuselage is glued. Be sure to build a left and right fuselage side.

Lay the plan out on a smooth, flat surface and fold the front over the end of the table at F1. Trial-fit motor-box sides, F1, F2, F3, and fuselage sides over the plan, and make any final adjustments so that the parts fit properly. This is a good time to cut the fuselage floors, FL0, FL1, FL2, and FL3, and fit them to the fuselage. This is also the time to cut and fit the aft-most former from 3/8 balsa sheet.

Cut two lengths of 3/8 square balsa to fit each former station. Mark a centerline on one piece from each station. Trial-fit and pin the whole assembly together including the forward tank floor FL0, making sure that the fuselage is straight along the centerline. Use the wing tube socket center phenolic and tube to check for square. Do not glue the phenolic wing tube socket into the fuselage at this time.

Note that former F1 is wider at the top than at the bottom to fit the shape of the cowl. The fuselage has a slight twist built in to allow this fit. You can see in a picture that the orange building square is flush at F3 but not at F1. At F3, the fuselage sides are 90° to the building surface and the fuselage is built 90° from there to the rear. Make sure to use some weight to hold the fuselage flat on the building board.

F1 should fit the fuselage flush inside the cutout between the upper and lower 3/8-inch longerons. After you're satisfied with the fuselage alignment, glue the structure together. At this time you can fit the precut 3/8-inch upright former gussets into position next to their corresponding formers. Make sure to glue these sticks into position only after the rest of the structure has been aligned and glued.

After the main part of the fuselage is glued, you can unpin it from the table and flip it over to finish fitting and gluing the rest of the 3/8-inch stick structure and upright gussets at formers F1, F3, and along the rear of the motor box. We will laminate some 3/8 square to the top inside surface of the motor-box sides as a stiffener after the firewall has been installed. This is also a good time to finish gluing the floor (FL0) to the motor-box sides.

Cut, fit, and glue six gussets at the top of the fuselage at stations F4, F5, and F6.

Glue in fuselage floors FL1, FL2, and FL3. (FL0 should already be in place.) Cut and fit the top and bottom 1/4 square balsa

diagonal bracing from F6 to the rear. We also glued in the top 3/8 diagonal braces over the radio-compartment area, but for convenience you can wait to do this after the radio equipment is installed. Don't glue in the brace over FL1 until after the wing tube socket is installed.

Glue on the 1/4 balsa stringer formers BF1, 2, 3, 4, and 5, centered over the 3/8-inch cross structures. Sand the rear of the fuselage square, and glue on the tail-wheel plate.

Bottom Stringers: Delta splice a 12-inch section onto a 48-inch length of 1/4 square spruce for each 60-inch bottom stringer. Fit the stringers to create a flat bottom. Adjust the notches as necessary to keep the stringers straight. The stringers should follow the plan and bend at BF3 (see photo). The stringers go from F2 rearward to the tail-wheel plate. Sand them to fit flush at the rear.

Add 1/16 x 1/4-inch capstrips to F2 and F3. This gives a nice surface for sticking down the covering. Center the capstrip on F3, but fit F2's capstrip to the rear of the former.

Landing-Gear Plate: Using the plan, cut the landing-gear plate from 1/8 aircraft plywood and the doublers from 1/8 light plywood. Scribe a line at a 1/8-inch depth on the inside of the motor-box sides and glue the doublers to the inside of the motor-box sides, aligning them. Referencing the plan, mark two points for drilling bolt holes that will attach the landing-gear "L" brackets. Cut two 4 1/2-inch lengths from one-inch, .050-thick extruded angled "L" aluminum, available at most hardware stores.

Line up the brackets to match the top of the doubler just shy of touching F2. Use scrap blocks of wood and clamp them in place to drill for the bolt holes. Drill all the holes while clamped in place. Use 6-32 cap screws with blind nuts on the outside, and bolt it all together using Loctite. Glue the landing-gear plate down flush inside the motor-box sides. Erik decided that he wanted the additional security of lock nuts on the bracket bolts.

With your compass, mark a line 3/4 inch inside each side of the motor box, and mark the center of the landing-gear plate. Line up your landing gear, and mark it according to these lines. Drill four holes for 8-32 bolts. Line up the gear on the centerline of the LG plate, leaving a 3/32-inch gap between the gear and F2 (note that in the photo we used a 3/32 capstrip for a spacer), and drill through the LG plate and the "L" brackets.

Using 8-32 cap screws and lock nuts, bolt the landing gear to the fuselage. Leave a 3/32-inch gap between it and the gear, and glue on the LG1 1/4 balsa former.

Tail-Wheel Plate: You can see in the photo how the tail-wheel plate was contoured at the edges. We also decided to lighten this area and were able to do so because our rudder servos will be mounted in the hatch compartment. An additional section of wood was removed from the fuselage sides under the stabilizer. This will also aid in later maintenance and assembly. If you plan to use a heavier engine, we suggest that you mount the rudder servos in the fuselage sides under the stabilizer.

We used an Ohio Superstar Haigh-type tail wheel that requires an antirotation block to be installed inside the fuselage. The block was made from laminated scraps of 1/8 light plywood. The result was light and strong compared to hardwood. We mounted the assembly with 2-56 cap screws and blind nuts set into doublers inside the tail-wheel plate. Do not use wood screws to hold the tail-wheel brackets.

Fitting the Cowl: With a sanding block, true the edges of the cowl so that the parts have a good fit. We found that the Aeroglass cowls are very good and require only a light amount of sanding to make the parts square and perfect. Tape the halves together. With a compass, mark a line on the cowl former approximately 1/32 inch (.030) from the outside and carefully sand

off material a little at a time, checking cowl fit as you go. The idea is to get the cowl to fit flush with the fuselage sides and F1.

Once you're satisfied with the fit, mark the former to be cut at the cowl seam. Place the marks approximately one inch apart, centered on the 1/2-inch overlapping seam. *Do not cut at this time.* Bolt the cowl former in place with 4-40 cap screws and blind nuts. Use four in the bottom half, accessed from inside the cowl, and three for the top half, accessed from inside the hatch. We made small doublers from 1/8 light plywood for the blind nuts. Do a final fit check and correct any imperfections with the fit.

To prevent getting glue on F1, separate the cowl former from F1 with waxed paper and bolt the cowl former back onto F1. Tape the cowl into place, and glue it to the former with medium ZAP. Be careful not to get any glue between the cut marks that you just made. After the cowl is secure, remove it from the fuselage and add a fine fillet of Plexus Methacrylate or similar adhesive over the ZAP.

With the cowl halves together, mark and drill five holes on each side for the 4-40 x 1/4-inch button-head screws. Back the holes up with a small piece of 1/8 light plywood and install small 4-40 blind nuts. We used nylon washers on the outside of the cowl to be a little kinder to the paint. Cut the ring roughly 1/4 inch on either side of the cowl half overlaps. We made our marks a little too large, as seen in the photo. Sand a nice beveled edge in the cowl ring to finish it off, and add a bead of Methacrylate to any part of the ring that is not fully glued to the cowl.

Sheet the area between F1 and LG1 with 1/16 balsa. The sheeting will glue to the inside of F1 and lay over the top of LG1. First sand a bevel on LG1 to line up with F1 (ensuring that the sheeting will lay flat on LG1). We made a 1/4-inch-wide 1/8 balsa lip on the inside of F1 to give the sheeting something to lay on while being glued. Preglue the sheets together to do half the area at a time. One stringer in the center between LG1 and F1 will give you an area to start from. Use a paper template to get the shape just right, and trial-fit before gluing. Perform this procedure with the cowl in place to ensure proper alignment.

Odds and Ends: Using 1/16-inch sheeting, fill the open areas on each side of the landing-gear mount. Follow what is shown in the photo here, and put it in at an angle. If you try to fill the gap, the gear's flexing action will break the balsa. The way we have it positioned leaves room for the gear to work.

Trace the top half of F1 onto a sheet of medium-density 3/8 balsa. This will be used as a stiffener for F1. Leave approximately 1/16 protruding past the top so that when the hatch is installed all the parts can be block-sanded to align perfectly. With a compass set at roughly 1 inch, trace the outside line to form the inside line. Drill three relief holes for the cowl bolts with a piece of sharpened 3/8-inch-diameter copper tubing. We also glued in some 1/32 aircraft-plywood washers to keep the softer light plywood

from crushing. Glue the stiffener in with the cowl completely installed to keep the former aligned and flat.

Glue a length of 3/8 square balsa into the corners of the motor box and F1 from the bottom of the motor box to the stiffener you just installed.

At this point you have finished the wood portion of the fuselage for your 35% Extra 300LX. The wing and stabilizer tube sockets will be aligned and glued into place after we have the wings and stabilizers ready for alignment. Next month we'll sheet and trim all the foam parts, looking at several different methods to get the job done. MA

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■ Mike Hurley

Project Extra

Volume II: Sheeting Foam Components

Fully assembled in the shop, the 35% Extra 300LX takes quite a bit of building space, but it will be envied out on the field!

THIS INSTALLMENT of Project Extra will cover sheeting and finishing foam parts. As I stated in the introduction to the project, this construction series is intended to span model-building in general but still apply to the Extra 300LX. This article will give some insight into sheeting foam and an overview of today's most common sheeting methods. As you will see in this article, there are many ways to accomplish the sheeting portion of any aircraft, and you can successfully sheet the foam for your Extra with any of these methods.

For a step-by-step account of how we chose to do the sheeting on our Extra, go to the AMA Web site—www.modelaircraft.org—for this month's PDF download of Project Extra construction details.

Choose Your Wood: The Extra has many foam parts. The wings, stabilizers, rudder, a large hatch, and the turtledeck are foam. We experimented with various methods of attaching the wood to the foam and gluing the individual sheets together, and we came up with several acceptable ways to do both.

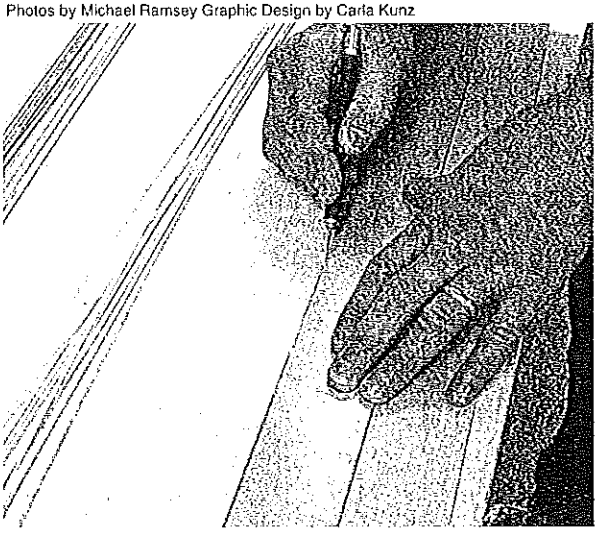
Before we get started, it would benefit you to take a look at the wood you are using for sheeting your foam parts. Most models from 40-size sport airplanes to 40% monster International Miniature Aerobatic Club (IMAC) airplanes are using 1/16 balsa to sheet almost everything including the wings. We use 4 x 48-inch sheets as a basis, and cut them down from there.

There's a big difference in density of balsa; in one batch we found a sheet that weighed 11 grams and another that was 70 grams! The heavy wood should be a tad stronger, but I doubt that there is any sheeting application that needs lumber like that 70-gram plank. Imagine the variations you could have if you were to blindly start gluing sheets together at random. It really is better to know what you have from the start by weighing each sheet on a good digital scale. I picked mine up at an office-supply store for $29.

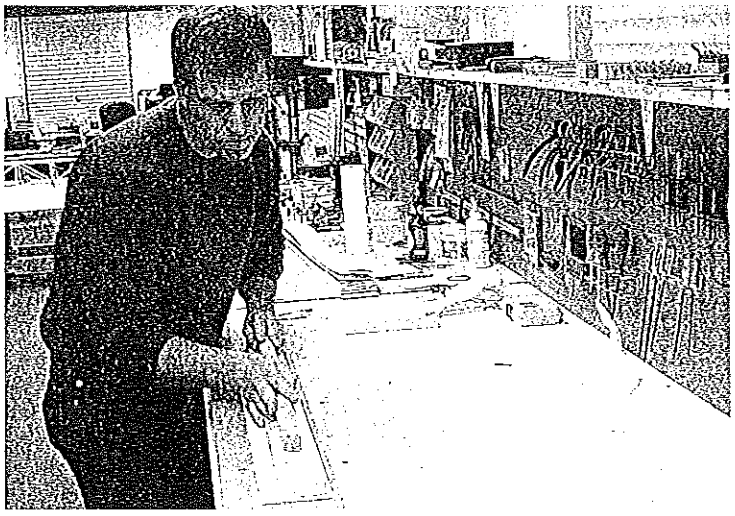
Use the lighter, more bendable woods for shorter runs like the stabilizers or for places that require a tight bend like the turtledeck. But remember that the light wood is very soft and gouges easily, making handling and your finishing job a delicate process. Use harder wood if you want a more robust surface to finish.

A soft, contest-grade sheet weighs something in the neighborhood of 14-18 grams (4- to 6-pound density). We used

Photos by Michael Ramsey Graphic Design by Carla Kunz



To begin edge-truing sheets before gluing them, use a long straightedge and X-Acto knife. Cut off only what's necessary to straighten the edges.



Erik built this sanding fixture as a final step to a perfect edge for gluing. Run sheets back and forth across the block, and edges will be ready for gluing.

these everywhere but the main wings. We used planks that came in at 18-22 grams (6- to 8-pound density) for the wings, and we tried to avoid any wood exceeding 24-25 grams. Before any foam was glued, we weighed the individual parts and made sure that the left and right sides were as near the same weight as possible.

Choose Your Glue: Edge-truing the sheets before you start gluing them together helps the process immensely. Our builder Erik Richards made his edge-truing guide from particleboard and a piece of angle aluminum with 150-grit sandpaper glued to it. Trim the edges with a four-foot straightedge and a sharp hobby knife or a razor blade, then get a final edge by lightly guiding the sheets along the edge-truing surface.

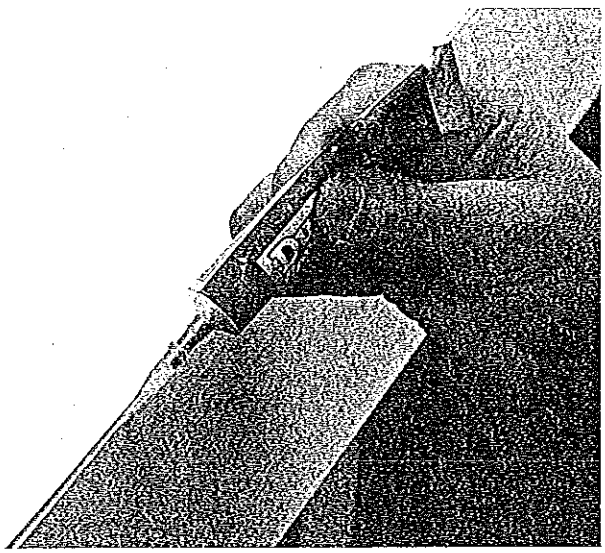
There are several ways to approach gluing sheets together and several glues to choose from. We're striving for an analysis of the pros and cons of these differing methods. I experimented with some of the more common methods for this article, edge-gluing with cyanoacrylate (CyA), Duco, or Ambroid model-airplane cements, and common carpenter's wood glue. All of these methods produce acceptable results and with practice can be quite nice.

All methods start by taping the edge-trued sheets together down the entire length of the sheet on one side, and flipping it over and bending at the tape line to expose the edge. The glue is applied to the edge, and the sheets are folded back together.

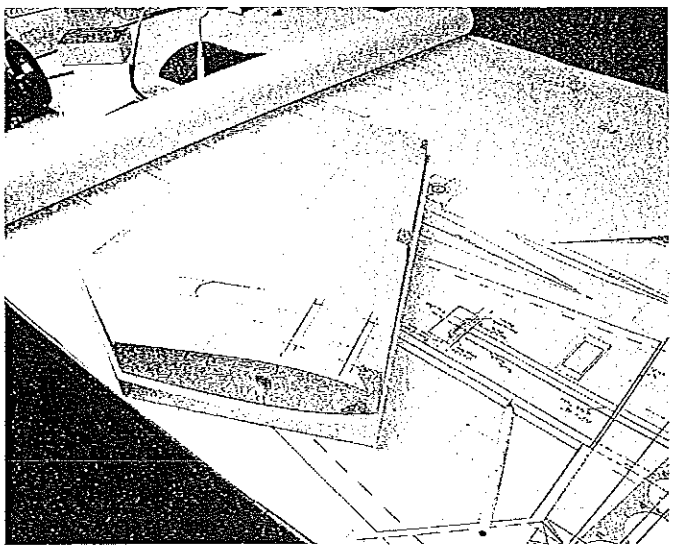
Thick CyA applied in a very thin line with a fine tip to the edge of the sheet worked very well with a little practice. As you move the bottle along the edge, the glue seems to drag out of the bottle. Thin CyA can be a mess and results in severe hard spots that are unsandable if you try to avoid the edge-gluing method and soak the seam with it. The thick CyA works well because it gives you a little more time to align the edges before it sets.

Once the edges are together, dab up any excess glue with a paper towel and sand lightly with a block and 150-grit paper. Before the glue hardens completely, flip the sheet over, peel off the tape, and sand again. The trick is to keep the glue to a minimum because any overspill will harden the wood and become difficult to sand. After I got the knack of using the CyA I liked it very much. It was the quickest of the edge-gluing methods and yielded a clean, smooth sheet of wood. On the other hand, too much glue will result in hard edges that cannot be sanded out, so the glue application is very important.

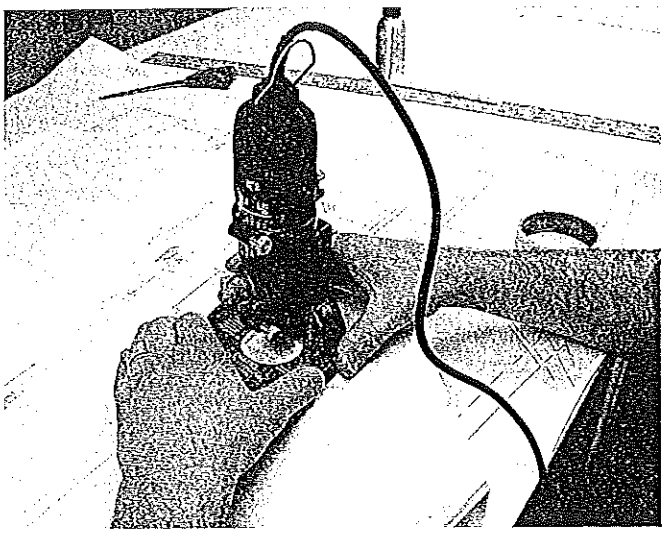
I've read that CyA can soften with heat, so I did a test. I heated the sheeting with my covering heat gun and measured the temperature with a Raytek digital surface heat gauge. I got the wood hot enough to melt the foam underneath it (250 degrees Fahrenheit) with no noticeable sign of softening the CyA. Okay, so it's not a completely scientific test, but surely the act of covering your airplane or



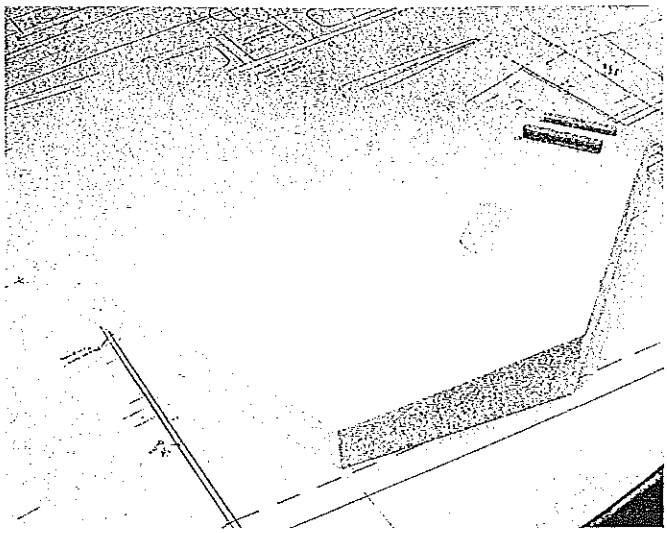
Whether you're using Duco, Ambroid cement, cyanoacrylate, or wood glue, applying the glue is the trickiest part.



The trick to a perfect layout, and to remembering what's under the sheeting, is to first make a template with poster board.



A router attachment on a Dremel tool is perfect for cutting the reliefs for inlaying balsa in the foam core.



Besides the servo rails and cutouts, a stress plate is also inserted under the balsa for the control-horn dowels.

allowing it to sit in the sun will not affect the joints glued with CyA.

Working with old-fashioned wood glue takes speed and practice. I could not get the glue to lay out in as fine a bead as the CyA even with the use of a glue syringe, so cleanup was a bit more involved. After the pieces are folded together, you need to work quickly to scrape the excess with a plastic squeegee. A damp rag will help to remove the remainder, but the glue starts to set fast. The added step of having to retape both sides after a cleanup and sanding meant that there was quite a bit more work involved, and the need to let it set overnight added to the time factor. As was CyA, wood glue was very hard once it set up completely; if you don't get it level and clean before the drying process, you end up with an unsandable raised edge.

Old-timers may remember Duco and Ambroid cements from the stick-and-tissue models of our youth—a time before CyA was invented. The method with these cements is very much like with wood glue, but it does not dry as quickly, so after the glue is applied and the sheets are folded back together, it's just a matter of carefully scraping the glue off with a squeegee and wiping down the wood with a paper towel. Do a quick, light sanding with 150 on a block and retape. Flip the sheet over, peel off the tape, and clean up and sand this side like the first, and retape to let it dry overnight.

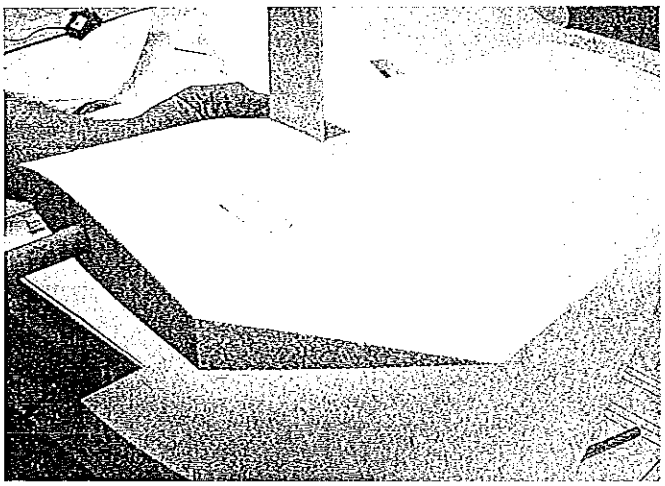
Erik likes this method the best because the classic airplane cements give you more time to sand before they start to set up. With Duco or Ambroid it may be easier to achieve a seam-free finish in the end. I prefer the CyA because it is much quicker, and, being a little less picky, I was satisfied with the result of the seams.

Another method has popped onto the scene in just the last few years that many people are using, especially in the Scale Aerobatics arena. If you are going to sheet your wings using Probond polyurethane glue, you may completely forgo gluing the sheets together. The polyurethane glues expand while drying, forcing their way into every crack and crevice; this action will glue the sheets together in the process. Simply tape the sheets together on the outside as you normally would, and move on to the sheeting process.

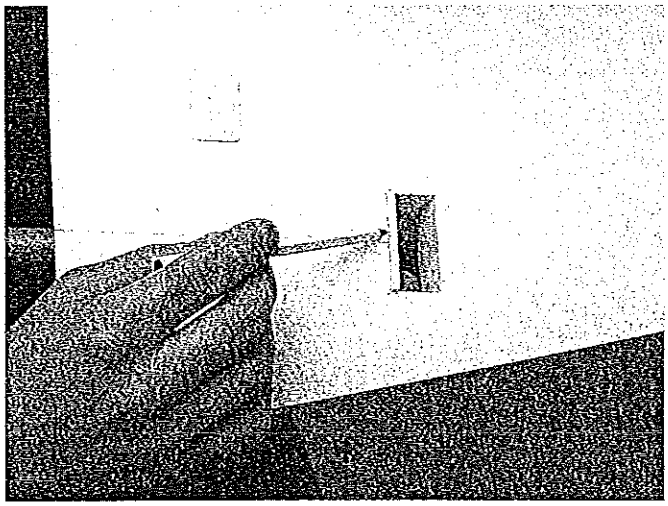
Most of the time only a small amount of glue gets past the tape onto the outside of the wood. Sanding the sheets smooth and clean afterward was possible with this method, but it took a light touch and some patience.

Prepare the Foam Cores: Before we discuss the various sheeting methods, let's prepare the foam cores. We must first determine where a number of points will need attention, such as servo bays, hard points for control horns, alignment dowels, etc. We like to make a template from thin poster board so after the cores are sheeted we can align the template and know where we located all the stuff that was buried in the foam under the sheeting. We'll know where the servo bays are, where the dowels go, and so on.

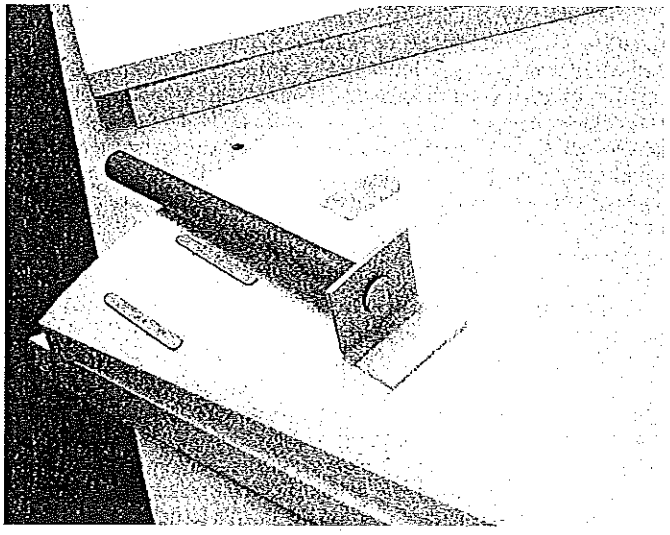
An easy approach to an accurate template is to slide poster board under the plan. Working on a building surface that allows pins to penetrate, place a pin at each corner of



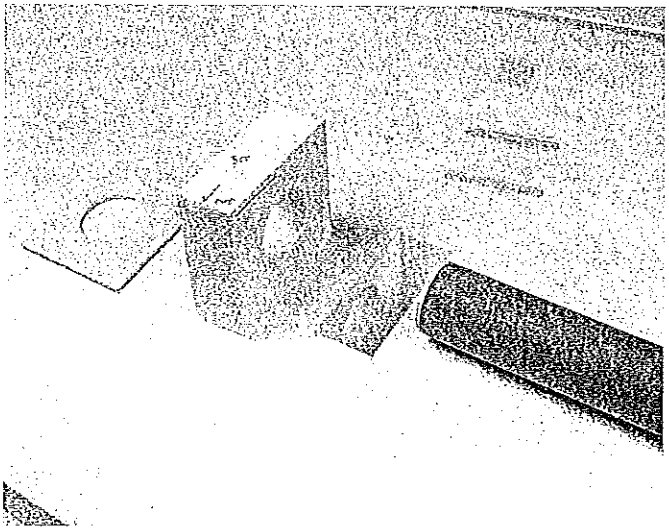
A stress-bearing plate is inserted in wing and stabilizer to support tube sockets. An ink-pad stamper was used to mark light plywood for cutting the tube hole.



After the hole is fitted and the tube is in place, cut the stress-bearing plate to fit.



These are the parts for the tube socket assembly and the stress-bearing plate. Epoxy was used to glue everything.



Scrap foam was used to fill the opening. Once it's glued in place, it will all be sanded to fit. The end of the tube socket is capped with ⅛ light plywood.

the part and at each corner of the objects that you want to locate. We wanted to bury dowel stress-bearing plates for the control-horn dowels and ¼ x ⅜ x 2¼-inch spruce servo rails. Remove the poster board from under the plan and connect the dots (holes that you made with the pins). Later we'll use the template for marking and cutting the hinge lines, so be sure to add that to the template.

We used a Dremel tool with a router attachment to cut bays for the bearing stress plates and servo rails. The servo rails were sunk into the foam enough for the servo to fit nearly flush with the surface of the wing or stabilizer. Be sure to account for the skin's thickness when making your depth calculation.

Since Erik will be vacuum-bagging his wings, he added very soft balsa to the rails to temporarily bring them flush with the foam. This way the sheeting will stay consistent under the pressure from the vacuum-bagging. Later when the servo bays are cut out, he will cut away the balsa so that the servos can sit farther down into the bay and stay flush with the wing's surface.

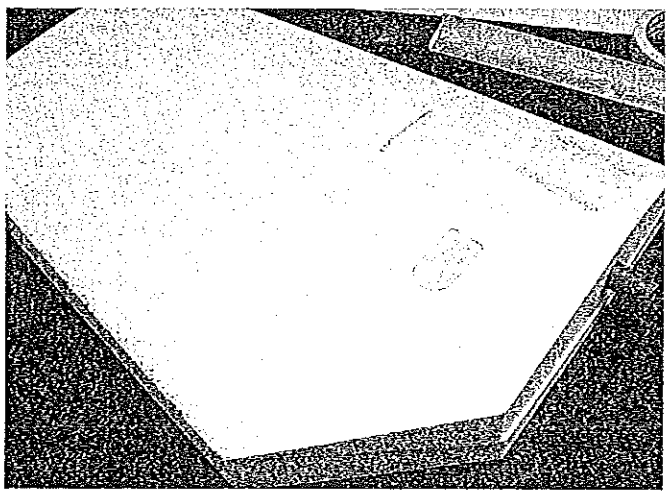
The control-horn stress-bearing plates are there to tie the top and bottom stressed skins together and make for an even fulcrum for the horn to pivot around the hinge. A ½-inch dowel will pass through and adhere to both plates. A bolt will pass through the dowel and act as the control horn. To me this is just about the ultimate control-horn configuration for foam surfaces. It's extremely strong and rigid, uses the entire thickness of the surface for mechanical advantage, and is serviceable in that the bolt does not need to be epoxied in place and can be removed and replaced at any time.

The stress plates are installed so that they protrude slightly into the cut area for the leading edge (LE) of the elevator or aileron. Later when those surfaces are cut from the wing or stabilizer, the stress plates will be cut too, then they are sure to glue flush against the LE material. The corners on everything that we install in the cores are rounded. The rounded edges have less tendency to produce a stressed point or a failure point.

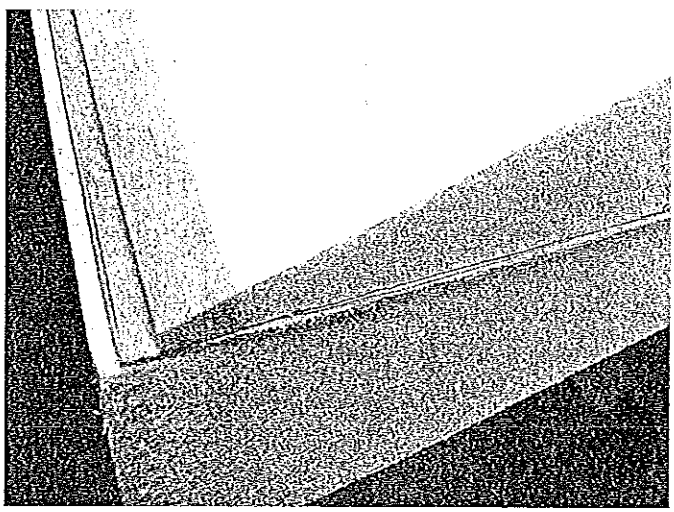
Make the tube socket stress-bearing plate. In the foam core is an open bay where the stress plate holds the wing tube socket. This stress plate is very important; without it, the foam would start to crumble in just a few short flights. We measured a piece of light plywood to fit perfectly from side to side inside the bay but had excess hang out of the opening on both sides of the core. We used the tube socket end dipped in an ink pad to mark the location to make a hole in the stress plate for the socket.

After the hole is marked and cut to fit perfectly around the socket, place it back in its location with the tube in place, and trace the outline of the wing core. The idea is for this plate to glue the tube socket, the foam, and the wing skins together, so leave it slightly oversize when cutting to fit so that you can sand it perfectly flush with the core and the sheeting will bond to it. We will also fill the bay with scrap foam and sand it flush so that the whole assembly is securely glued together.

It's time to glue the dowel stress plates, the wing tube socket, the wing tube socket stress

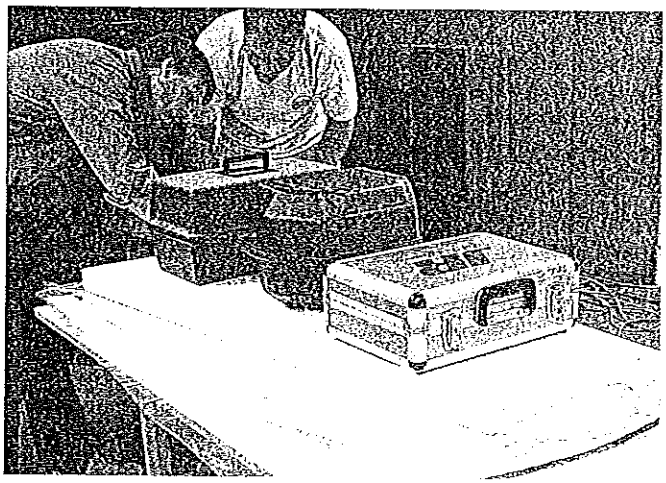


Finished foam core after wood pieces are glued in and sanded flush. It's important that sanding be smooth and there are no gaps or openings to show after sheeting.

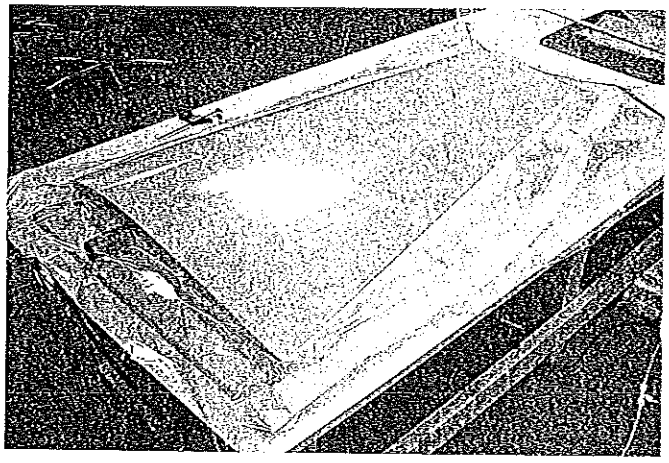


The assembly process entails an internal TE. Tying in the sheeting to the TE makes for a much stronger finished product.

Once the vacuum has started to draw, all wrinkles and folds must be smoothed away. Any imperfections left in the bag will be permanently marked in the sheeting.



Shuck was placed on top of bagged wing and light weight was used to hold core flat. When glue is dry, cut ends off bag just inside seal and reuse for next wing.



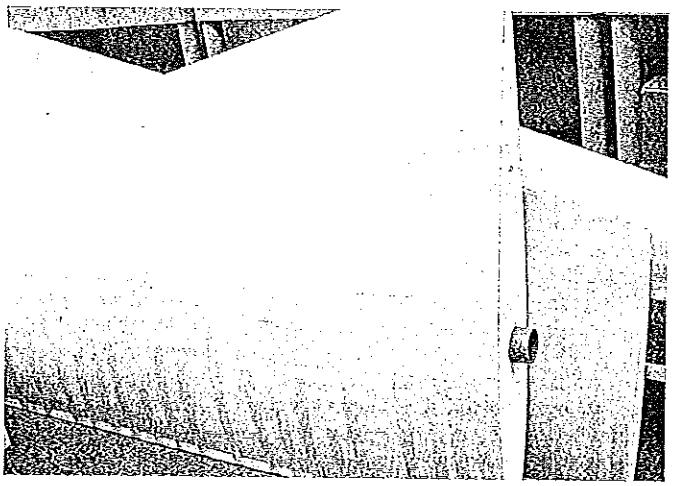
When the bag is smooth and even, turn up the regulator to reach approximately 8 inches Hg.

plate, and the servo rails into place before sheeting. In our foam cores, made by FlyingFoam.com, the channels for the servo wires are already cut into the main wing foam. For the stabilizers we'll just use a ½-inch copper tube to cut a channel later. Cap the end of the tube socket with ⅛ light plywood and sand it flush. This will act as a tube stop. Without it, the wing or stabilizer tube could migrate into the foam and cut as it went.

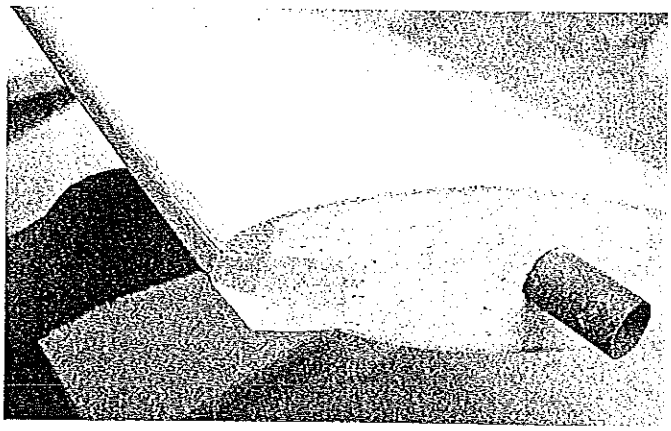
We used epoxy to assemble everything. Other glues that are compatible with foam, such as carpenter's glue or Probond polyurethane, are fine too. After the glue is set, sand the installed components flush to the core's surface. Make sure that there is at least ⅜ inch of excess socket material extending from the root of the wing or stabilizer. You can see that the stress-plate bay has been filled with scrap foam, the servo rails and stress plates are in and flush, and that everything should glue nicely to the sheeting we are about to apply. The servo bays and holes for the control-horn dowels will be cut after the sheeting is in place.

On our wings and rudder we decided to bury our trailing edges (TEs) inside the sheeting. This method is structurally much stronger than butt-gluing the TE to the wing after it is sheeted. One of the worst enemies of large control surfaces, especially long ailerons, is flex. A flexible surface is more prone to failure because of flutter. We are striving for very light yet very rigid surfaces, and although it may be a bit more work to build the TE into the wings, the strength advantage is well worth the effort.

The idea is simple. Glue the TE to the bare foam and shape it to create an extension of the foam, then sheet over the whole assembly. The wings on the Extra were not designed to have completely sharp TEs, but the cores from FlyingFoam.com are cut oversized and go to a point so that you can cut them to achieve your desired final result. We



Use ½ light contest-grade balsa for the LE. Cut it slightly oversize, and attach it using a liberal amount of epoxy.



To ensure a straight contoured LE, mark the centerline with a piece of masking tape. Use a razor plane to work it to shape. Do the final finish with a sanding block.

cut exactly 1 inch off the TE of the wings and rudder and added a half inch of balsa to create our TE, then we sanded the balsa flush with the core. After the wings are sheeted your TEs will already be done, and all that will be needed is a cursory sanding to true up the TE.

Now it's time to fit the wings and stabilizers to the fuselage and sand them to get a flush fit. Since you can't cut off the phenolic tube at this point, it may be a good idea to make a thick dummy root rib that will fit over the phenolic and fit tight against the fuselage side. Adjust by sanding the foam wing or stabilizer root until you get a nice, tight fit.

Sheeting Techniques: With the construction of a foam wing, the strength is achieved by the shearing action between the sheeting and the foam. The thickness of the wing also plays a role. The density or strength of the sheeting itself is the least critical factor in the strength of the wing. So the method by which the sheeting is glued will, in large part, be the determining factor in the wing's strength. A spar may help, but I have never found them necessary when the sheeting is done properly.

I don't claim to have all the answers, and for most of us the ultimate way to accomplish the task at hand may be a combination of methods. Let's look at three methods for applying the sheeting to the foam: epoxy or Probond with weights for holding the sheeting to the skins, contact cement, and vacuum-bagging. Erik will vacuum-bag his wings. You can get in-depth info about what we did during that process in the more detailed online construction manual. For the purpose of this article we'll pay a quick visit to each method rather than try to give in-depth instruction.

A close friend of mine, Norm Cassella, a longtime builder with more than 60 completed ⅓-scale Lasers and countless other models, uses spray contact cement for all of his foam sheeting. His models have proven themselves in time with countless hours baking in the sun. Many of them are still flying weekly and in perfect condition after 10 years!

The completed Extra you see in this article was built with the method I'm going to describe. The trick is to use an industrial grade of spray glue. Some builders have used 3M #77 and have had less than satisfactory results. We have had great luck with 3M 08074 spray trim adhesive, available at your local automotive-parts store. It won't melt the foam when applied correctly, it doesn't lift in hot weather, and it holds fast for years without drying out.

Contact cement is probably the quickest way to sheet foam, and although it is far less work than the other methods, it may not be the easiest! If the two pieces to be glued touch in the wrong spot, you could easily have a ruined wing because they instantly adhere on contact and will not separate without destroying one of the parts.

As with any sheeting method, a good, flat table or work surface is essential to attain a straight wing panel. We were lucky to obtain a couple of 5 x 3-foot slabs of machined marble. It's about as perfect as you can find without the expense of a machinist's table.

With contact glue, trial-fitting is the key. Start with the TE and roll the wing on the flat surface to the LE. Mark the corners and double-check the marks. Spray the contact cement on both surfaces to be glued and let stand until tacky as per the directions on the can. It usually takes approximately 10 minutes. Too much build-up will take longer to dry and may melt the foam, so don't overdo it. You're after a medium, even coat. Getting the TE flat on the first contact is very important to obtain a straight TE. Tack down the TE, then just roll the panel flat on the table to the LE and you're done! I use epoxy to adhere the end caps and edges and make sure they are glued well to any exposed sheeting. This ensures that the sheeting will not lift from an edge.

Newsflash: While I was sitting here writing, Erik weighed the two sheeted wing panels complete with TEs, phenolic sockets installed, servo rails, and dowel plates. They are *exactly* the same weight! (We had to weigh them in grams to verify ...) That's how accurate you can be when you pay attention to the details. Amazing! (Again, he is vacuum-bagging with epoxy.)

Most modelers use the weighting method, and it works virtually the same with epoxy and polyurethane. Trim your glued or taped sheets to fit in the shucks as tightly as you want. We leave roughly ¼-inch overhang all the way around.

Erik likes to seal the wood before applying any epoxy so that it does not soak into the wood too heavily. He prefers to

use hairspray for its light weight and spray-on convenience, but Balsarite will seal the wood slightly better. Hairspray is also ready to sand in just a few minutes, whereas Balsarite must dry for several hours. Sand the hairsprayed surface with 320-grit paper on a foam block, and wipe it clean with a tack cloth or vacuum it.

Weigh the epoxy (or at least use a measuring vessel) to get the same amount on each wing panel. Spread it evenly with a plastic spreader or your spouse's department-store credit cards (I find that the Neiman Marcus and Lord & Taylor cards work the best ...) until the whole surface has a shine. Don't allow any significant buildup. Push any excess off onto some waxed paper.

On your flat building surface, place the assembled wing core and skins into the shucks with the top of the wing down. Align the assembly and place a flat and true piece of ¾-inch particleboard that spans the entire core on the top to spread the weight that you are about to add. Most people use bricks or heavy blocks to weight the core. It takes at least 200 pounds or more on a wing this size to get a good, tight bond evenly across the wing surface. Add the weight, and let the cores dry overnight.

As I mentioned, Erik wanted to use the vacuum-bagging method for our airplane. Vacuum-bagging is a process in which the wing is placed in a plastic sleeve and sealed, allowing the air to be pulled out with a vacuum pump, which creates uniform pressure around the entire wing assembly. At 8 inches Hg, the equivalent would be to place approximately 1,800 pounds on the wing panel. The vacuum also tends to pull the glue farther into the porosity of the wood and the foam, creating a better bond with less glue.

This method requires special tools and materials. On average you can get started vacuum-bagging for roughly $300. See the sidebar for a list of tools, materials, and suppliers.

The wing and skins are inside the plastic sleeve while the shucks are lightly weighted on the outside to hold everything in place. In a picture you can see the vacuum pump, the sleeve, and various hardware to get everything doing its job. To follow our procedure step-by-step, go to the AMA Web site. After the sheeting is in place, we will have to install and shape the LEs, root plates, and tips. We used ⅛ light plywood for the wing and stabilizer roots and ⅛ balsa for the tips with ½-inch contest-grade balsa sheet stock for the LEs. Shape them per plans. You can read more about the procedure in our Web construction manual.

Good luck with the sheeting process, and remember that the goal is to get a straight wing panel. Next month we'll finish the foam parts, fully trammel the aircraft for perfect alignment, and cut out and hinge all the control surfaces. MA

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Equipment for Bagging Wings

The Composite Store
Box 622
Tehachapi CA 93581
(800) 338-1278
www.cstsales.com/Vacuum_Bagging/vacuum-bagging-systems.htm

Aerospace Composite Products
14210 Doolittle Dr.
San Leandro CA 94577
Order desk: (800) 811-2009
Technical assistance: (510) 352-2022
www.acp-composites.com/acp-vbs.htm

Following is a list of the items we used:

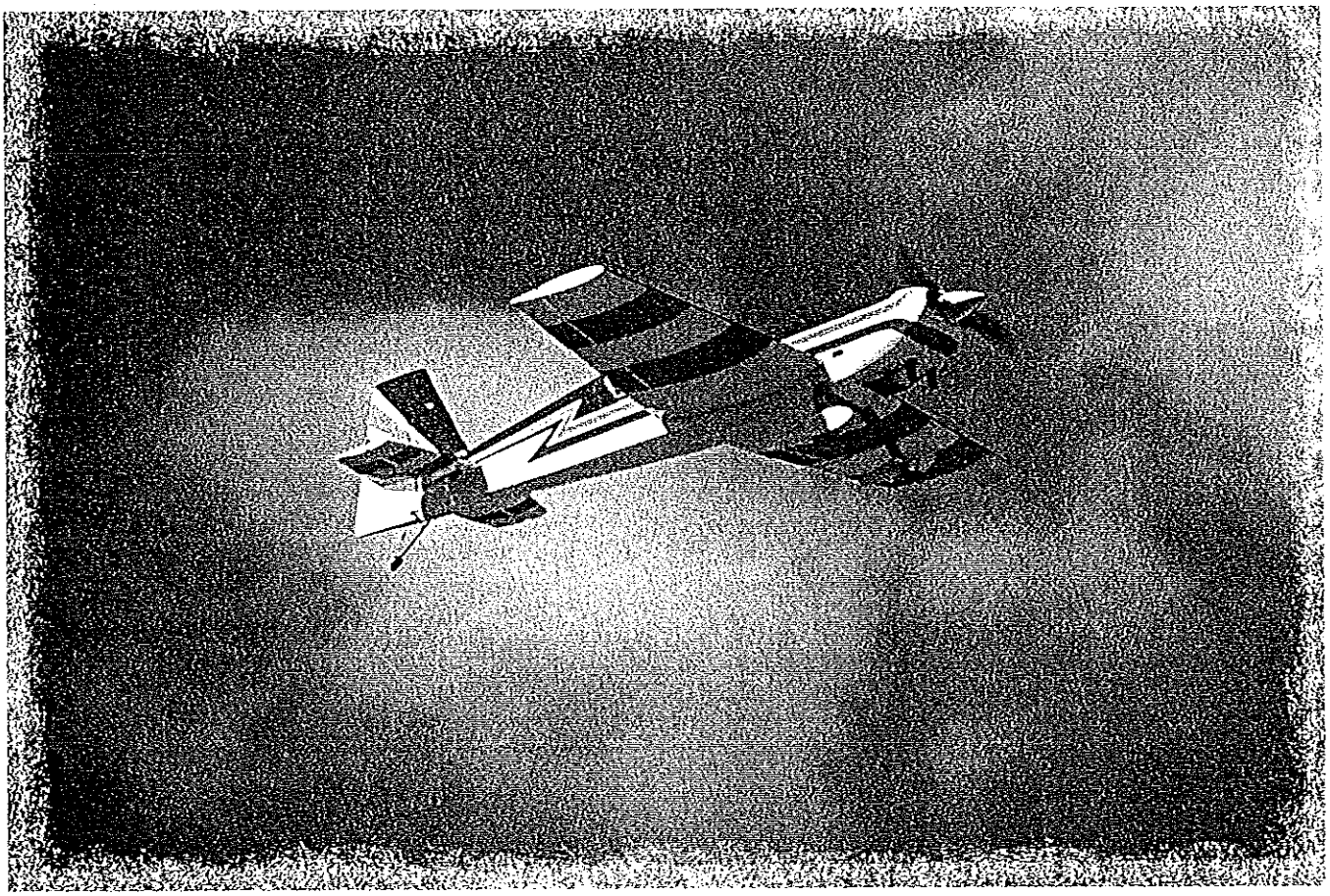
- Pump and regulator
- Vacuum line
- 3 yards 36-inch-wide nylon tube (bag for wings)
- 3 yards 18-inch-wide nylon tube (bag for stabilizers)
- 1 roll of tacky seal
- 4 yards 2-inch breather strip

—Mike Hurley

Project Extra

■ Mike Hurley

Volume III: Trammeling and Incidence



CRITICAL SETUP adjustments are an integral step to building any aircraft that is expected to fly well, but they are especially important when seeking precision flight characteristics. As with all of the chapters in "Project Extra," it is hoped that you can use these steps and ideas on any aircraft that you are building. To that end, I've gone into considerable detail so that you might transfer these instructions to your own projects.

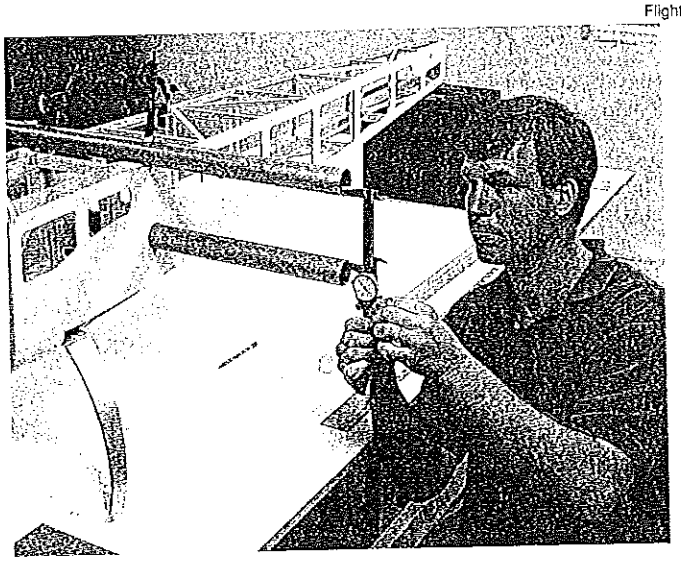
On the most basic level there are three critical horizontal adjustments to be concerned with—the engine thrustline, the wing incidence, and the horizontal stabilizer incidence. Our Extra 300LX is designed around one horizontal line: the thrustline. All of the design measurements are taken from this reference line. This airplane was designed to have an alignment of 0-0-0—engine mounted along the thrustline, 0° wing and 0° stabilizer incidence. The top longeron follows parallel to the thrustline just 11 5/16 inches above the thrustline, and the engine's crankshaft is centered on the thrustline.

All three of these adjustments work together to give you an aircraft that flies at a level *attitude* while holding *altitude* at differing throttle settings. This is especially important in precision aerobatics flying. The wing incidence will affect the airplane's attitude. A positive incidence will give your model a nose-high/tail-low attitude, and a negative adjustment will raise the tail.

Incorrect alignment of the engine with the thrustline or incorrect stabilizer incidence may cause the aircraft to change altitude with varying throttle settings. This becomes evident on vertical lines where you have full power for an up line or power off for a down line. Don't worry about perfect elevator to stabilizer trim; it means very little if you have a slight amount of trim on the elevators as long as the airplane can cope with all attitudes of flight.

For exacting results, the following adjustments are made before the control surfaces are cut from the wings or stabilizers. Follow the same procedure for the wing and stabilizer. The stabilizer alignment is referenced from the centerline of F3.

Fitting the Tube Socket: Project Extra uses a phenolic wing tube socket glued into the fuselage, so the first order of business is to set that socket into the fuselage and get it aligned perpendicularly and



Erik checks alignment of tube to fuselage with dial caliper. He and author also measure with wings attached using 8-foot-long aluminum angle to check wing level.

To check fore and aft alignment on a model this size, steel cable is superior to string because of string's stretching factor.

horizontally. We cut the socket to approximately 10⅛ inches and fit it into the fuselage, sanding it flush to the sides (but don't glue it in at this time).

To fit the tube horizontally, the best method is to flip the fuselage on its back using a perfectly flat table, and take measurements from the tabletop to the wingtips. We didn't have a perfect table, so Erik Richards used a spare wing tube clamped to the top of the fuselage and took measurements at the tips. Then the wings were placed on the tube, and an 8-foot piece of angle aluminum was used to measure the wings.

We made tiny adjustments by sanding the fuselage slightly to adjust the socket then remeasuring until the horizontal angle was perfect. You can use a small wedge or a toothpick to hold the adjustments until you are ready to glue.

Wing Alignment (Trammeling): Next we checked the fore and aft alignment of the wings to ensure that they are square to the fuselage centerline. To do that, Erik made a nice little device from a steel cable. A piece of string is largely inaccurate at the distance we have with a model this size because it will stretch.

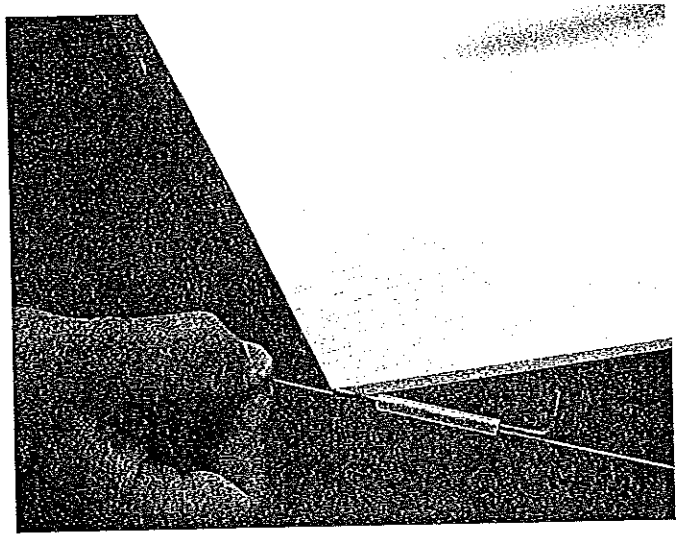
On one end there is a loop for pinning to the fuselage, and on the cable he used a piece of fuel line and an Allen wrench for a pointer. Pin the loop of the cable to the rear former centerline on the top of the fuselage, then slide the pointer to the trailing-edge tip of the wing. Walk to the other side of the airplane and check the other wing. Again, adjust the fuselage tube socket until the trammel (wing alignment) is perfect.

From ⅛ light plywood, make a pair of 3-inch square tube socket doublers with a 1.610-inch-diameter hole at the center. It may help to make the hole slightly undersized and sand it until you get a snug fit on the phenolic; the doublers need to have a good, tight fit. Box in the area where the doubler fits to the fuselage with two pieces of ⅜ square balsa.

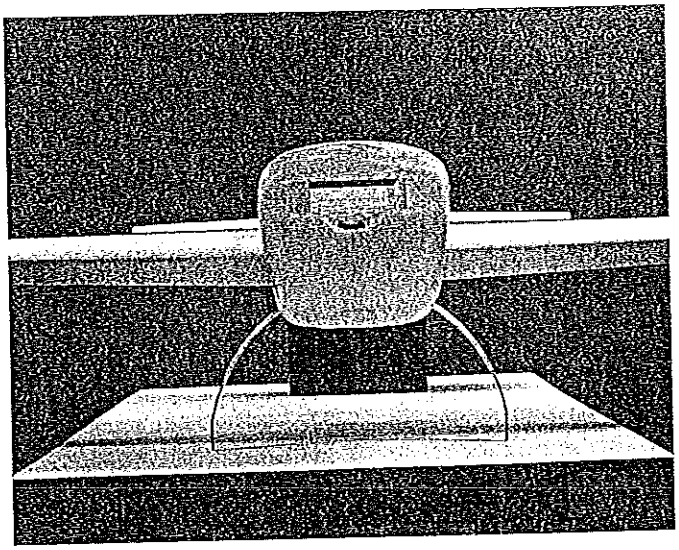
Fit the socket into the fuselage with the doublers in place, then square the tube to alignment using any wedges you may have made to keep the socket in place. Do a final check to see that the socket is where you want it, then tack-glue it to the fuselage with cyanoacrylate (CyA). Once you're satisfied with the socket's placement, you can final-glue the socket to the fuselage sides and slide the doublers over, and glue them in place to the ⅜-inch balsa framework and the socket.

After the tube socket is finished, you can add the last diagonal brace into the fuselage.

Follow the same procedure with the stabilizer tube socket, except it does not utilize an inside doubler. However, a circular doubler may be used glued directly to the inside of the fuselage sides if a large adjustment is necessary to bring the tube into alignment. Make



Attached to the cable, Mike and Erik use a sharpened Allen wrench and a piece of fuel tubing as a pointer.



When wings and stabilizers are aligned and level, centerline of stabilizers should be parallel to top line of wing.

sure that the horizontal alignment of the stabilizer is adjusted to the top line of the wing or the wing tube, even if it is slightly askew from the fuselage. The head-on photo shows the relationship of the stabilizer to the wing. Since the stabilizer has no dihedral, the centerline of the leading edge should be on the same plane as the top line of the wing.

Setting Incidence: The wings and stabilizers are square and level to the fuselage (trammeled), and the tube sockets are set, glued, and trimmed, so now it's time to set incidence. We put a block under the rear of the fuselage and set the top line to level using a SmartTool digital meter. The SmartTool is accurate to one-tenth of a degree, and when building a competition aircraft, we insist that all our final settings are within that tolerance. Incidence was measured with a Robart tool using the optional long bar and modified with a piece of 1-inch aluminum angle as a platform for the digital meter.

As a starting point, use a short piece of ¼ square balsa glued to the outside of the fuselage as an alignment guide. Set the incidence for each panel to zero, then CyA the block to the fuselage side. We will remove the blocks after the dowels are in and the incidences are set.

Trace the outline of each wing panel to the fuselage side, then mark your dowel points as indicated on the plans, making sure to center the points vertically using the outline. With a 12-inch length of sharpened 5/16-inch brass tubing, drill the alignment pin holes in the fuselage sides. Be sure to back up the inside of the fuselage with a scrap piece of plywood so the tubing doesn't shred the grain as it bores through the wood.

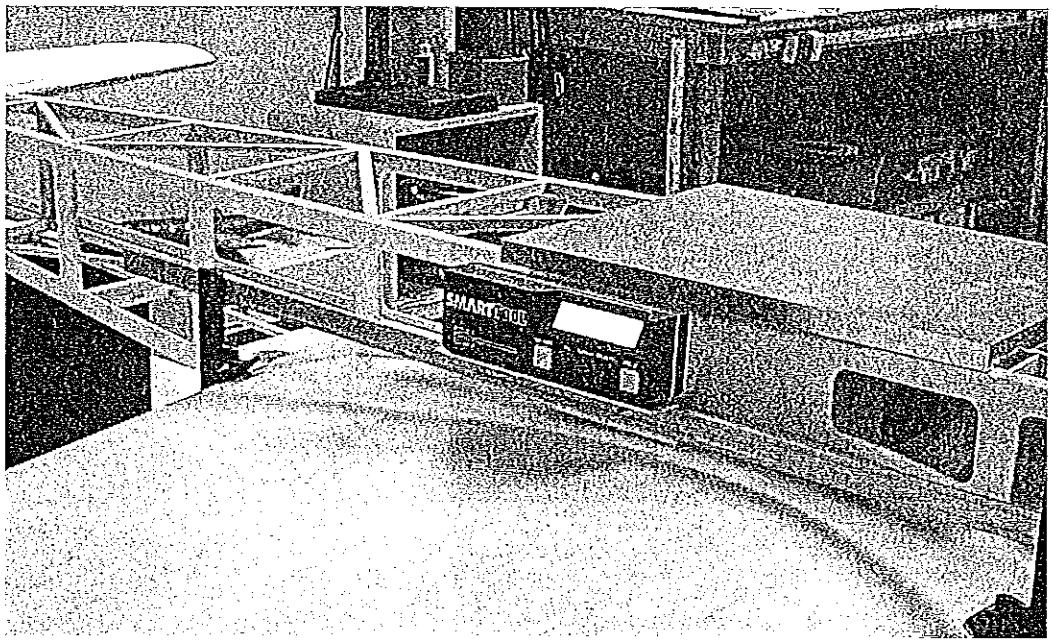
Install one wing panel at a time, and, using the fuselage holes as a guide, drill the alignment pin holes into the wing from the opposite side of the fuselage. After the first hole is done, insert a dowel to hold the alignment before you drill the second hole.

Cut six (two for each wing panel and one for each stabilizer half) 3-inch sections of 5/16-inch hardwood dowel to use as alignment pins. Sharpen one end of each dowel, and lightly bevel the edges of the other. Epoxy the dowels into the root, leaving approximately 5/8 inch extended from the root. The sharpened end of the dowel should slide right into the foam, giving a nice, snug fit.

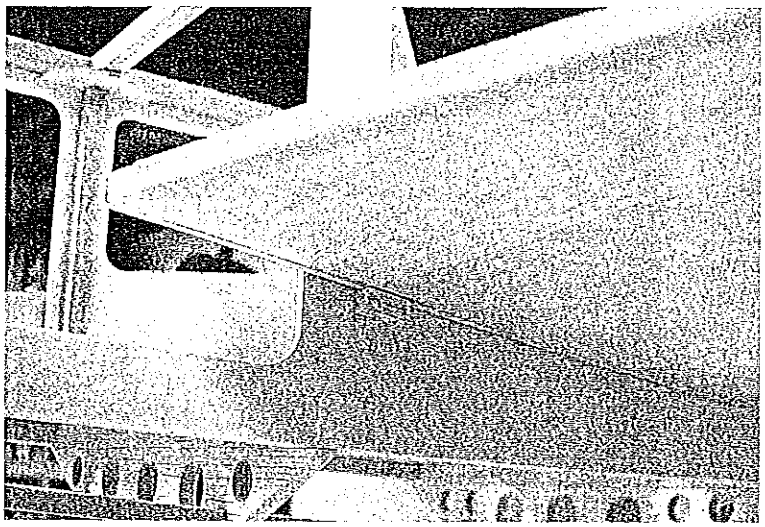
The plan incorrectly shows the dowel pins at 90° to the root of the wing. Remember that you should orient the pins so that they are *parallel to the wing tube,* thus they slide into the fuselage locations at the correct angle with no binding. If you drilled your dowel pins like we show here, the pilot hole should already have the correct orientation.

Once the pins are glued in place it's time to do the final incidence adjustment. Just as before, make sure the fuselage is zeroed (level), then fit the wings in place with the dowels inserted into the holes and the root

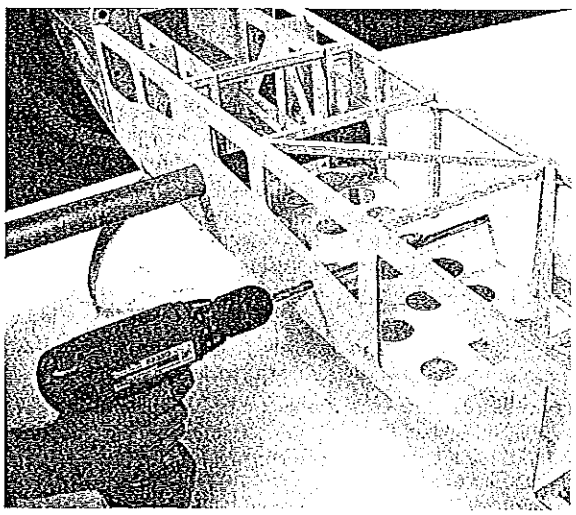
For Web-only content, go to www.modelaircraft.org/mag/index.htm. There you will find online supplements to this groundbreaking *MA* series.



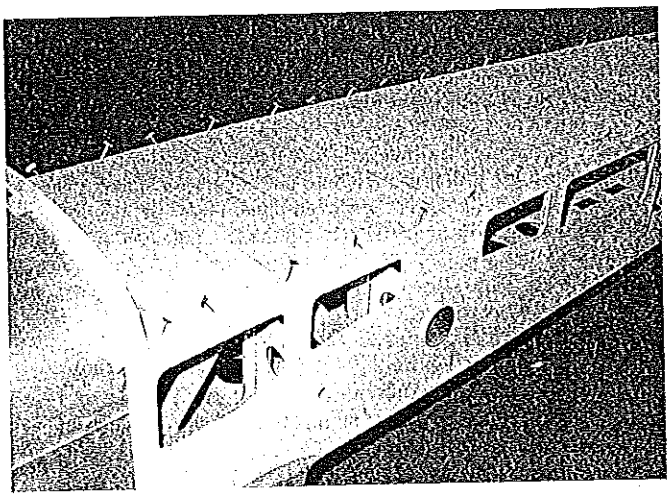
For setting incidence Mike and Erik use Robart incidence meter with optional long bar and homemade platform for SmartTool digital meter. Accuracy is to 1/10 degree.



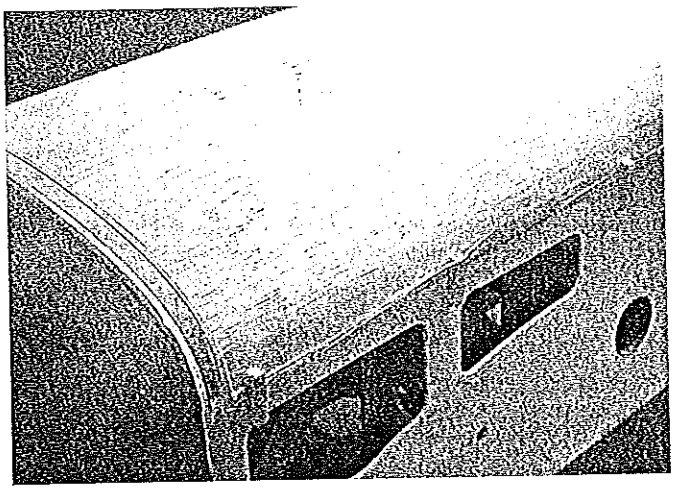
To hold their incidence position they glued in a small piece of balsa block while they drilled for the dowels.



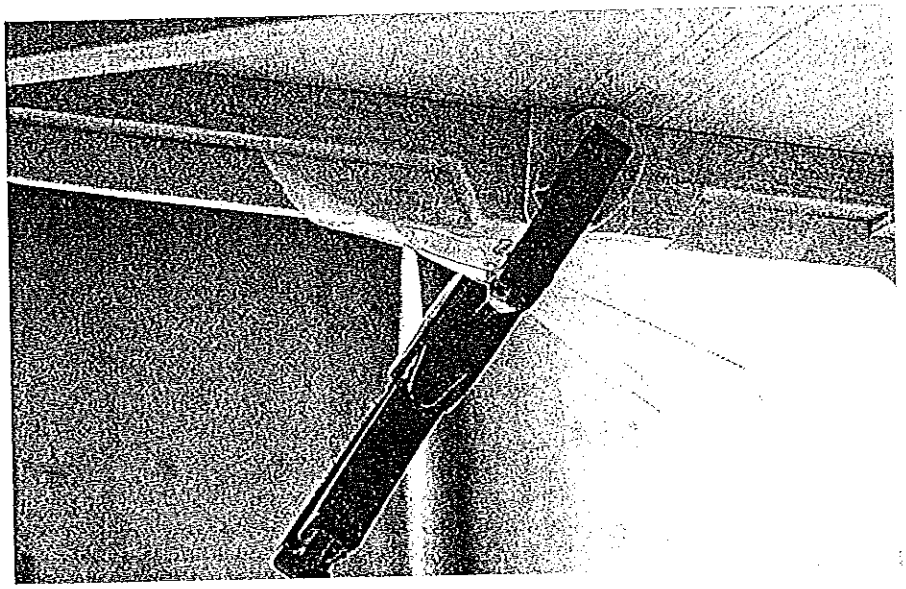
A critical step in drilling dowel holes is aligning dowels with wing tube. Drilling hole into wing root from opposite side of fuselage ensures properly positioned dowel hole.



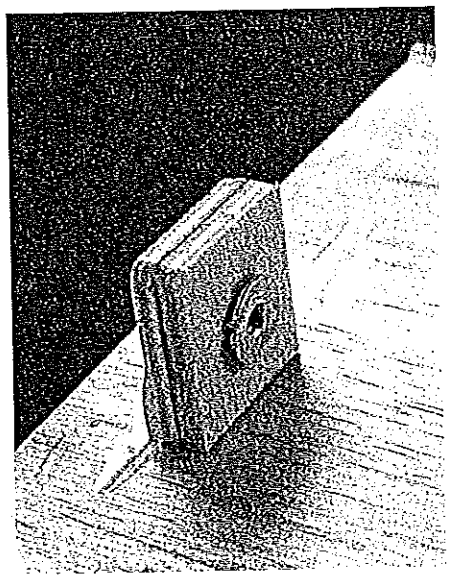
The hatch is generally assembled using fuselage as fixture so everything fits perfectly when finished. Base of hatch is aligned, trimmed, sanded to fit perfectly onto fuselage.



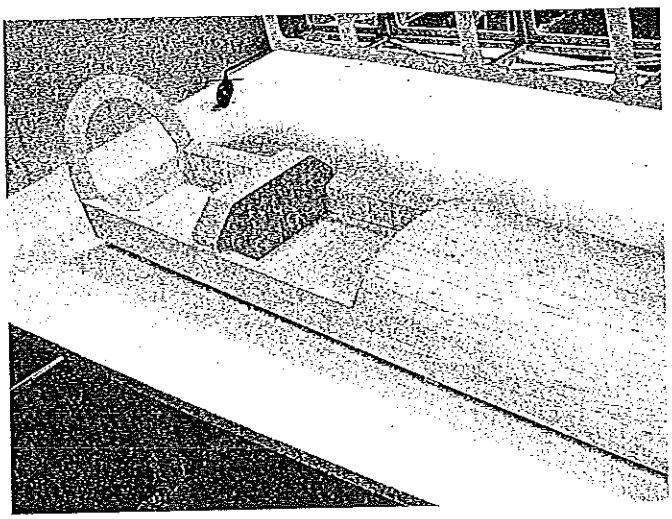
Hatch is glued to hatch base while on fuselage. Piece of waxed paper is used as glue barrier, and temporary balsa blocks are used to keep everything in alignment.



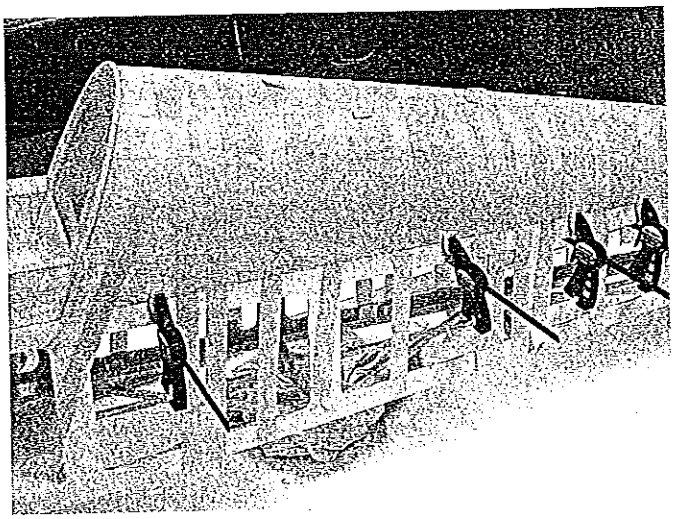
Mike and Erik used the fuselage as a fixture when gluing the hatch hold-down tabs in place. Clamp everything together while the glue dries.



The finished tab has been doubled to the inside with the blind nut installed.



The cockpit is sheeted, the instrument panel is installed, and the tabs have been glued in place.



Once the hatch is finished, you can glue on the turtledeck using the hatch as a guide for its placement.

flush against the fuselage side. With a file or sandpaper, adjust the holes to obtain a zero reading on the SmartTool on both wings and the stabilizers. It's okay to open up the holes quite a bit if necessary, but try to keep the fit so that you can hold the wing tight against one stop up or down with the meter at zero.

Cut four 1½-inch-diameter light plywood "doughnuts" with a 5/16-inch center hole that fits the dowels snugly to use as the final alignment setting. We used scrap left over from cutting the fuselage lightening holes for our doughnuts. With the wing held at "zero," glue the doughnuts in place inside the fuselage over the pins, being careful not to get any glue on the dowels. Do the same for the stabilizer pins, but the doughnuts can be smaller, at roughly 1 inch in diameter.

Hatch and Turtledeck: Before we separate the control surfaces from the wings and stabilizers, we'll finish the foam hatch and turtledeck. If you haven't already sheeted the hatch and turtledeck, now is the time to get that done. Our cores took a bit of sanding to get the shape just right to fit the front of the fuselage before we did the sheeting. Fit them carefully here so there will be less work later.

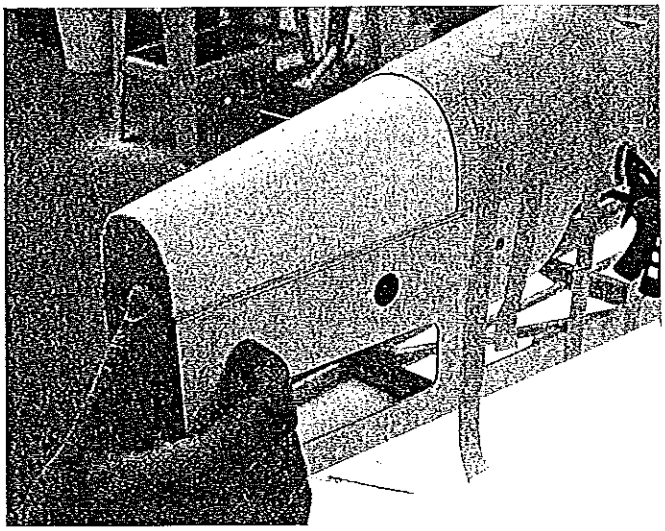
The foam for the hatch is cored out for weight savings. Put a front end cap of 1/8 balsa on the turtledeck. We use only 1/16 balsa for the base of the hatch. To make the base, lay 4-inch sheeting sections across the fuselage to former station F6 (approximately 34¼ inches), and mark the outline with a pencil. Remove them from the fuselage, and cut and glue them together. We pinned the sheet to the fuselage and sanded the sides flush to obtain a perfect fit.

Remove the pins and fit the hatch. Remember to use a piece of 1/8 light plywood at the front edge to get the proper spacing for the front hatch end cap. Use some waxed paper under the hatch base, and glue the hatch onto the base using the fuselage as a fixture. To keep everything aligned, we used short sections of ¼ balsa glued to the fuselage sides, then we held it all together with masking tape while the epoxy dried.

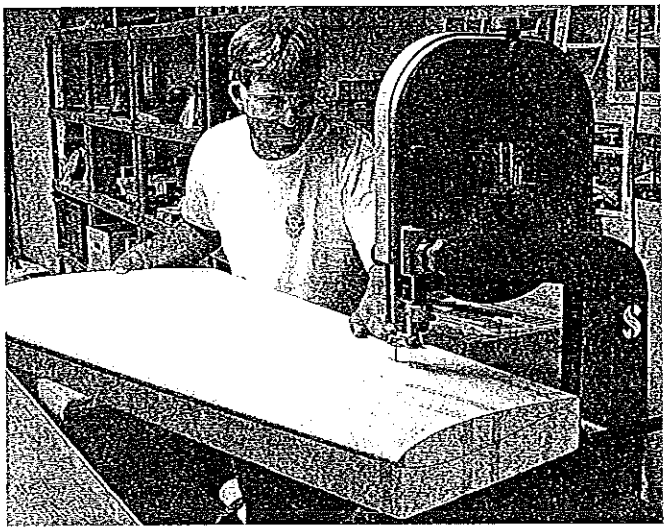
Using the plan as a guide, cut the opening for the cockpit. Erik used a large level as a cutting guide and angled it out slightly at the bottom to give the cockpit sides a tapered look.

Sheet the inside of the cockpit and build the center instrument panel with 1/16 balsa. The template on the plan for the instrument panel is a guideline. You'll need to fit it to your specific cockpit. Use two identical pieces for the front and back, placed roughly an inch apart, and sheet over the top. No strength is required for this piece.

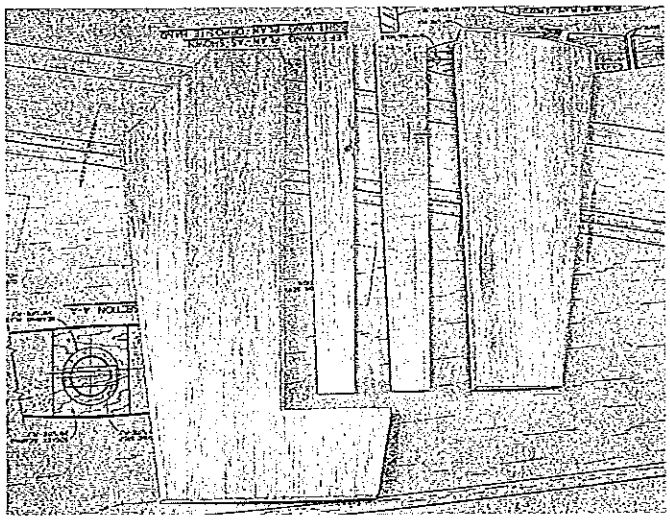
For the hatch retaining bolts we inserted four small tabs that fit just inside the fuselage along the top longerons. In the photos you can see that Erik added small doublers to the longerons, but



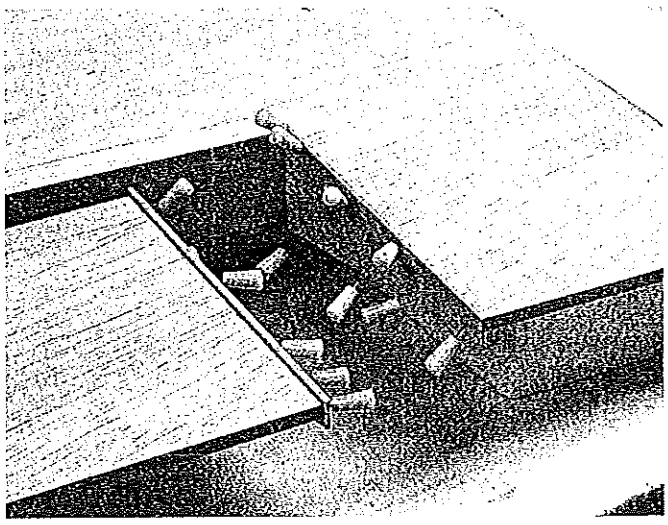
Using foam core from turtledeck, cut and fit an extension to turtledeck that will be used as rudder fillets later.



With incidences set and fuselage alignment done, cut control surfaces from wings and stabilizers. Be sure to use foam-core shucks as base to keep cutting lines aligned.



Elevator surface cut away from stabilizer and section of material removed that will become leading and trailing edges for hinge lines.



Use 1/16 balsa for all the end caps except the tips. Mike and Eric used 1/8 balsa for tips of wings and rudders for durability.

they're unnecessary. See the plans for locations. Tape the hatch in place ensuring the proper location (use a dummy sheet of ⅛ light plywood at the front for spacing), and, with an ink pad, use one of the tabs for a stamp marking the location for each of the four tabs.

Cut the balsa away for the tab locations and slice the foam, but don't remove any foam. Sharpen one end of the tab so that it can fit snugly into the slit you made in the foam. With the hatch taped in place, epoxy the tabs into the hatch. Be sure to protect the fuselage from excess glue with waxed paper, and clamp each tab while the epoxy dries to be sure of a snug fit.

When the tabs are in and the epoxy has set, double the tab to the inside with some scrap ⅛ light plywood. Re-place the hatch onto the fuselage, and drill through the fuselage and the hatch hold-down tabs. Install a 4-40 blind nut in each tab.

To cut the front end cap and the rear canopy former, trace the outline from the front of the hatch and the front of the turtledeck onto ⅛ light plywood. We opened up our canopy former for weight savings, leaving 1⅛ inches spacing around the top and 1¾ inches at the bottom. You can put some conservative lightening holes in the front end cap, but we left ours solid. When you glue, use the turtledeck as a guide to get the canopy former angle just right. From the front side of F1 drill the 5/16-inch dowel holes into the hatch. See the plan's page 3, former F1A for location. Again align the dowels while gluing with the hatch in place.

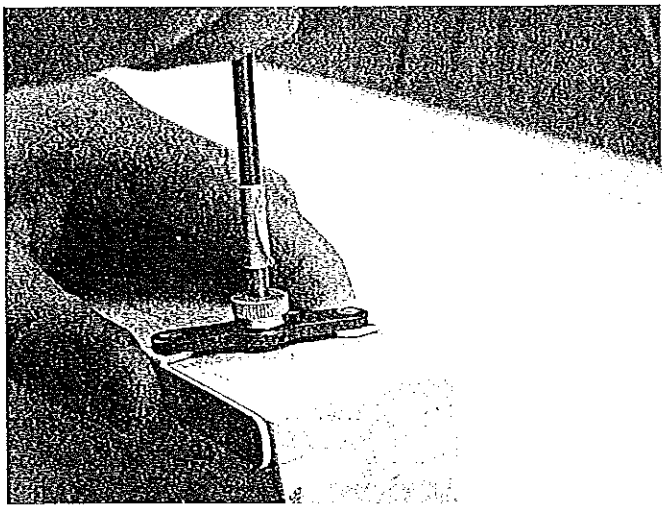
With the hatch in place and protected by a separator of waxed paper, glue the sheeted turtledeck to the fuselage. Tape the turtledeck down, and use clamps or balsa tabs to maintain alignment while the glue dries. After the glue has set, clean up the seam by block-sanding it smooth with a large "T" bar. We used the inner core scrap from the turtledeck to make a rudder fillet. Cut and sand it to follow the contour of the turtledeck, then sheet with leftover 1/16 balsa. For this piece we used spray-on contact cement. Set it aside for later.

With the airframe squared up and the incidences set, it's time to cut out the control surfaces for hinging and final preparation. Mark the lines you'll use from the plan or from your original template that you made when setting up the foam cores. Tape the control surface into the foam shuck to keep it level; this ensures that all of the cuts are made on a vertical plane. A good band saw is the best tool. (When cutting foam, remember to turn the saw off if you have to back the blade out of a slot.) You will remove a center section from each core for the trailing and leading edges of the hinge lines. Refer to the plans.

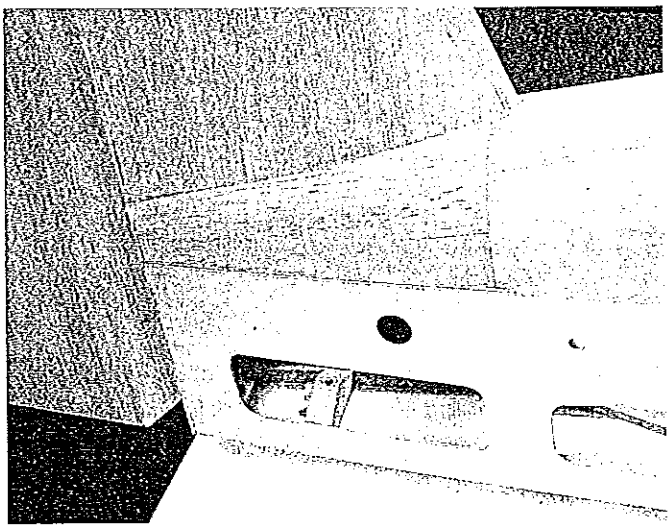
(Hint: when cutting the ailerons from the wings, set one wing half into the bottom shuck so that the band saw fence follows the cut, then you must set the other wing in the top shuck with the opposite side up.)

From sheet stock, cut and epoxy-glue hinge-line sections of trailing and leading edges. The wings and vertical stabilizer are 1/2-inch thick, and the horizontal stabilizer uses 3/8-inch stock. (If you want more than 45° of elevator throw, you can use 1/2-inch stock for the elevators too.) After the glue has set, finish-sand the hinge-line stock to fit flush to the flying surfaces. Don't bevel anything yet; we'll drill and do a trial installation of the hinges before we bevel.

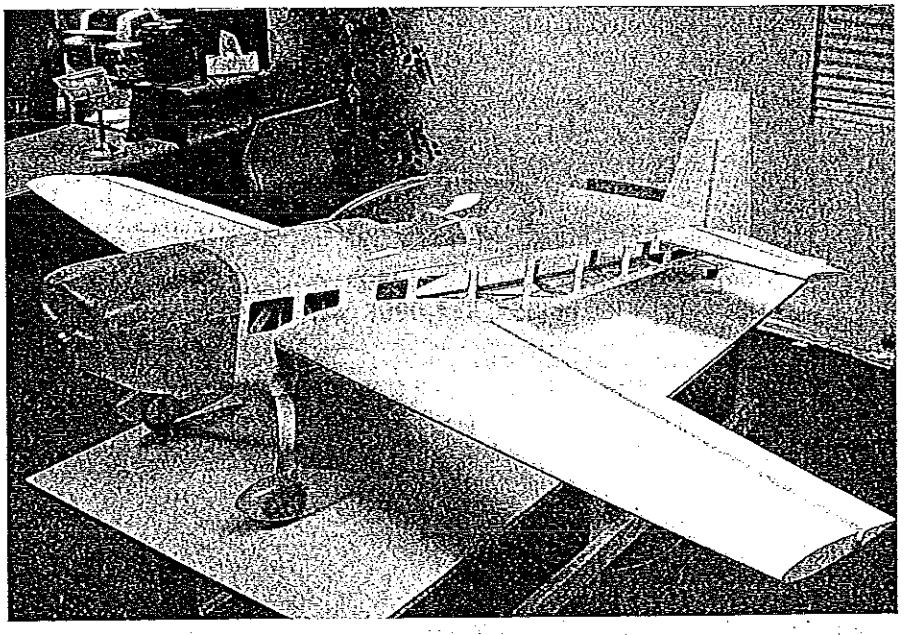
End Caps: After all of the hinge stock is in place and sanded, it's time to install end caps for all of the open foam areas. For wing and stabilizer tips, we used ⅛ balsa. You can get away with 1/16 for further weight savings, but the pieces become a little more susceptible to hangar



Before hinges are beveled, mark and drill hinge pin holes. Mike and Erik used a Robart tool for aligning the bit and a piece of sharpened copper tubing to clean-cut holes.



The final rudder fillet has been installed and shaped.



The assembled Extra 300LX airframe is ready for fitting hardware.

rash. If you are careful when you handle your airplane, it should not be a problem. Cut 3/16 inch off the inside of each aileron to create space for two end caps and a 1/16-inch gap. Don't install the tip cap until the hinging is done. That way, if the aileron is not perfectly aligned you can block-sand it flush before you install the end cap.

Mark out the hinge positions according to the plans. We used large Robart hinge points and the Robart alignment tool for making hinge holes that are centered and straight. Find the appropriate size of copper tubing, and sharpen the inside with an X-Acto knife for making the hinge holes. The tubing will cut the hole without ripping and make for a better fit and glue adhesion. Mark the tubing with a piece of tape to indicate the proper drilling depth.

Once all the hinge points are done, it's time to bevel the hinge gaps. Mark the centerline and the bevel point on each side of the hinge wood. It's okay to bring the bevel right down to the edge of the wood. To keep the lines straight, use masking tape to ensure that the final sanding point is correct. Erik used a Master Airscrew razor plane to get close to the final shape, then he finished up with a sanding block.

Double-bevel all the hinge-line stock so that you can get enough control-surface deflection for 3-D maneuvers—45° or more for rudder and elevator, and 25°+ for ailerons. Remember that the trailing edge for the rudder follows the fuselage all the way to the bottom, and it is glued to the rear of the fuselage. We didn't bevel it until the rudder was glued to the fuselage. After the hinge locations are marked and drilled, you can fit the rudder and glue it in place.

We placed the stabilizers on the airplane and aligned the rudder by measuring the top center point of the rudder to the tip of each stabilizer. The distance should be exactly the same. Note that the rear of the turtledeck does not have an end cap; TD2 shown on the plan is not needed. The rudder hinge line will be beveled after it is glued in place and the fillets are installed.

To make the fillets, use the fin/fuselage template on sheet 1 of the plans. Tape the template to the centerline of the fillet core that you made earlier and cut it out while flat on the band saw. You do not get the required taper that way, so it will take a bit of sanding to fit the fillets for a clean appearance. Erik stuck a piece of sandpaper to a plastic bottle for a nice, round contour. Epoxy the fillets in place, then you can finish the bevel on the rear of the rudder.

Next Month ... At this point you should have a nearly completed airframe ready for fitting your servos and electronics. The photo shows the gear cuffs and wheel pants in place, but the canopy has yet to be trimmed.

Next month we'll cover those steps and build and install all of the control hardware, finish the wing and stabilizer fasteners, build the firewall, and mount the engine. The following segment may seem like a process you've gone through many times in the past, but these steps can be critical for an airplane this size. The processes we'll outline will help to ensure precision flying and enable your airplane to last for many trouble-free years. MA

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Project Extra

Volume IV: Controlling Systems

Project Extra is a large model with a 106-inch wingspan and is built for performance aerobatics. Ed Alt photo

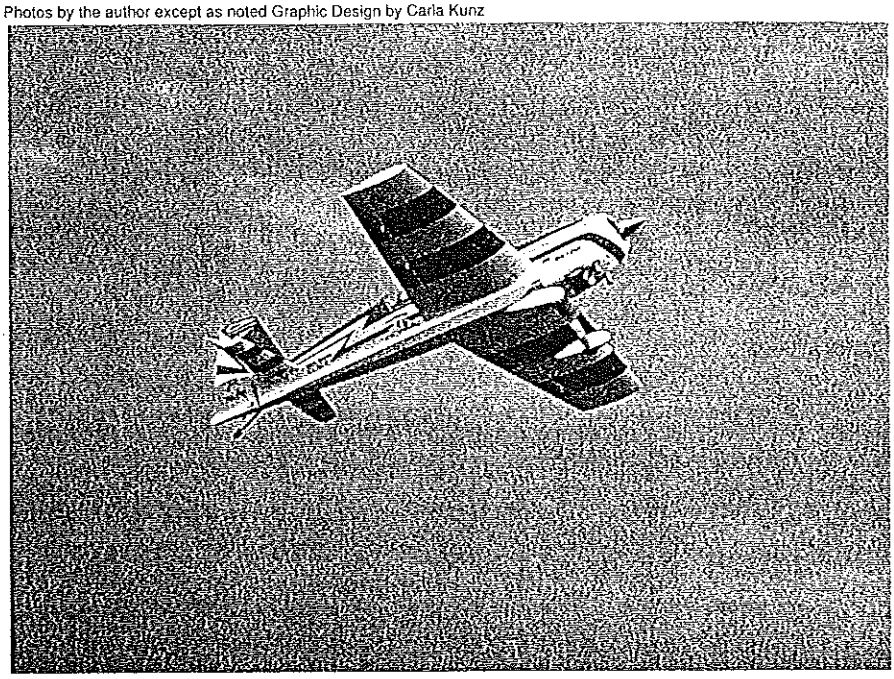
IN PROJECT EXTRA Volume IV, it's time to power up the beast. We'll install the components that will move the control surfaces, power the aircraft, and power the electronics in the airplane. For those of you *not* building the model, there is a great deal of useful information about servo and control setup and geometry that can help any modeler build a better control system.

Installing critical flight-control components, hardware, and power systems will give your aircraft life. What kind of life will depend on the components you choose and the care with which you install them. This is a place where many modelers try to skimp to save a few coins, but this is no place to go cheap! On an aircraft of this size and power, I don't believe there *is* a place to try to be frugal. Costs for this project can add up fast. This airplane needs to have a level of hardware and equipment that makes it reliable and safe. A model this size can be dangerous, so I don't recommend building it on a budget. Servos, linkages, hardware, propeller, spinner, etc. have to be of the best quality. Going with anything less is irresponsible.

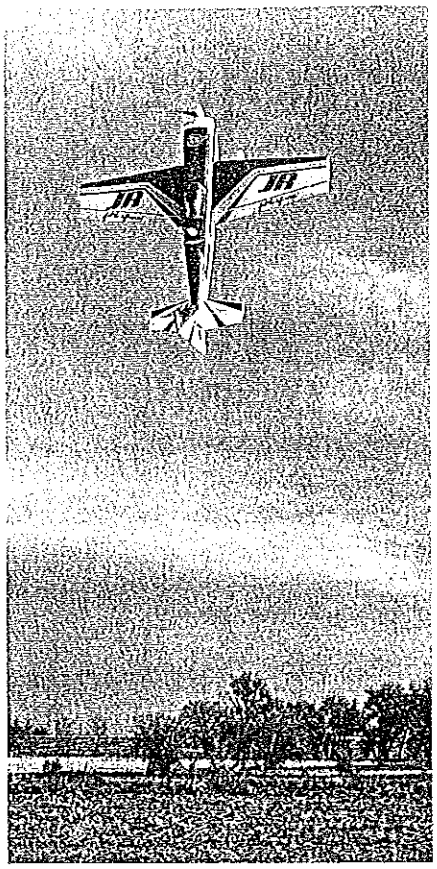
I like to think of my airplanes as having a generic setup that does not involve a lot of complicated connections or procedures. But understand, to properly set up an aircraft of this size and type is not a simple matter and will be much more involved than your basic sport airplane.

Electronics: The electronics lineup for Project Extra will be as follows: one receiver and two receiver batteries running through two switches. You can plug the second battery/switch into any open channel on the receiver. There will be a total of nine servos; two in

Photos by the author except as noted Graphic Design by Carla Kunz



With practice, maneuvers such as the elevator or harrier are easy to perform with the Extra 300LX. Michael Schauer photo.

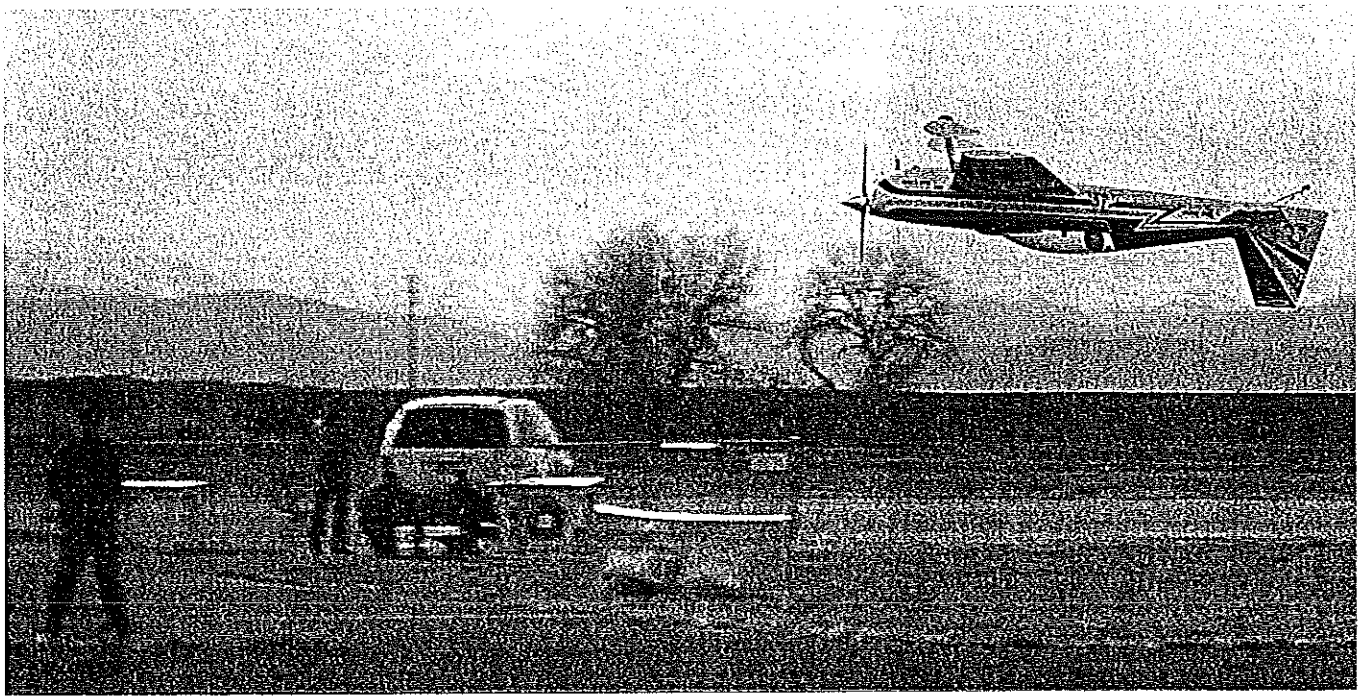


Right: Because of its neutral characteristics, the Extra is stable in difficult maneuvers such as the torque roll or hover. Schauer photo.

each wing, two for the rudder, one in each elevator half, and one throttle servo. The wing servos will be mixed like any other two-channel wing so that differential is adjustable. The servos in each wing half will be matched with JR MatchBoxes. The rudder servos will be mixed through the radio with a multipoint mix.

Okay, I'm gonna take back that frugal comment. Here's where you can save a few bucks or, better, redirect a few coins toward getting the right servos and hardware. Exotic electronics, multiple receivers, optical isolators, regulated batteries, power distribution systems, etc. are not needed in this airplane. They all do a job and they do that job just fine, but in my experience complex electronics are not necessary for you to have a successful 35% competition aircraft that is safe and reliable.

For some of the larger models with more servos and bigger control surfaces, sophisticated electronics can become a must, and I have some of those systems in my own 40% aircraft, but for this project I'd like to keep it simple and concentrate on making the setup secure. It may be a letdown for some of you that we aren't



Slow-flight ability and positive control characteristics make this a model that will instill confidence. Schauer photo.

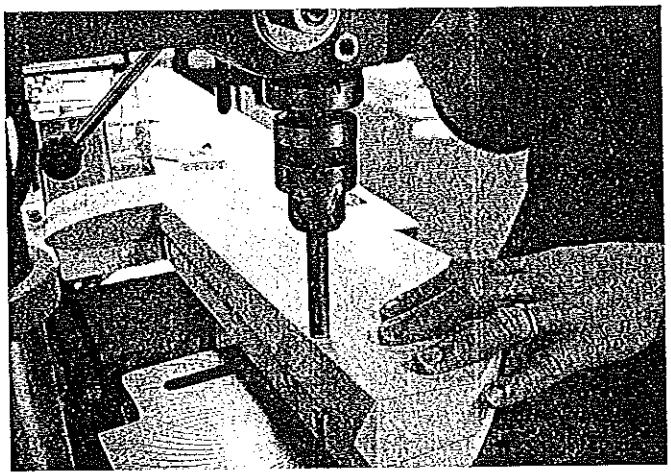
going to discuss those systems, so here's a bone: I'll highlight sophisticated electronics in an upcoming Scale Aerobatics column. And although two receivers are not needed for this model, you can learn more about multireceiver systems in the May 2002 *Model Aviation* Radio Control Scale Aerobatics column.

One thing that separates the big airplanes from the smaller ones is the amount of vibration that the model and all of its components will experience. No matter what engine you use for your Giant Scale airplane, it will have harder vibration pulses and all of the electronics need to be isolated as much as possible. On the subject of redundancy, most receiver failures are caused by vibration, so proper isolation mounting should help protect your receiver. Even the material you use to fasten your components to the aircraft is important; a heavy nylon tie will transfer vibration more readily than will a soft Velcro strap.

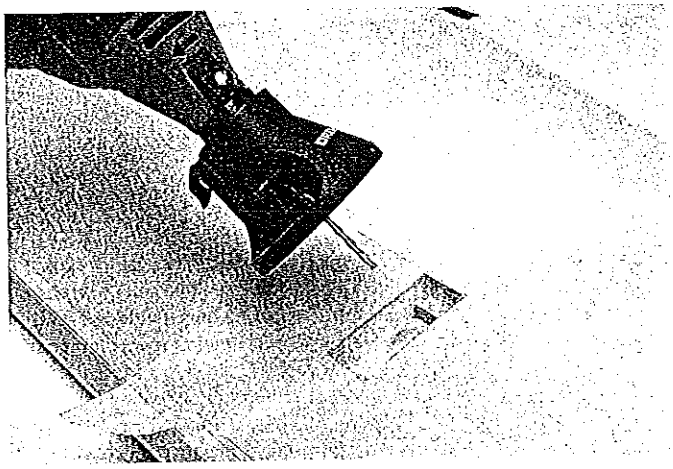
Erik Richards and I like to use the Du-Bro foam rubber sold in hobby stores. It's exactly the right density for protection from vibration. A piece of ½-inch Du-Bro foam under your receiver, battery, or ignition module fastened with a Velcro strap will work fine. If you are going to use nylon ties, it's a good idea to wrap the entire component before it is tied down. I've seen many airplanes out there with electronics Velcro-fastened directly to the model's wooden structure. That's taking a risk in my opinion.

Let's discuss servos and control linkage hardware, and why we've chosen the parts that we'll use. In doing research for the Scale Aerobatics column, I've had the chance to test and evaluate control rods, horns, connections, systems, and servos. Servo choice is an interesting topic because there are so many brands and so many opinions. It's important for builders to stick with name brands that have been proven to perform safely and accurately on large Scale performance airplanes.

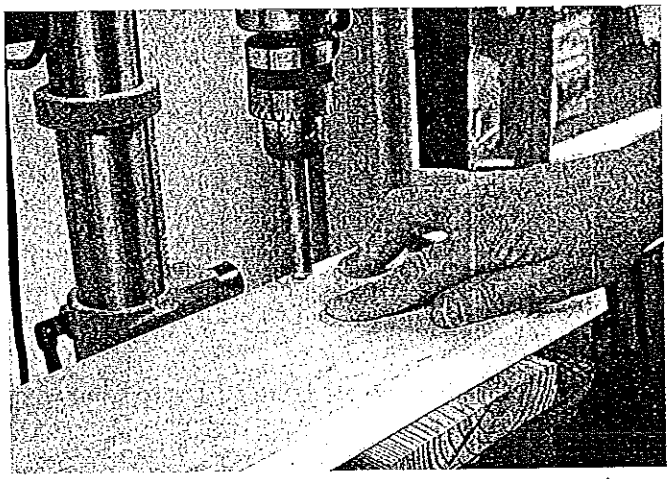
Futaba, Airtronics, and JR make excellent servos for Giant



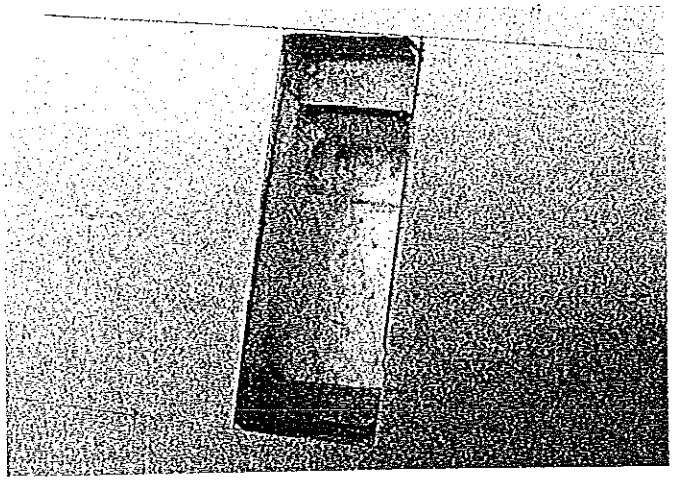
With finished elevator in foam-core shuck, use drill press and ½-inch sharpened brass tube to cut holes for servo horn dowels.



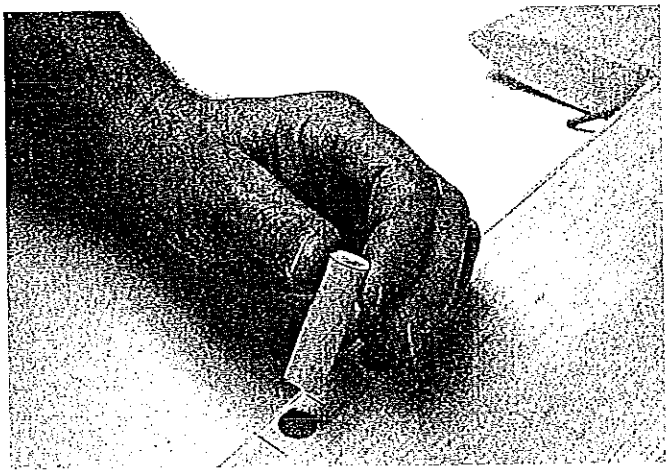
Erik Richard used a router attachment on a common Dremel tool to cut the servo bays in the wings. Two cuts are necessary.



With aileron you'll need to measure center of front, rear trailing edges and use piece of foam to keep them level on drill-press table.



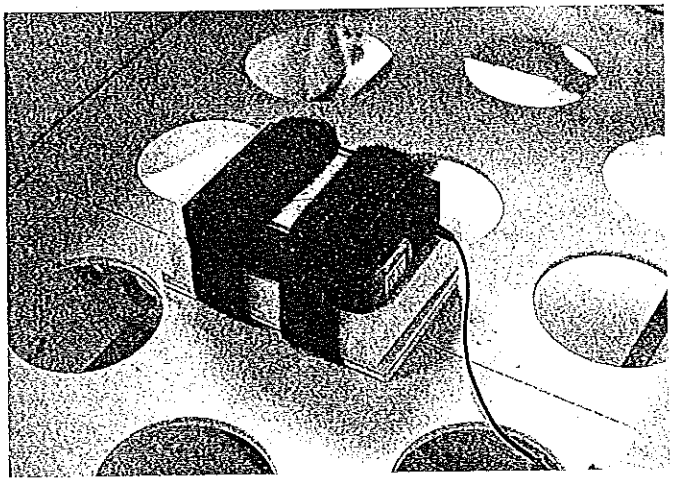
The first cut will be at a depth for locating the servo rails, and the second cut will be full depth for the servo body.



Measure and cut ½-inch hardwood dowels to be used as control-horn locations that will be tapped for control-horn screws.

Scale. We chose JR DS8411 digital servos for this project. They have a rating of 155 inch/ounce of torque and a speed of 0.16 second/60° at 4.8 volts.

Servo Arm Geometry: Geometry and force/connection



A pad of ½-inch closed-cell foam was used to insulate receiver from vibration. Put a piece of tape over crystal to keep it in place.

relationships are going to be a big part of this phase of the project. It's important that you understand how your mechanical connections will interact with the parts they link.

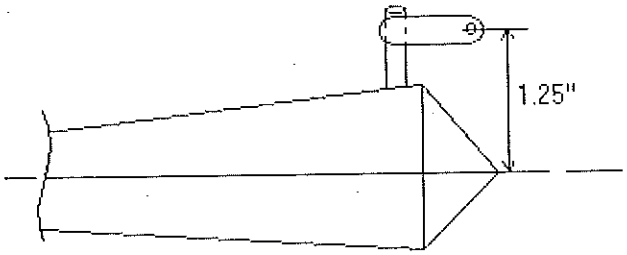
For the control rod ends we will utilize ball links that are bolted to the servo arms. We use the ball links because they are simple to use and reliable. But because the connection is offset to the rotational center of the servo arm, any force will tend to create a twisting motion on the servo arm. If the servo arm were to twist, that in turn would put a side load on the control rod. So in order to tame the twist and ensure a solid connection, aluminum servo arms are a must when using ball links.

The heavy-duty plastic servo arms sold by some of the aftermarket companies will work fine when used with a clevis that is supported on both sides of the arm, but they will twist when used in an offset environment such as a ball link bolted to one side of the arm. I used SWB arms on this project. The arms come pretapped to accept 4-40 bolts.

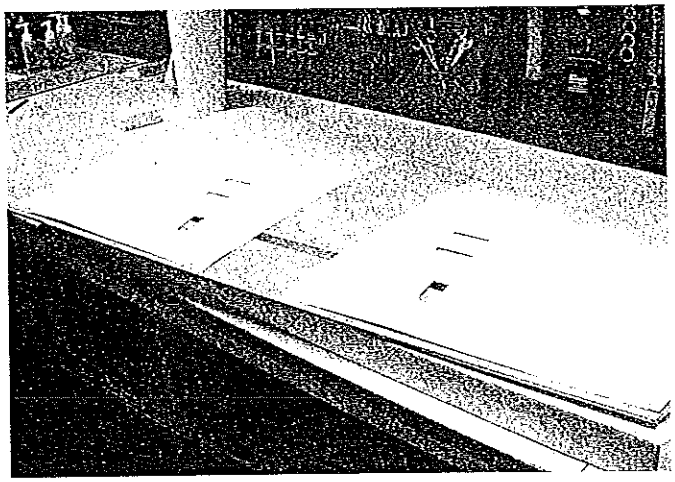
The wings and horizontal stabilizers will have the servos mounted in the bottom of them, vertically, nearly flush with the outer skin. There will be a short control rod linked from the servo arm to a mild steel bolt that will act as the control horn.

As a basic starting point, the longitudinal centerline of the servo should be 90° to the hinge line—*not* parallel to the aircraft's centerline (for the stabilizers they will be both). We will use SWB aluminum arms that are 1.25 inches (L in Diagram 2) to achieve 45° of elevator surface deflection at 100% travel. The idea is to strive for a control-horn length of 1.25 inches measured from the center of the hinge line (the beveled point) to the center of the control rod

Diagram 1

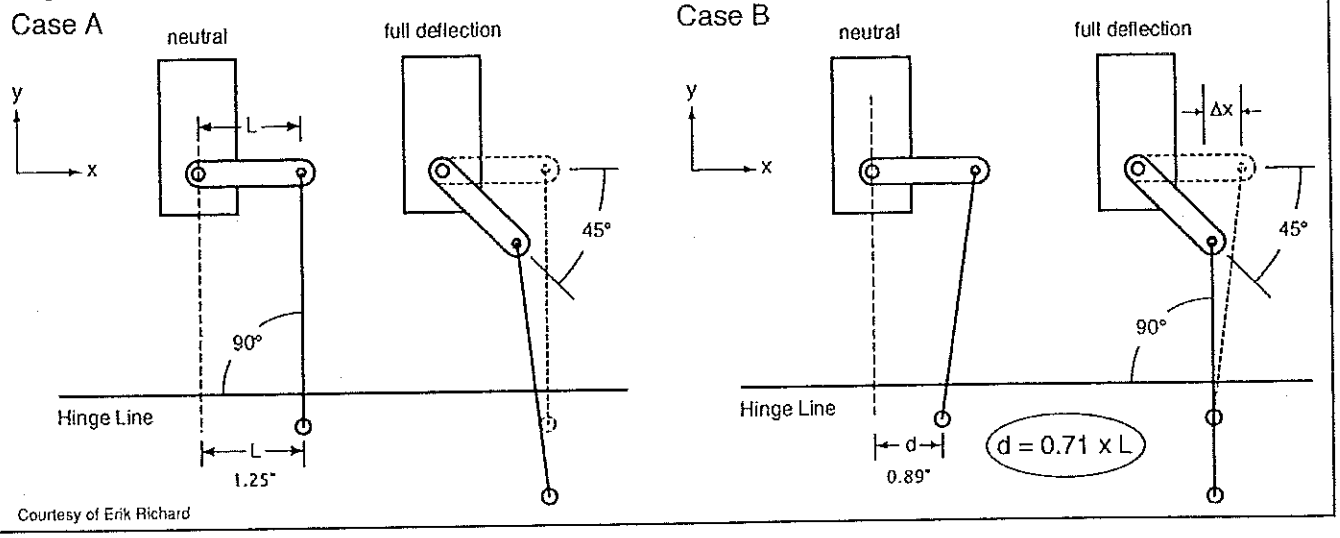


Control horn should be measured from the center of the hinge line to the center of the control horn clevis. The height of the clevis should be equal to or greater than the servo arm length.



Use templates you made during foam-preparation stage of building process to locate servo rails, control-horn dowel locations.

Diagram 2



Courtesy of Erik Richard

connection point (Diagram 1). We want to create a 1:1 ratio so that we get all the deflection we need without compromising (or reducing) the applied force (mechanical advantage) generated by the servo.

You can increase the mechanical advantage from your servo by utilizing a control horn that is longer than the servo arm, but you will lose deflection degrees. You can also increase the surface throw by using a servo arm that is longer than the control horn, but this ratio decreases the servo's mechanical advantage so it is not recommended. The whole thing works kind of like gears on a bike. I find that a 1:1 ratio is just right when 45° of deflection is desired.

The servo rails mounted in the wings are approximately 2.5 inches, so positioning the servo in relation to the control horn is just a matter of mapping them out before the servo bays are cut. Since the movement of the servo arm is on a different plane from the control horn, let's take a look at how we can arrange them to get the best end result.

You can see in Diagram 2, Case A, that when the servo arm is centered at 90° or parallel to the hinge line, the control rod is positioned 90° to the hinge line. As the servo arm travels in an arc the x displacement decreases, causing the control rod to change its angle with respect to the hinge line. At 100% travel the arm has moved approximately 45°. The movement up until this point is fairly linear along the y axis, but past 45° the slope degenerates in a nonlinear manner.

Mechanical force also decreases as the x axis distance decreases and the control rod moves farther from 90°. We have a situation where the mechanical force from the servo arm actually decreases as the arm travels to full deflection, but the required applied force is increasing from flight loads as the surface is deflected farther into the air stream.

In Case B the control rod is 90° to the hinge line at the point where the servo arm has reached full deflection of 45°. In this case the force is greatest at full deflection, where flight loads are likely to be the greatest and the deflection travel is closer to a fully linear motion. None of this is truly critical, but it makes sense to arrange the positions of the components to get the best advantage possible. In Case B with a 1.25-inch servo arm, we found that the best location for the control horn is 0.89 inch from the centerline of the servo (d in Diagram 2).

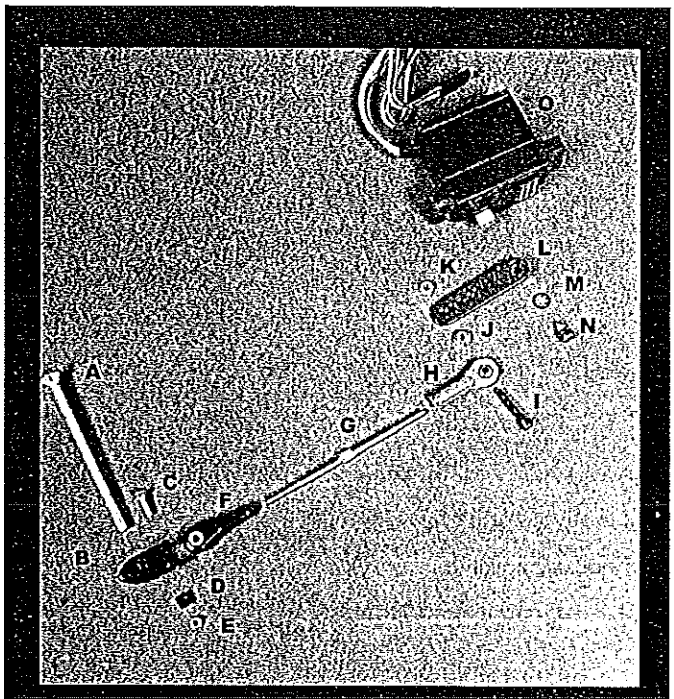
For a sophisticated software program that will allow you to design your own linkage systems, take a look at the Linkage Design program from Envision Design at http://members.cox.net/evdesign/.

Find the locations of the stress-bearing plates using the template you made for the wing cores, and if you embedded servo rails under the skins as we suggested during the sheeting portion of the construction phase, you'll need to locate them with the original templates as well. When determining a location, the dowel should just touch the beveled leading-edge stock. Find the location for the bay in reference to the dowel position as described, and mark it all out on the wing panels.

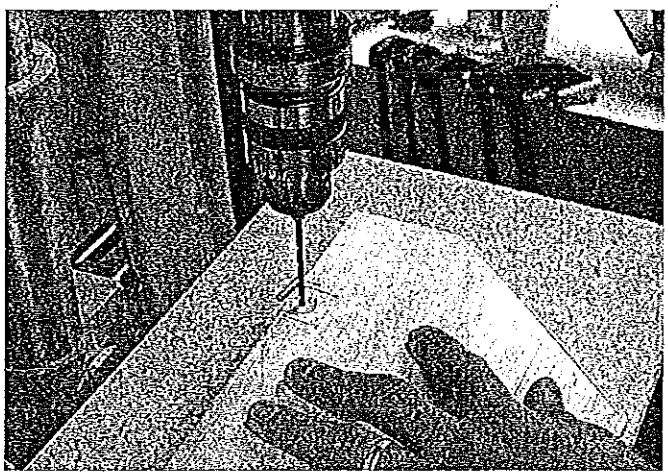
We used a Dremel tool with a small router attachment for cutting the servo bays. Mask off the area around the servo bay to protect the wood. We cut the bays freehand, but if you want to be more accurate with the edges of the bays you can pin some ¼ square balsa sticks in the appropriate positions to act as a cutting fence.

Decide how far you would like your servos to be recessed into the wing panel. We recessed the JR DS8411 servos to ⅜-inch deep. Make the initial cut to the depth of the desired servo recess according to the outside dimension of your servo. The remaining depth should be cut only between the servo rails to finalize the servo bay. If all was done correctly, the servo lead tunnels in the FlyingFoam.com wings should be accessible.

Installing the Dowels: Now that we know where everything goes, let's install the dowels we'll use for mounting the control-horn bolts into the ailerons and elevators. The rudder will use a special horn manufactured by Jerry Nelson for his pull-pull system. With the template that you made when you prepared your foam cores, find the stress-plate locations for each control surface. We marked the locations on the wood. Tape the control surface into its original shuck, and check to ensure that the center points (leading and



Parts labeled A through F come in Nelson 10-32 swivel link kits. A is 10-32 mild steel machine screw that will be used for control horn. It is threaded into ½-inch-diameter birch dowel embedded in control surface. Clevis (B) threads onto A. F is special link that fits into B with bushing installed instead of steel ball. The 4-40 machine screw (C) fits through B and F and is secured with threaded insert (D) and locking nut (E). G is Hangar 9 titanium Pro-Link. H is Nelson gray (now dimpled black) left-hand threaded ball link. Conical standoff (J) comes in package with ball links (H), as does slotted 4-40 machine screw and lock nut (K). Mike replaced slotted machine screws for much more user-friendly Allen-head cap screw (I). L is SWB 1.25-inch aluminum servo arm. L is attached to servo (O) using metric 3 x 6mm cap screw (N). Washer (M) comes with servo and acts as locking device, but before model is flown you should lock all servo arm screws in place with Loctite.



After control-horn dowels are in place and sanded, drill hole for tapping roughly an inch deep. Drill from the bottom!

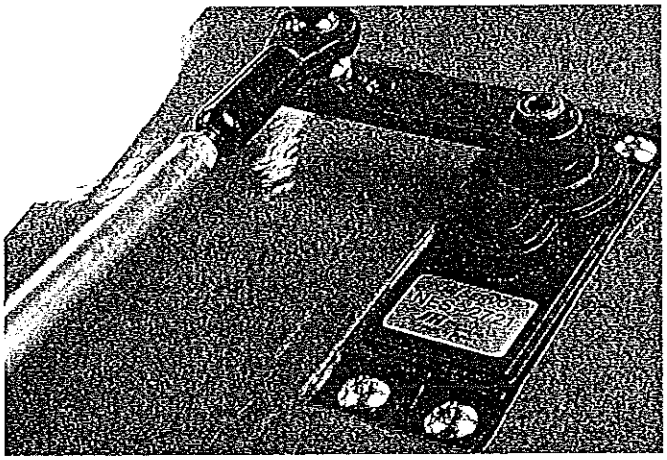
trailing edges) are equal all around (level to the work table) so that the dowels will be aligned correctly.

Because the CNC-cut wings from FlyingFoam.com are cut with dihedral built into the core (cut flat instead of on center), cutting the aileron dowel holes is a bit more complicated. We measured front to back and at the ends and learned that it worked to simply prop up the trailing edge to match the height of the centerline of the leading edge.

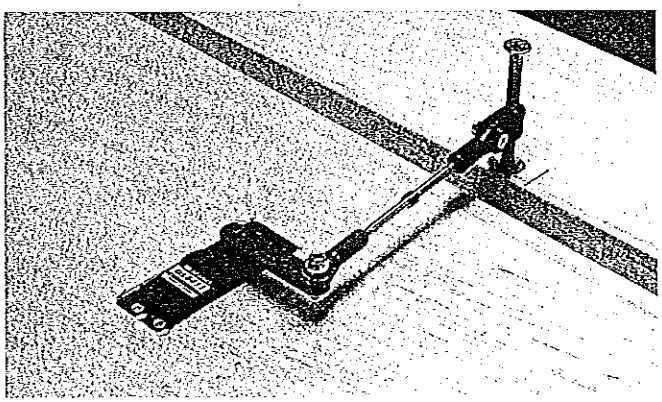
I've used reamers for cutting the holes but have found that a sharpened ½-inch brass tube gives a smoother cut. The only way to get a truly straight hole is to use a drill press. Be sure to set your drill press to the slowest setting and work quickly so that the cutting tube does not heat up and melt the foam. If you do melt some foam, don't sweat it; make a thick paste of epoxy with microballoons for setting the dowels. Clean the cutting tube between each cut.

For dowels you need to find good-quality wood—preferably maple, but a hard birch would also work fine. Avoid the pine or poplar dowels found at hardware stores. Insert a length of ½-inch dowel into the hole and mark it for cutting. Notice that it will follow the contour of the control surface. Try to avoid finish-sanding as much as possible because this wood is hard to sand. When satisfied with the fit of the dowels, epoxy them in place.

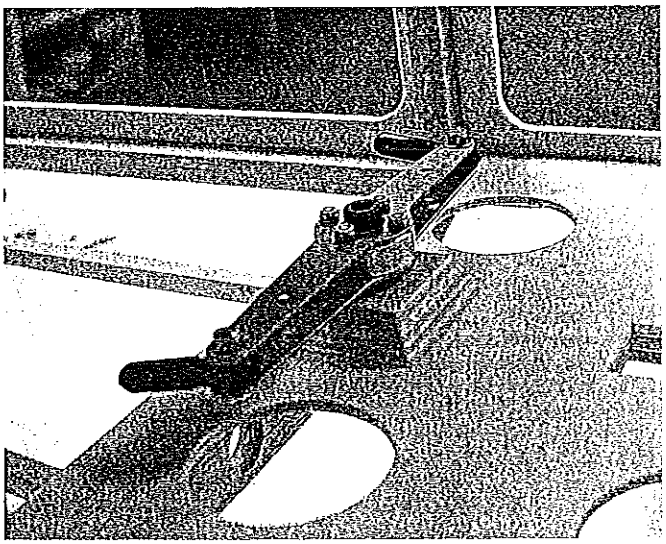
Once the dowels are glued in place, you can drill the dowels for your control-horn bolt. The bolt will be tapped into the dowel, and the hole should not go completely through the dowel and exit the top of the control surface. Make sure that you are drilling the dowel on the bottom side of the control surface. Be sure to use the proper drill sized to tap for the appropriate thread. Drill and tap into the dowel to a depth of approximately an inch.



As shown on the plans, aluminum tubing available from K&S is suitable for tapping and makes a great control rod.



Make all control linkages, but don't cut control-horn screws to length until after they are epoxied in, which will be done *after* the model is covered.



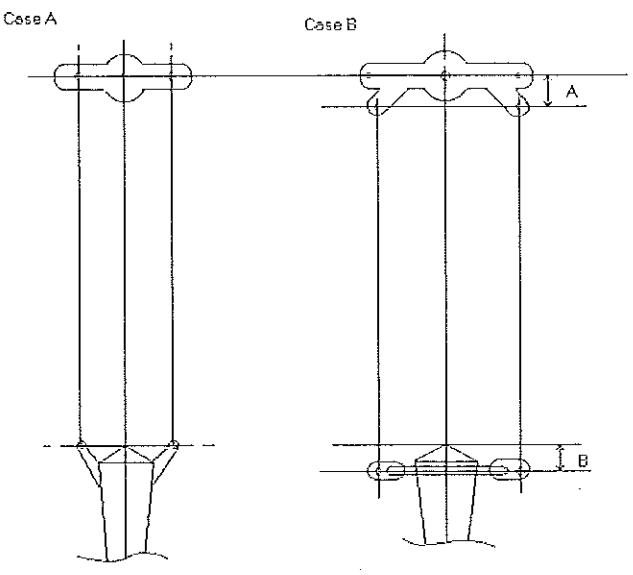
Bellcrank is used for rudder pull-pull system and is connected in line with servos under hatch. Note use of light-plywood spacer to align bellcrank to servos.

Control Hardware: You can see that we have paid a lot of attention to geometric relationships. Here's where the difference between a 60-size sport airplane and a Giant Scale airplane gets really important from a precision and reliability standpoint.

On the plans there is an isometric drawing depicting the servo linkage system. The control rod shown is a thick-walled aluminum tube that has been cut to length and tapped at each end to accept a 4-40 stud backed up with an aluminum lock nut. (K&S manufactures the tubing; ask for part number 6030 from your local hobby store.) The aluminum-tubing system is reliable as a control rod, and it looks great if you take the time to polish it. But for the sake of not having to build each rod, we went with Hangar 9's new titanium control rods called Pro-Links.

Pro-Links are threaded opposite directions on each end, turnbuckle style, so that you can perform adjustments while the servo rod assemblies are installed in the aircraft. Easy maintenance is one of my top priorities when building a model. Nelson Hobby Specialties sells 4-40 ball links tapped both directions to work with the Pro-Links. Black plastic ends have the normal right-hand threads, and the black end with a machined dimple (formerly gray plastic as labeled in the photo as "H") ball links are tapped left-

Diagram 3



handed. For additional information about linkages, see the January 2002 *Model Aviation* Scale Aerobatics column.

The point is to have a solid, firmly bolted, secure linkage system that does not flex or vibrate. For control hardware we used Nelson (formerly Rocket City) 10-32 swivel link kits, item RCL71A. The 10-32 is slight overkill, so if you'd like to go a little lighter you can use the 8-32 kit item RCL70A with no problem. The labeled photo shows an exploded view of the parts that we used to make up the control linkages. It is essential to build linkages to this level to maintain the aircraft's integrity in operation.

The parts labeled A through F come in the Nelson 10-32 swivel link kits. The 10-32 mild steel machine screw (A) will be used for the control horn. It is threaded into a ½-inch-diameter birch dowel embedded in the control surface. The clevis (B) threads onto the machine screw (A). A special link (F) fits into the clevis (B) with a bushing installed instead of a steel ball. The 4-40 machine screw (C) fits through the clevis (B) and the special link (F), and it is secured with a threaded insert (D) and locking nut (E).

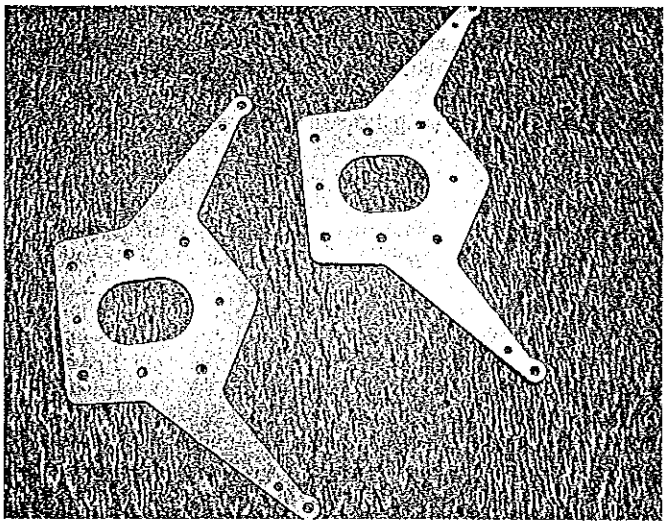
G is a Hangar 9 titanium Pro-Link; they are sold in various lengths in a package of two. H is the Nelson gray (now dimpled black) left-hand threaded ball link. The conical standoff (J) comes in the package with the ball links (H), as does a slotted 4-40 machine screw and a lock nut (K). I replace the slotted machine screws for a much more user-friendly Allen-head cap screw (I).

L is an SWB 1.25-inch aluminum servo arm. The arm (L) is attached to the servo (O) using a metric 3mm x 6mm cap screw (N). I replace the factory Phillips screw for the much easier-to-use cap screws. The washer (M) comes with the servo and acts as a locking device, but before the airplane is flown you should lock all of the servo arm screws in place with Loctite.

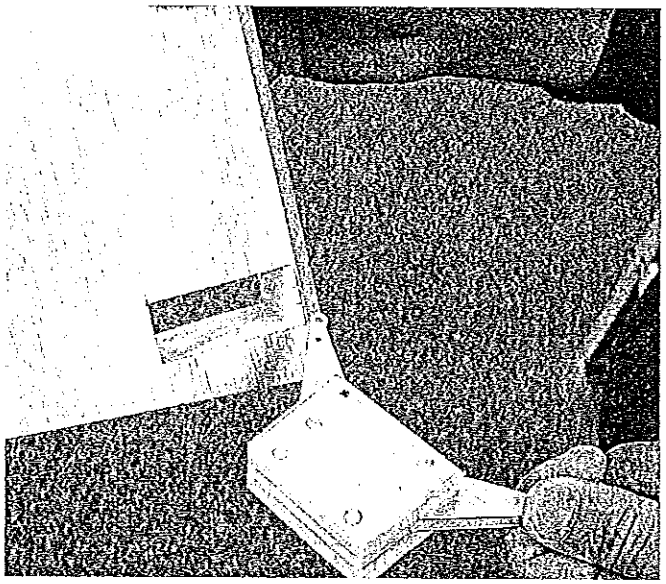
We prefitted everything in the wings and made up all of the control linkages and servo extensions. The control-horn bolts will not be glued in until after covering the airplane. At that time we will epoxy them into the dowels and use a Dremel cutoff wheel to remove the head of the bolt and trim to the appropriate length.

Pull-Pull: For the rudder, Erik wanted to use a slightly different control-horn system from what I had on my airplane. To his credit, the rudder horn on my prototype Extra (and the one shown on the plans) is rather outdated. We are going to use the pull-pull rudder control outlined on the plans with slight variations to accommodate the new-style rudder horn.

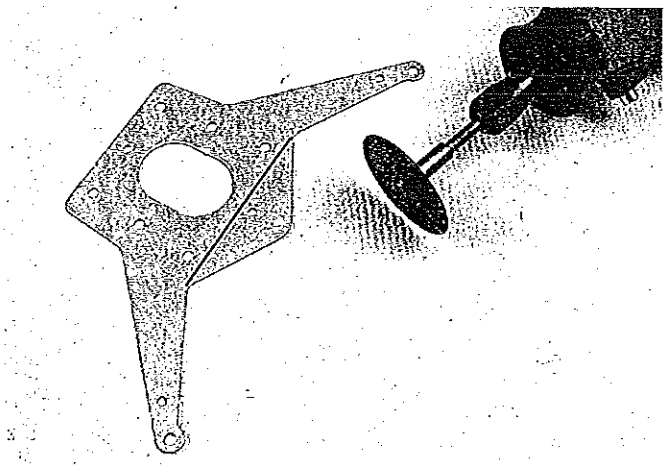
The rudder will utilize two JR DS8411 servos ganged together and attached to a bellcrank. The bellcrank will have two Kevlar "Kev-cord" cables that attach to the rudder horn. Kev-cord and the end fasteners (Kev-cord connectors) are available from Aerospace Composite Products. The rudder horn and bellcrank we used are



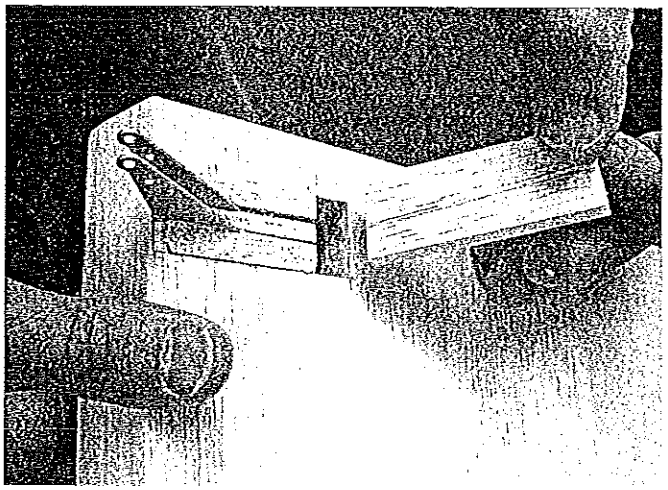
The author used aluminum control horns specifically made for Giant Scale rudder systems by Nelson Hobby Specialties.



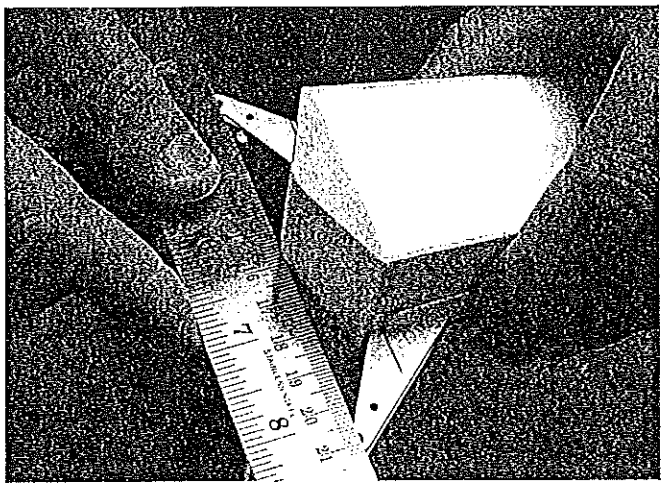
The control horn was fitted into wooden sandwich with dowel pins holding everything in place and glued into the rudder.



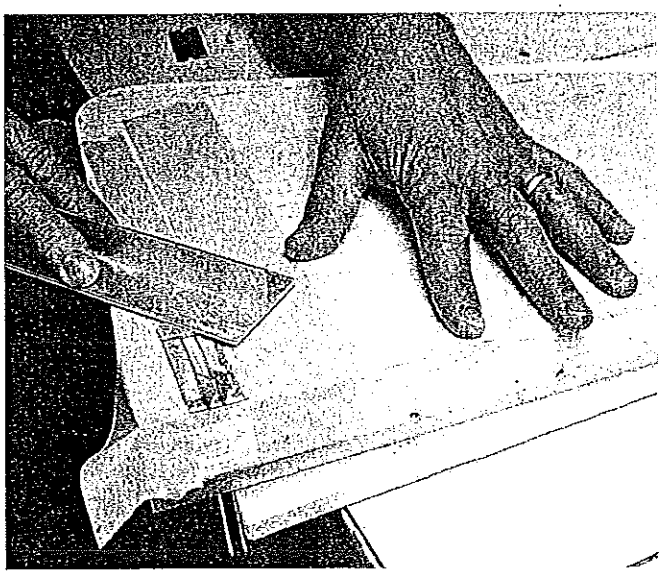
The Nelson control horns were cut so that the author wouldn't need to remove a portion of the leading edge of the rudder.



Balsa spacers were used fore and aft to get the positioning of the rudder horn just right and to ease assembly.



Before rudder horn is glued into position, make sure everything fits just right. Center of control-horn eyelets should be lined up with hinge line.



After everything is in place and dry, sand whole assembly flush to rudder. Use a couple pieces of masking tape to prevent gouging soft balsa rudder skin.

from Nelson Hobby Specialties and are made to match each other for this type of setup.

It's important that the geometry for the pull-pull system be exact; if it is not, the cables may droop when the surface is deflected. Diagram 3 shows two examples of how you can set your system up and ensure tight cables throughout the entire range of motion.

In Case B (our prototype Extra), notice that the distance of offset of the control-horn connection from the hinge line (B) at the rudder needs to be duplicated at the bellcrank (A). In Case A, the control-horn connection is in line with the hinge line and lined up with the pivot point. The bellcrank should also have the connection points in line with the pivot point (like our new Extra). It is important that the width of the bellcrank be the same as the width of the control horn for both systems. Do not cross the cables.

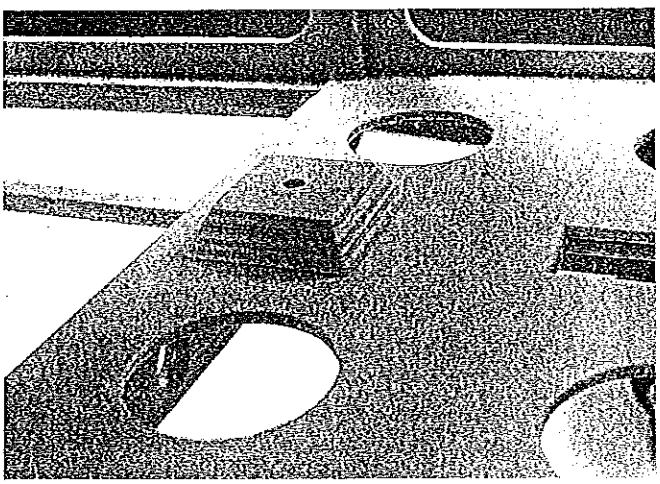
We chose a 4-inch Nelson rudder horn and bellcrank. To mount the rudder horn, Erik sandwiched the two plates in wood to be epoxied into the rudder. Since much of the rudder's strength is dependent on the leading-edge hinge cap (rudder post), we did not want to cut it when installing the horn assembly. So before the plates were assembled, Erik cut the hinge-beveled shape from the rudder-horn plates with a Dremel and a cutoff wheel.

For the horn assembly we used ¼ balsa on top and bottom and two ⅛-inch pieces of light plywood between the plates. Find the best position for your rudder horn, and cut the balsa and foam away to fit the horn when fitted with the wood sandwich; in our case, it was 2⅛ x ⅞ inches.

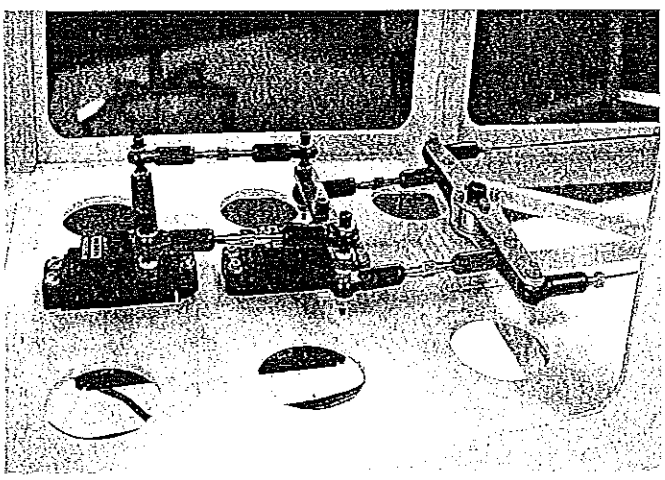
Erik fitted the plate separation to the steel ball of the ball ends by sanding the center light-plywood section to the thickness of the ball. Mark all of the pieces to fit the shape of the opening, and cut it to leave a bit of overhang that will be sanded flush after everything is glued in place. We used a piece of plywood at the front of the system that we could sand and adjust to get the control connection points to align with the hinge line. Aft of the sandwich is a gap just less than ¼ inch, so that installation would be easy and a ¼-inch piece of balsa could be wedged in to hold the whole assembly tight.

Once the parts have been fitted and cut to size, drill six holes through the sandwiched assembly for dowels. Erik used ⅛-inch dowels at the front and ¼-inch dowels for the rear four. Epoxy the sandwiched parts together and sand the dowels flush. Epoxy the whole assembly in place, making sure to align the horns 90° to the centerline of the rudder. Once dry, sand everything flush with a sanding block.

The business end of the pull-pull system uses two servos ganged together in line connected to a bellcrank. We used SWB 2.5 full servo arms with a Nelson bellcrank and Pro-Link control rods. From inside the fuselage we made a light-plywood



If you're using a pull-pull system for the rudder, you'll need to add some structure to bottom of fuselage floor FL3.



Two servos were ganged for maximum rudder authority. Servos are linked with Hangar 9 titanium Pro-Links for easy adjustment.

platform to raise the bellcrank up to line up with the servo arm.

We use a bellcrank rather than connecting the cables directly to the servo for several reasons; it takes the load from the tightly stretched cables rather than the servo grommets, output shaft, and bearings, and it enables the correct geometry.

At this point I hope you have a better understanding of Giant Scale performance control systems. It would be impossible to fully document each step of the building process in the pages of this magazine, so the basics are covered here but there is much more waiting for you on the AMA Web site. Go to www.modelaircraft.org/mag/index.htm for further details on control systems and loads of pictures in an easy-to-download and -print PDF format. In addition to more detail about what we've discussed here, you can learn about the fuel system, mounting the fiberglass, and installing the engine.

Now that you've done all the work to set up your airplane for its engine and flight controls, rip it all back out and grab some sandpaper. It's time to start the covering and painting process! That's what we're gonna do in the next issue. See you then. AMA

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Project Extra

■ Mike Hurley

Volume V: Covering and Paint

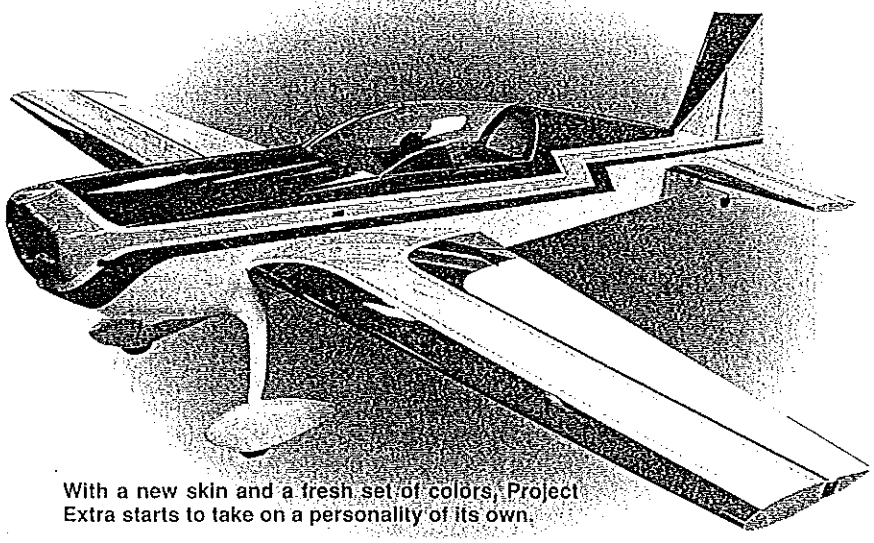
The author's model bears his signature Bulldog Competition Aerobatics logo. Companion and mascot Spike inspired the logo.

TRADITIONALLY, Giant Scale models have used varying methods of finishing, from fiberglass and paint to Stits cloth and dope. Although the results with these methods can be beautiful, many of them are geared more toward appearance than overall final performance. That's not to say we aren't concerned with appearances in Scale Aerobatics (SA), just that we want the airplane to be aesthetically pleasing *and* remain as light as possible. SA aircraft are finished like most sport airplanes—with iron-on plastic coverings and paint for the fiberglass parts.

Admittedly, there are craftsmen in the modeling community who are better suited to a tutorial on covering, so I'm not going to go too deep into the subject. But I will try to share several tips and hints for getting a professional-looking finish for an SA airplane. I'll also discuss fitting the canopy and finishing the cockpit, and I'll touch on methods of painting the fiberglass parts. If you want some information on the basics, go to www.monokote.com/monoinst1.html for MonoKote and try http://horizon.hobbyshopnow.com/articles/1115.asp for more info on UltraCote.

Most SA modelers use UltraCote- or MonoKote-brand coverings. There has been a long-standing debate about which works better and which is easier to apply. As anybody who has ever finished a model with one of these brands can tell you, it takes a bit of practice to get the knack of working with iron-on coverings no matter which one you choose. The answer to which is easier to use is simple: the one you are used to. Erik Richards and I have more experience with MonoKote, so we will use that.

Before the covering can begin, we have a few last-minute items to finish up. It's time to fit and trim the canopy. Cut the front and rear sections out of the canopy so you can fit it onto the model. Center the canopy side to side as close as possible. Since this canopy was



With a new skin and a fresh set of colors, Project Extra starts to take on a personality of its own.

originally designed to fit another aircraft, it is a tad too big. We cut the canopy to the size indicated on the plans, which should knock approximately four inches off the rear portion of the canopy.

Tape the canopy in place on the airplane. Using ¼-inch Fine Line tape (or any striping tape), mark out where you want to cut. The tape works well for fine-tuning placement and ensuring that you get straight lines. Carefully trim and fit the canopy. At the front edge of the canopy where it fits over the top of the hatch, Erik left in a slight amount of the curved fillet to give a slightly better fit and more gluing surface.

Erik decided to finish the cockpit with a speckle-texture paint. There are many types of texture paint; some are made to simulate granite or stone. We used paint from Pep Boys auto parts that is made for finishing automobile trunks.

There are a few tricks to using this speckle paint. It's best to use a primer base coat before applying the paint. The speckle goes on wet and does not cover well, so the base color gives you the ability to use much lighter coats. Be careful to keep the coats of paint and speckle light and fairly dry, or you might warp the wood. A few dry coats are much better than one heavy coat. Mask off the hatch well so you don't get overspray on the wood.

Mask the area for your dash panel. For a lightweight dash we used a composite of some of my digital photographs that I put together on my computer. I printed it on glossy paper and spray-glued it directly to the wood. If you go to the Project Extra Web site (viewable at www.modelaircraft.org/mag/index.htm), you can download the dash image to use in your Extra.

At this point Erik has not decided on a pilot. Remember that the cockpit area is not built to hold any significant weight, so a bit of reinforcement to the hatch floor will be necessary if a pilot is added.

Before you begin to apply any covering, it is important to prepare the wood surfaces. As I discuss the way we like to do it, know that there are many ways to accomplish a great finish; ours is not the only way.

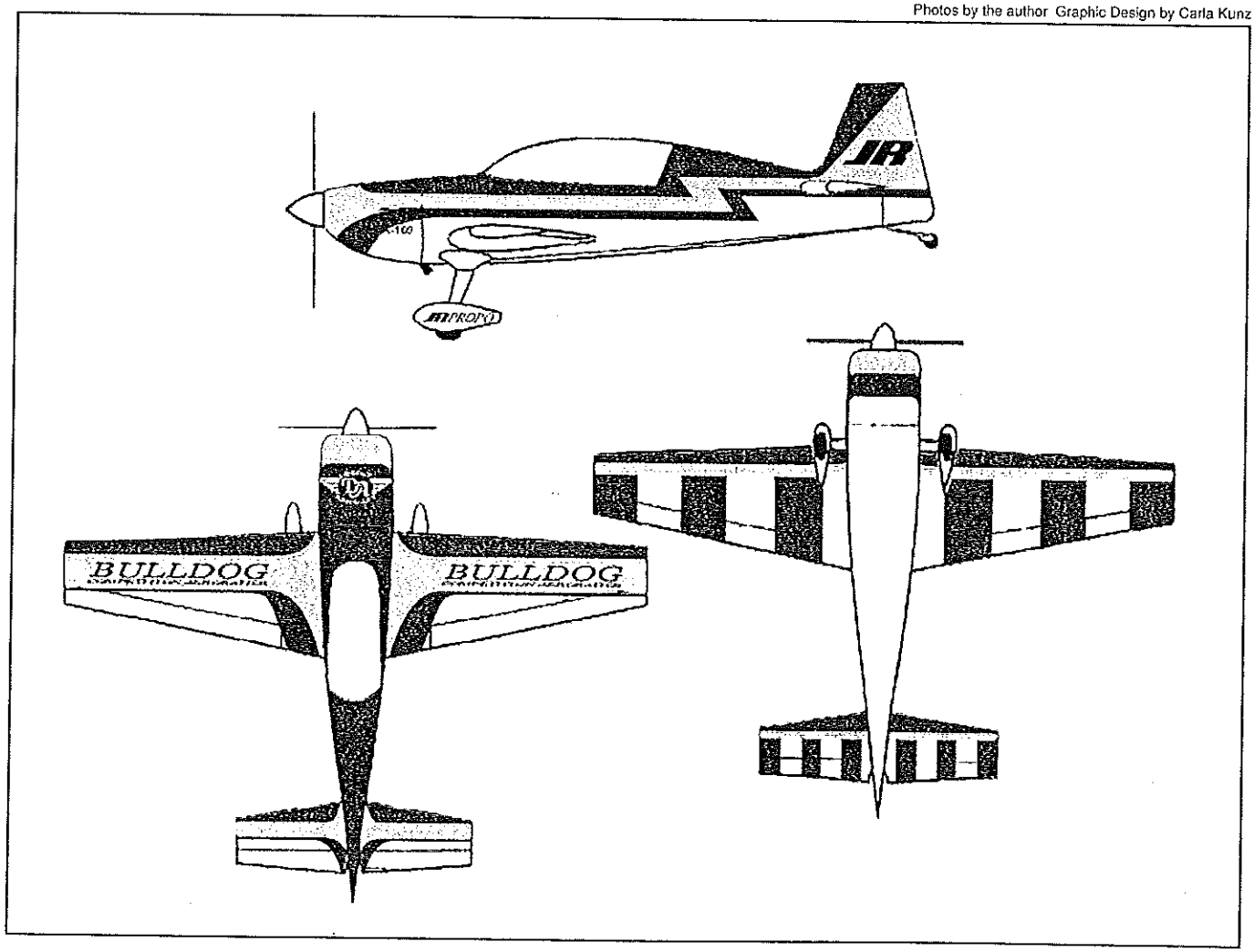
Erik likes to final-sand everything with 320-grit 3M Tri-M-ite Fre-Cut sandpaper; it has a gray color. The 3M papers stay sharp longer and resist loading up. Erik likes to spray-glue the sandpaper to a scrap foam block. The foam is soft and contours to the shape of the wood but does not allow problems from palm or finger pressure points. Use a good-quality filler to fix any hangar rash or imperfections. We used NHP Micro-Fill model filler. It's easy to sand and super light.

You can seal the wood with a light coat of Aqua Net hairspray before you sand. Once sealed, the tiny balsa fibers created from sanding come off easier and a smoother surface can result. The downside is that with a sealed surface, the gas created from heating the MonoKote is more likely to get trapped as you apply the covering. The result can be a smoother finish, but it's much harder to avoid the dreaded bubbles.

We decided not to seal the wood for our airplane. Once filling and sanding are done, it's a good idea to thoroughly vacuum all of the surfaces to be covered using a brush attachment. The vacuum pulls the dust from the wood's pores. Wiping with a tack rag alone can leave dust particles in the wood's grain. We also spent a great deal of time vacuuming and cleaning the shop to keep airborne dust to a minimum.

In my estimation, one of the hardest elements of any finishing job is designing an exciting but tasteful trim scheme. Since this is a Scale aircraft, we wanted to start with ideas from full-scale Extra trim schemes and see if there was anything that looked good. Go to the search engines on the Internet and type in "Extra 300." You will eventually find many photographs of current schemes.

Photos by the author Graphic Design by Carla Kunz



Mike and Erik used three-view template, felt-tip pens to devise a color scheme. Erik used a software program to finalize the design.

Another good source for scale information is Bob's Aircraft Documentation at www.bobsairdoc.com. I ordered the three-views to use as a template for designing my trim schemes. Besides three-views, Bob carries scale documentation for more than 650 aerobatic airplanes—and 80 of them are Extras!

Erik and I made a bunch of copies of the three-view and spent an entire day trying to come up with a new scheme for his Extra. We came up with many interesting and unusual designs but decided on a derivative of the scheme on the prototype with our bulldog mascot Spike as the main graphic element.

Things to keep in mind as you design your color scheme are to use colors that are easy to see and give the airplane good definition when it's in the air. The shape of the model—not just the outline—should be easy to see. Dark colors tend to create a flat silhouette that makes orientation more difficult. I use the analogy that dark covering tends to create a "hole in the sky" wherever it's used.

The direction of the design's lines can also aid in orientation. If the general design has elements that go from side to side on the top of the airplane, orienting the design longitudinally for the bottom of the model will help differentiate the top from the bottom. It can also help to use colors for the bottom that contrast with the colors on the top of the aircraft. The idea is to be able to instantly know your airplane's orientation without any real thought. A good design will have that effect on a subconscious level.

Once you've decided on a color scheme, trace all of the outlines for the fuselage side, wing, and stabilizer in full size. Drafting vellum works well for tracing the plans. When the outline is done, use it to finalize the separate color details in full size. Erik used it to cut full-size templates from poster board. After a template is used for one wing panel, it can be turned over and used on the other side to ensure a uniform pattern.

To make the curves of any rounded corners come out with smooth, flowing lines we used ship's curves. You can get a set of inexpensive plastic ship's curves or French curves from the hobby store, an art store, or a drafting-supply shop. Using these as templates, complex curves can be drawn in a smooth and precise manner.

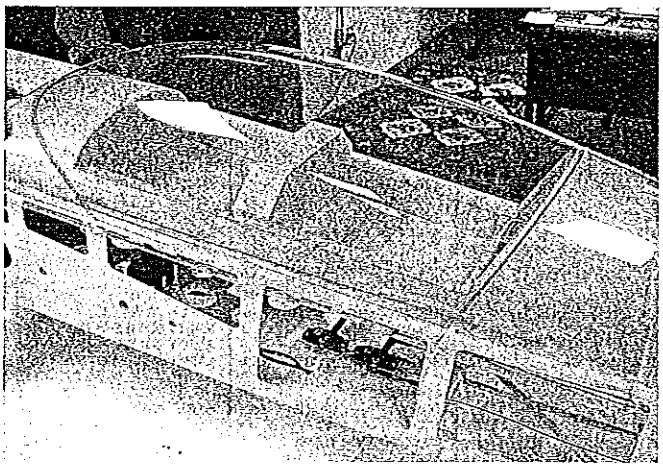
When you're ready to start covering, following are a few hints that have worked for us that may help you too. I like to keep any part being covered on a suitable piece of upholstery foam to keep it from being damaged during the covering process. Cover the ends and edges first. That way, the main body of the covering hides the corner intersections or loose ends and makes for a neat finish.

In tight inside corners, such as the transition from the turtledeck to the vertical stabilizer, start with a strip of covering ironed into the corner using a trim iron. With that you can cut your top layer into the corner without having to transition the covering. The result is a seam that is almost impossible to detect.

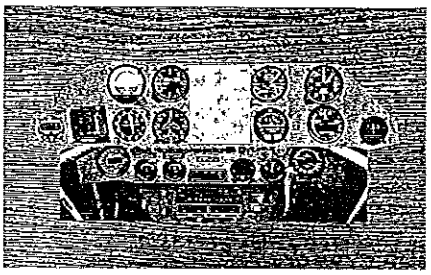
Stay away from putting covering over covering as much as possible by trimming your pieces to fit the shape needed before they are ironed on. I like to overlap the edges of neighboring covering sections by roughly ¼ inch. Put the most transparent colors on first, and overlap with the more opaque colors.

In some cases it will be impossible to avoid putting covering over other covering because of material expanses that transition open bays, such as the fuselage sides on this model or between the ribs of a built-up wing on other models. Covering adhesive is activated with heat, and when it is too hot it will convert to a gas. When covering goes over covering there is no place for trapped air or gasses created from overheating the glue to escape, and the result is ugly bubbles in the finish!

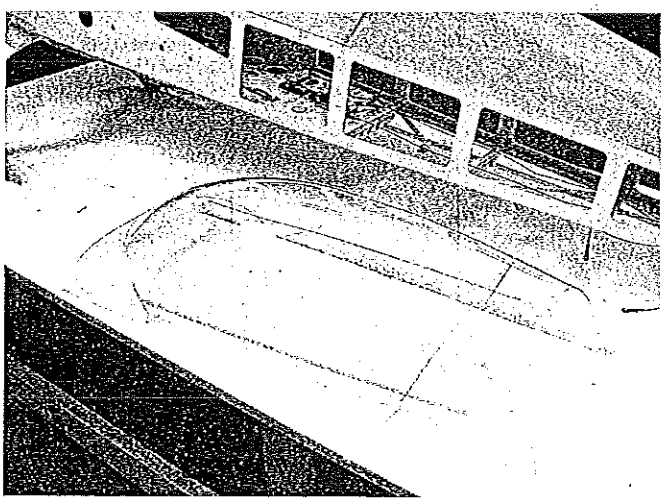
The trick is to be sure that no air is allowed between the two layers of covering while heating the glue, and to heat it only warm enough to make it adhere without giving off a gas. This is a tricky process that



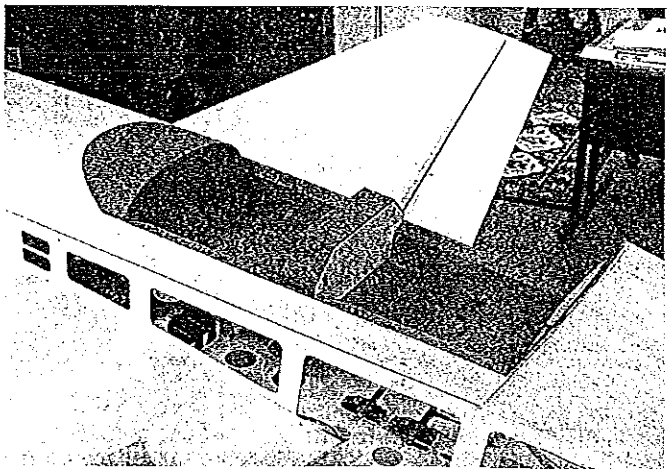
Use ¼-inch masking tape to mark the canopy for trimming. Fit the canopy to the fuselage, then apply tape as a marker.



To save weight, Mike made a photo composite instrument panel. You can download the full-size panel from the AMA Web site and use it in your Extra.



Masking-tape cut line ensures straight line, accurate positioning.



Erik finished the interior of his Extra's cockpit with speckle-type paint. This method is quick and attractive.

takes patience, practice, and a lot of willpower, but it can be done.

There are many methods to get a smooth finish with multiple layers. The following works well and stays put. Smaller pieces are easier than large sections. Let's use a stripe as an example. Measure and cut the stripe to the needed size. The top layer of covering will be tacked down at the starting point and held off of the surface as it's heated, so you must first mark off an outline of the shape to be ironed on. Use a felt-tip pen to outline the section or to make intermittent dashed lines. Be sure to keep it wide enough so the covering doesn't go over the ink. The guideline will keep you on track. It may take some trial and error to get your covering iron's temperature just right, so try a few practice strips first.

The temperature should be approximately two-thirds of what you normally use to seal MonoKote to wood. Tack down the covering at your starting point. Using only the edge of the iron, slowly heat the covering while holding the unheated portion up away from the surface. Slowly work along the stripe, taking it down and heating just to the point where no bubbles form. Use your free hand to hold the MonoKote off the surface and guide its path.

Be sure to only heat a section the size of the iron's edge. If you lay the iron flat, it will heat too large an area and cause bubbles. Work your way to the end of the stripe, holding the free end of the covering up and guiding with one hand while heating with the other. Don't worry that it's not strongly attached; it needs to hold only to the point where there are no loose sections or trapped gasses.

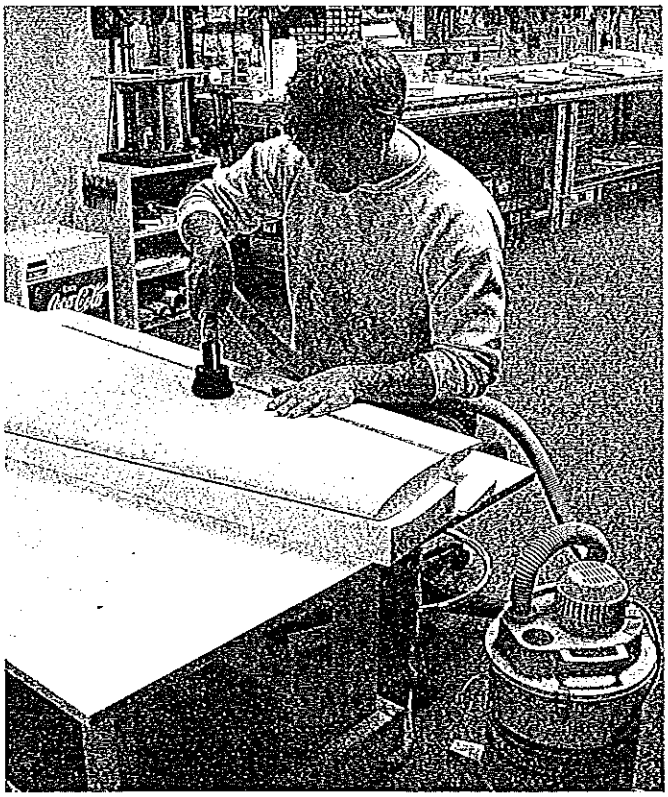
After you complete the section, use MonoKote Trim Solvent to remove the felt-tip-marker outline and seal the edges along the stripe. The solvent will secure the stripe in place in lieu of using a high level of heat. Be sure to get all of the stripes laid out on the fuselage before you begin the cowl-painting process. That way you can line up the cowl to match the stripes in paint.

For a nice finished look, any hole that needs to be cut after covering can be executed cleanly with an old soldering pencil. The high heat melts through the covering like butter and seals the edges so they don't come loose.

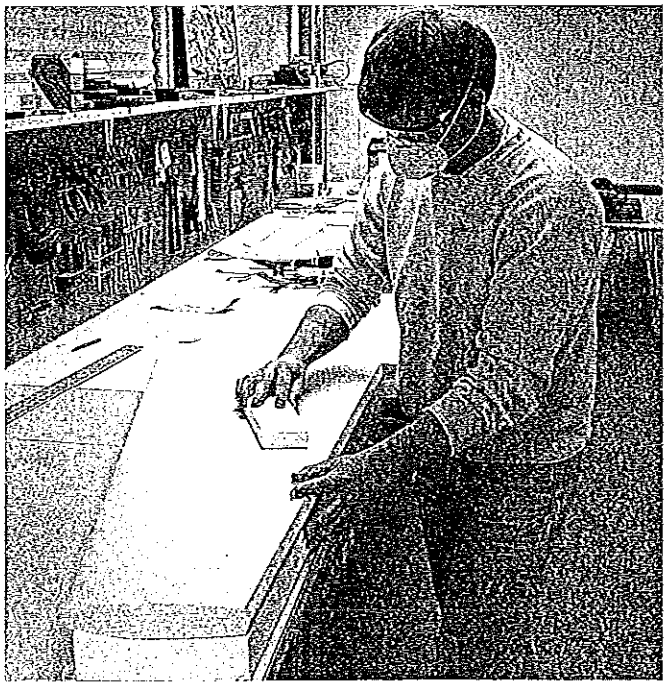
Paint: As with the covering, I'll touch on a few tips and materials that are common among SA builders that can give you a first-rate finish for painted parts. The first step is to wash all of the fiberglass parts with soap and water to remove any leftover mold-release agent.

The fiberglass parts from Aeroglass are smooth and have few pinholes. Be careful not to oversand the parts. If you remove too much of the thin top gel coat, you could expose trapped air pinholes under the topcoat. So only a cursory dulling of the surface with fine paper is needed. We used 400-grit paper sanded wet. I like to use automotive-grade primer, but you must be careful that you don't get too much buildup. A thin coat is usually all that's needed. Final-sand with 400 wet just to the point of an even, dull surface.

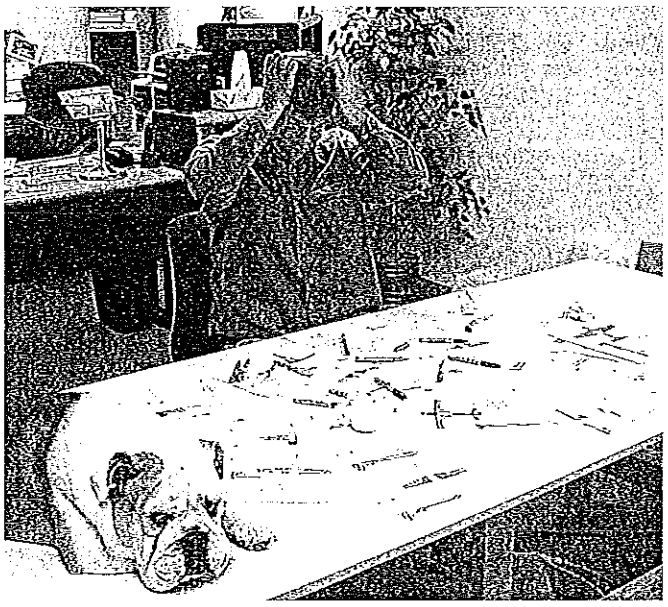
Because gasoline is less harsh than glow fuels that contain nitromethane, you can use many types of aerosol spray-can paints with a gasoline airplane that won't stand up to glow fuels. I know people



Vacuuming wood before covering is important. Brush attachment helps lift sanding residue from grain, helps covering material stay put.



Only cursory smoothing is required on wing panels. Take care not to remove any material from wood at risk of weakening wing.



Designing a color scheme is one of the most challenging steps in the process. Mike and Erik kept Spike nearby for inspiration.

who have used Krylon or Rust-Oleum paints with good results, but finding matching colors may be a stretch. I've done a few nice finishes using TopFlite LustreKote topped with catalyzed automotive clear enamel. The two or three colors I've sprayed matched well and, with ample time to dry, allowed a wet application of acrylic enamel clear with no adverse reactions.

When using paints from an aerosol can, be aware that they must air-dry, and with that there is a fair amount of shrinkage. When the paint shrinks, it seems to magnify any imperfections in the prepared surface, so small sanding scratches or pinholes really show.

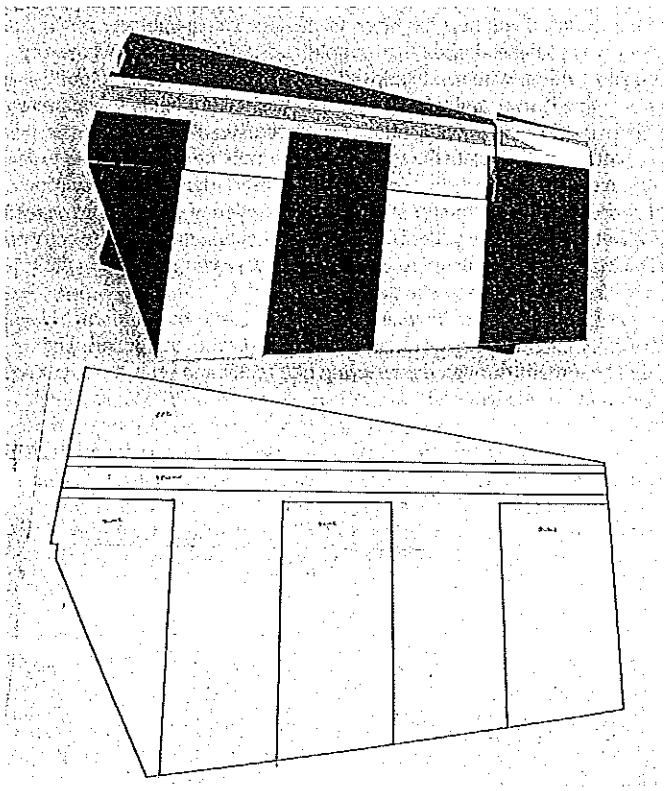
Erik and I prefer to paint our models with automotive paints. They are expensive and require a little experience and special equipment. If you've never painted with professional equipment and paints, you might want to check with others in your club who have painting experience to see if they can help.

Automotive paints are usually activated with a hardening agent and are often topped with a catalyzed clear. Radio South sells PPG polyurethane paint systems in the small quantities we need. The company has done all of the work of matching the covering colors and can advise you on everything you need to get the job done. Visit the Web site at www.radiosouthrc.com/r_c_flying_colors.htm.

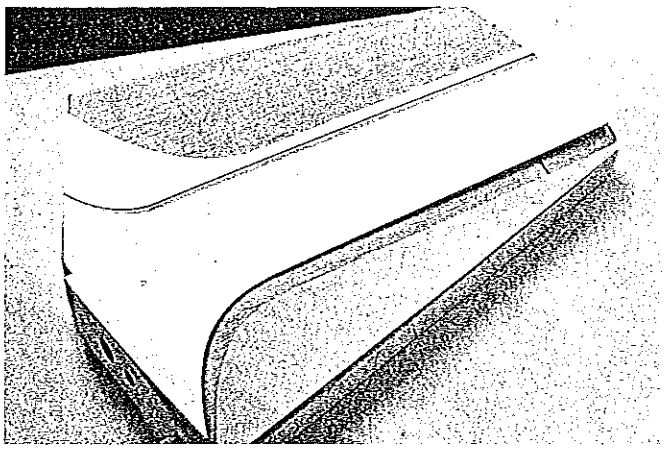
Most local paint suppliers can computer-match your covering for you. To get a match, iron a large swath of covering—roughly 6 x 6 inches—to a piece of balsa, and bring that in to the shop. That way you're sure to get the truest reading possible from the computer.

Another good choice in auto paints is DuPont's ChromaBase two-stage system. ChromaBase is slightly harder to shoot but has a distinct advantage over other painting systems. The base colors are not catalyzed; they go on flat (no gloss) and dry quickly. You're ready to remask and shoot the next color within 30 minutes each in succession.

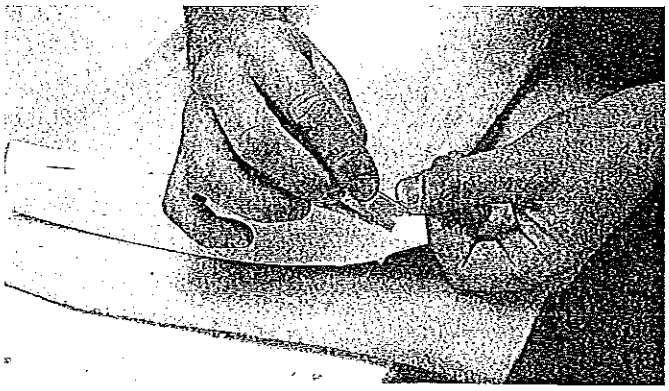
Having proper tools for making smooth, even lines and precise cuts gives the finished product a professional look.



Templates weren't used for every piece of covering, but it helps to make full-size drawing to fit all pieces together before cutting covering.



Once the color scheme was finalized, Erik made full-size poster-board templates which ensure smooth lines and a symmetrical look.



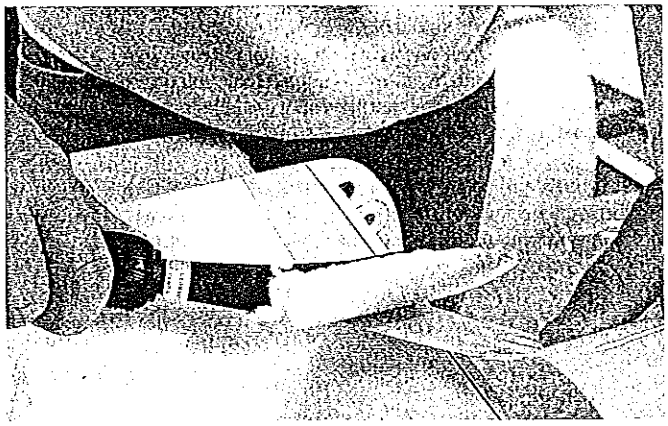
For a high-quality finish, cover the ends first, allowing an even overlap for the main body of the covering material.

Because you need not be worried about the gloss, the colors can go on thin—just enough for even coverage, meaning you also keep the weight down. The last layer is an activated clear that gives a smooth, high-gloss finish. Expect to spend $200-$300 for all of the supplies you'll need from your local automotive paint store.

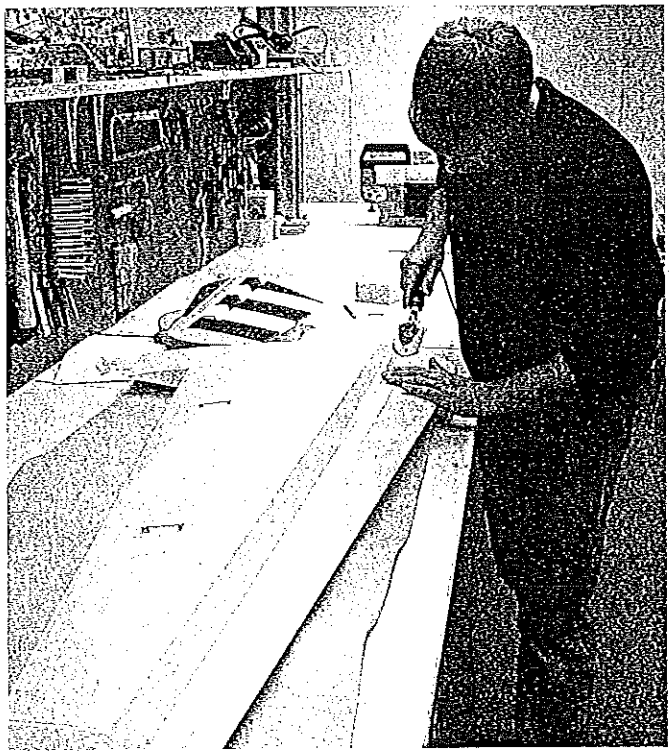
Be sure to paint in a well-ventilated area. I recommend using a good-quality charcoal-type respirator. If you're painting yellows or any colors that have some transparency, it's best to shoot over a white base. A white primer would be ideal, but that may be hard to find. You can do a light but even coat of white base paint before you add the colors.

For perfect lines on all of your stripes, use 3M Scotch Fine Line masking and striping tape. It is specially treated to make the paint

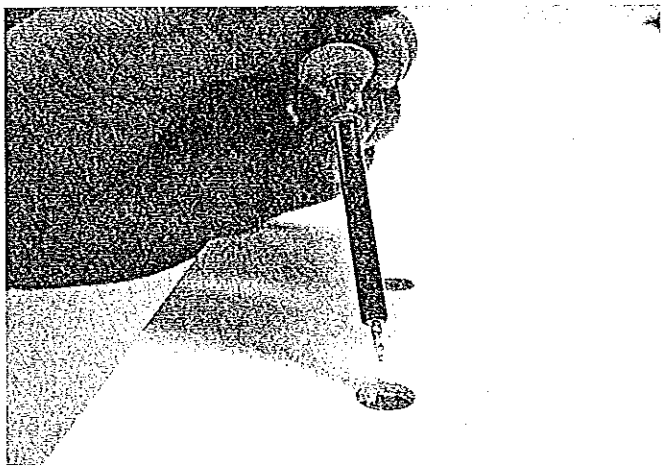
The Project Extra series is presented on the AMA Web site at www.modelaircraft.org.



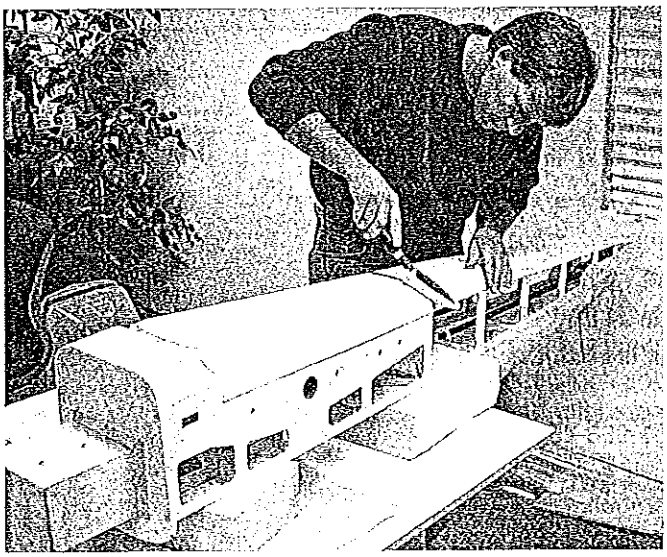
Putting covering on top of covering is the trickiest part of the process, but with practice the results can be nice.



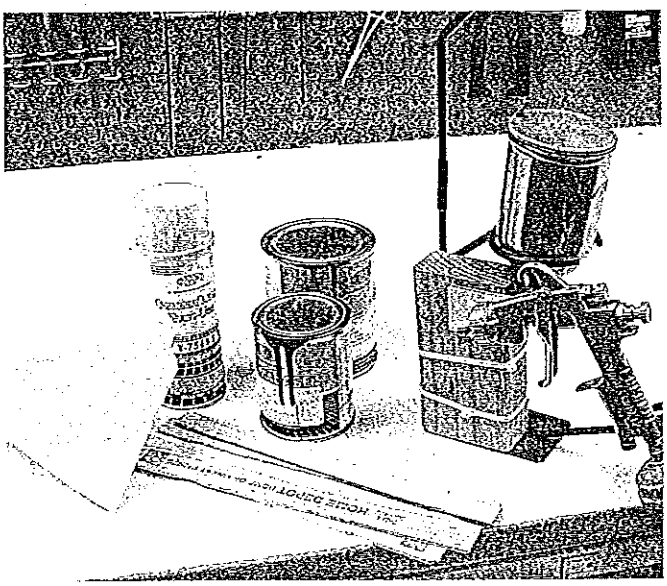
Lay the most transparent colors of covering on first so that the overlapping seams don't show through.



A quick and easy way to make clean holes and cutouts in the covering is to use an old soldering iron with a pointed tip.



Covering a large model isn't much different from a small one, but working with larger sections of material takes patience and attention to detail.



Many modelers prefer to use automotive paints and spray equipment to achieve a professional finish on their aircraft.

adhere to it, so a sharp, defined line results when it's pulled away. This tape also stretches easily so it can go around corners and curves and create odd shapes with relative ease.

Good luck and have fun putting a quality finish on your latest project. I think most of you will find that covering large models is almost easier than covering the small ones. The big pieces are easy to hold, stretch, and work with. Again, my aim was not to teach you the basics of covering or painting, but hopefully you were able to pick up a few tips that will help you along the way.

Next month will be the final installment of "Project Extra." We'll set up the airplane for the first flights, set the control throws, do a little computer mixing, and touch on the basics for trimming in all attitudes. MA

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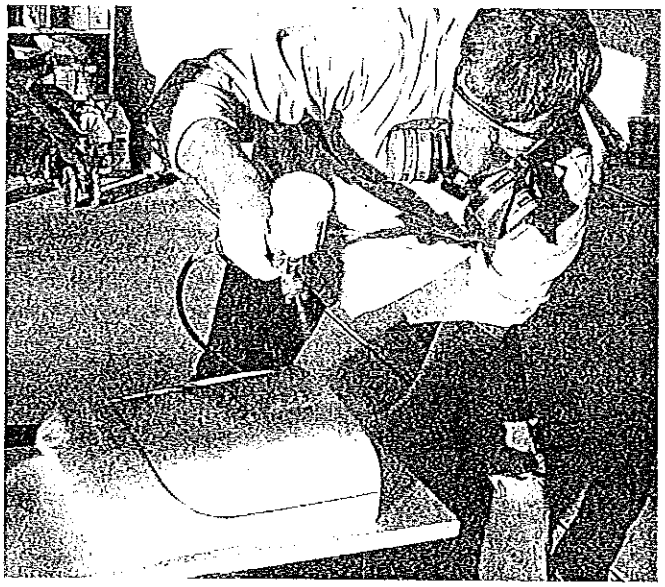
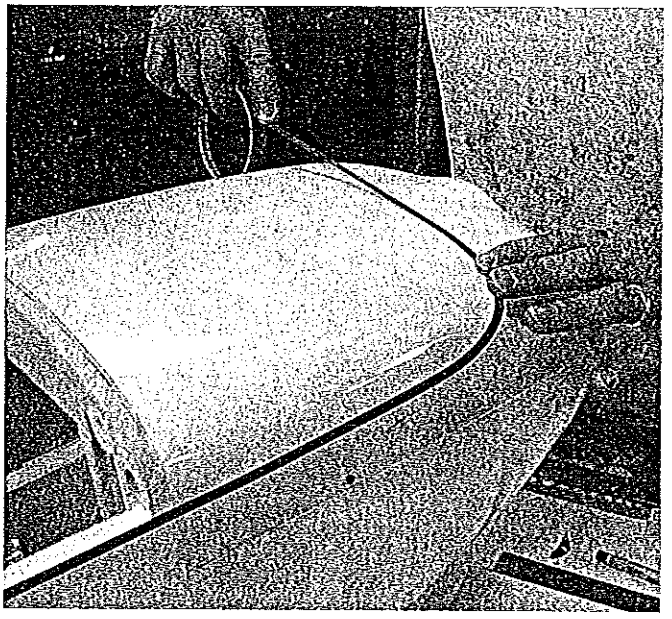
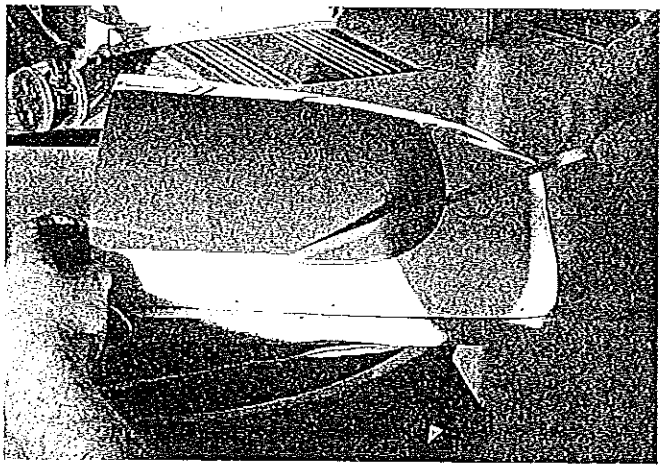


With white base coat, only a light, even coat of color is needed for coverage, keeping weight down and color edges clean.



A white base coat is essential for uniform finish and correct color match. Specially treated 3M Fine Line masking tape is key to clean paint edges and symmetrical curves.

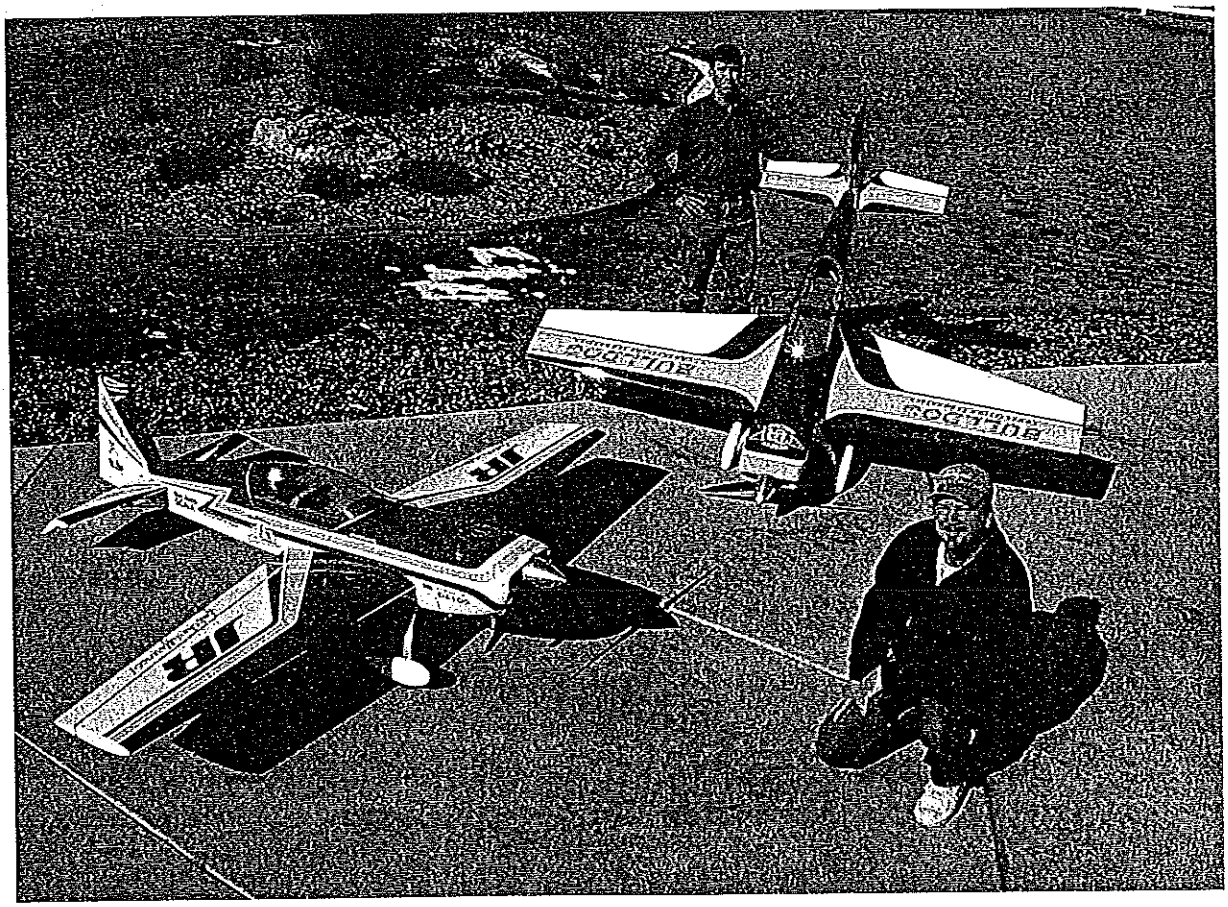


Carefully remove masking paper and peel back Fine Line tape while paint is still soft, to keep paint from chipping along edges.

Project Extra

Mike Hurley

Volume VI: Setup and Flight Preparation



Erik Richard (standing) and Mike Hurley show off their completed Extra 300LXs. Erik's is the one built throughout the course of the construction articles.

ON A RECENT trip to the local flying field, one of the members had brought his latest project, shiny and new, ready for the initial test flight. I watched as he and his buddies began to go over the aircraft, checking this and checking that. They adjusted the servo throw, and two or three guys started to remove pieces from the airplane while others made adjustments. Soon there was a large crowd around the airplane. After some time it was determined that the owner needed to take the airplane back home for some finishing before it could be flown.

Sound familiar? You might have seen this happen at one time or another. This particular flier was not a novice pilot; he had years of experience and was considered by many to be one of the best pilots in the area. Yet he came to the field with the intention of flying an unprepared and untested aircraft with the idea that a few last-minute items would be no big deal once he was there.

Come on! Don't go to the field and install your servos! Make all of your last-minute adjustments in the workshop and be 100% prepared to fly when you leave your shop. It's important to fully finish and ready any aircraft before it goes to the field, but it is especially important with an aircraft the size of the 35% Extra 300LX.

If you need the help of others in your club, ask those who you know have the experience you need rather than taking the chance on whoever may be present the day you go out for the initial flight. Get the help you need and test every aspect of your airplane, then you can be confident that you're ready when you finally do get to that first flight.

Setup: Volume VI is the last installment of Project Extra and it will help you get started with the process of setting up your airplane, but the final outcome is entirely in your hands. No one can tell you exactly how to set up your model to work just right for your personal preferences. In fact, Erik Richards and I will be setting up two separate programs/models on his radio for this Extra—one for his style of flying and one for mine. Our preferences and styles are that different. Only *you* know how you like your airplane to fly and feel.

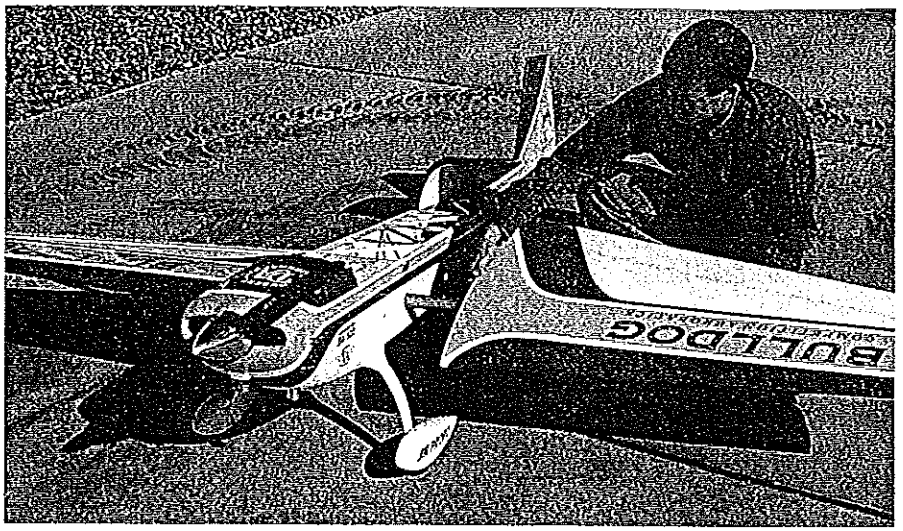
Anyone setting up an aircraft of this size and caliber should have plenty of experience with final adjustments by the time he or she gets to this model. One of the last things to think about before flying an airplane equipped with a gasoline engine (that you may not do with the

smaller models) is to Loctite all of the metal-to-metal hardware that does not need field assembly. Use thread locker that is made for hand-tool removal. That usually means the blue formula, but check the label.

I'm assuming that you know about basic preflight and finishing procedures for a new aircraft: installing, charging, and checking your batteries, sealing any exposed wood in the engine compartment, range checking, and other procedures common to modeling, so I won't go into those steps. But you know as an experienced modeler that all of those things are important for a successful aircraft. Again, if you have questions, get help from someone who has the experience. There's a terrific article on range checking at http://horizon.hobbyshopnow.com/articles/1079.asp.

In this issue we'll look at basic programming for the Extra so that all of the servos work together and you have some idea of how to set up a large aerobatic airplane. I'll give you some guidelines for balance and control throws and discuss standard trimming for a precision aircraft. I'll use the JR 10X radio for the examples because that's what I use, but you can do most of these things with any of today's computer radios.

Refer to your transmitter's instruction manual, and remember that many functions that perform the same tasks are referred to with different names by the different manufacturers. Each of these topics could encompass an entire article in itself, so I'll be limited to the basics. You'll want to expand the information on your own with a little experimentation, practice, and some help from your friends. Another source of information on how to set up an aerobatic airplane is http://horizon.hobbyshopnow.com/articles/1169.asp. Click on the PDF download for the whole article.



Field assembly is rather straightforward. Slide the wings onto the wing tube. Hook up the servos. Fasten the wing to the fuselage, and bolt on the hatch.

Mixing: If you followed our plan for Project Extra, the airplane uses two rudder servos ganged inline and connected to a bellcrank for the pull-pull system. I like to match my rudder servos utilizing a multipoint mix in my transmitter. Even with four servos on the rudder of my 40% models, I match two sets of two servos with MatchBoxes then use a multipoint mix to match the two pairs.

With the JR 10X the two servos are plugged into separate channels: Rudder and Aux2. Since the servos will be hard connected to each other, it's important that each servo's full range of motion matches perfectly.

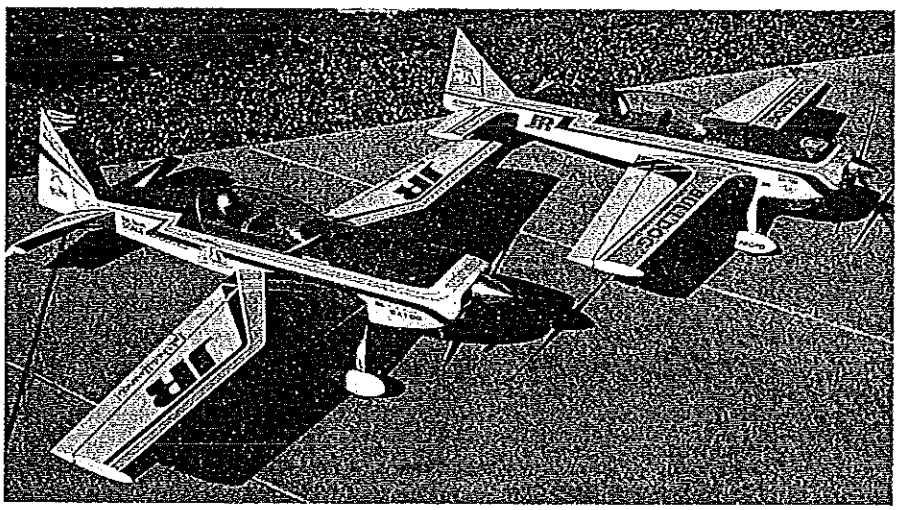
A multipoint mix has the advantage over other methods, including MatchBoxes, in that there are as many as five positions that can be adjusted, and you can tailor the mixing points to just those spots that need attention. For the servo/bellcrank arrangement, first adjust the linkages between the aft servo and the bellcrank. As we discussed in Volume IV of this series, the linkages must be centered and run parallel to each other so that they have equal movement without binding. Check that there is no binding in any movement before you power up any servos.

It's also a good idea to have any servo arms and linkages removed before powering up a servo for the first time. We found some interference between the ball link and the bellcrank and had to add some washers to the inside of the connection to spread the arms slightly and make clearance. The bind was not visually evident, and we wouldn't have found this problem if the servos had been powered up.

Once the movement is clean, you can install the second set of linkages, but don't connect them to the second servo arm just yet. I like to adjust the linkage so I can see the connection point looking through the hole in the ball links. Then with the transmitter, move through the travel and note where the ball doesn't follow the connection point precisely. I usually adjust the endpoints and neutral first. Most of the time that's all that's needed, but if there are places during transition that do not line up, create an adjustment point and line it up. Bolt it up, and you're ready to hook the cables to the rudder.

Follow the same basic procedures with the ailerons, but the mix is done using the MatchBox. The instructions that come with the MatchBox are clear, and the procedure is simple. The 10X has a preprogrammed mix for dual elevators, and we used flaperons for the ailerons so that differential mixing was available if needed. I'll write more about that later.

Before we get to the point of setting up any part of the radio, we need to ensure that all of the controls are working in the correct direction—especially the ailerons. Don't go any further until everything is correct! Standing behind the airplane looking at it as if it were flying away, move the aileron stick left; the left aileron should be up and the right aileron should be down. Move the stick right, and the right aileron is up and the left aileron is down. Do it now; don't wait 'til later.



With the proper setup and some practice, this Extra excels at 3-D maneuvers. Note the extreme 45° elevator deflection.

Control Throws: Here's where things can get sticky and settings will really vary with each pilot's personal abilities and preferences. I use JR's flight modes to

control all of my rates with a single switch. For me, using flight modes helps me avoid confusion.

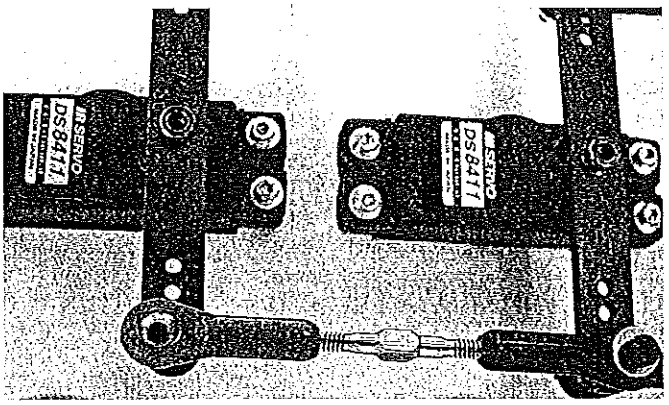
However, you should set up your radio close to the manner with which you are most comfortable. After you get more comfortable with the airplane, you can experiment with new switches and rate types, such as flight modes. If you're fairly new to 3-D, be sure to have a quick and easy way to escape the 3-D setting, and never fly a new model that does not have the option for a reduced-rate elevator.

For starters, let's set up the Extra with two sets of control rates. The elevator is the control that can get you into a lot of trouble fast, so I'll concentrate on that. We'll have a standard rate for everyday flying, which can be later optimized for precision, and a setting for maximum control throw, which is the 3-D mode.

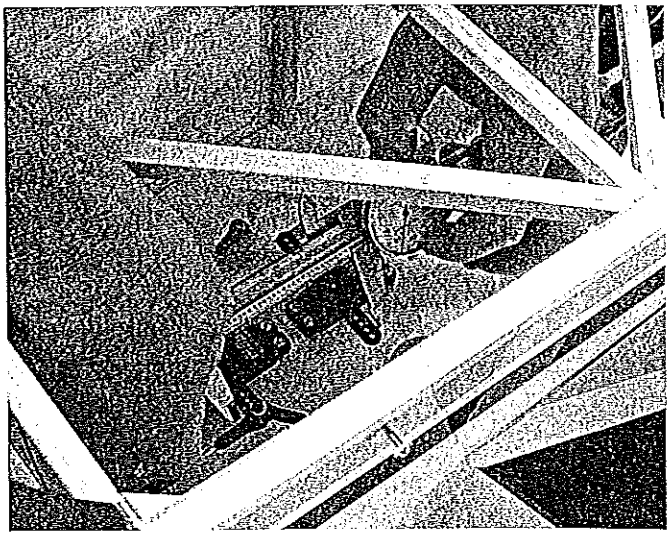
Setting surface deflection is another initial step where so many pilots tend to rely on the TLAR ("that looks about right") method. But really, this stuff is critical to an airplane that flies in a neutral manner and won't fight your every input. For control setup I use CRC Throw Meters to tell me, in degrees, exactly where the control surfaces are set. The CRC gauges are available from Central Hobbies at www.centralhobbies.com/.

One often-overlooked step in setup is matching aileron throw left

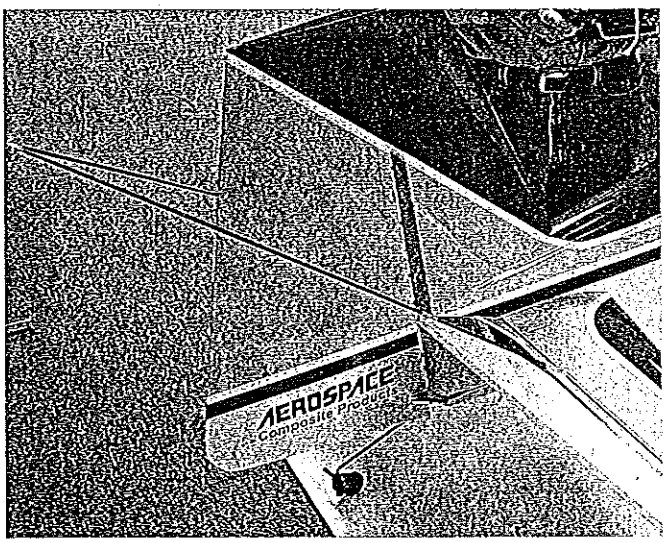
The Project Extra series is presented on the AMA Web site at www.modelaircraft.org.



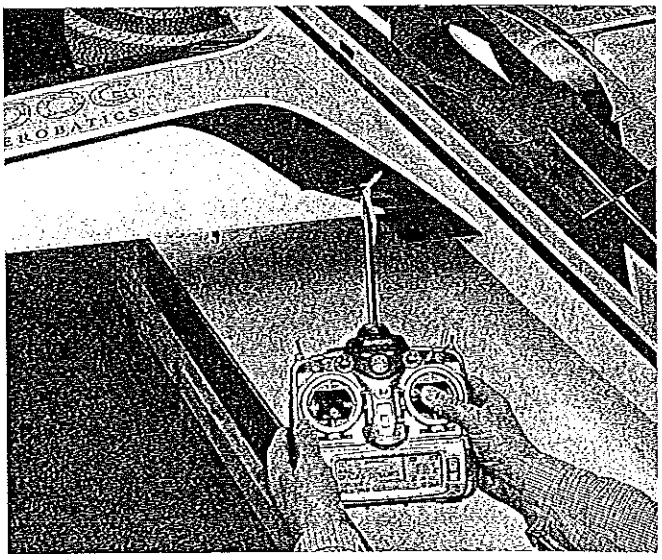
When ganging two servos for rudder pull-pull system, bolt one end of control rod to servo arm; leave other open for alignment.



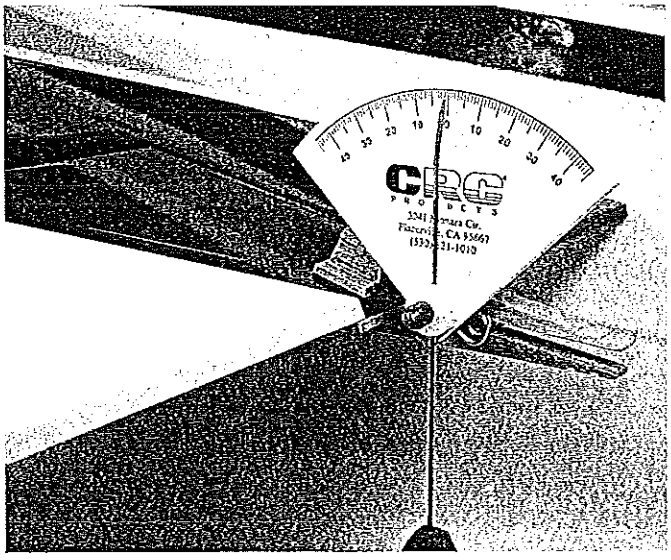
Make sure that your servos are correctly centered before you make any adjustments. Erik used a set of dial calipers.



To ensure that the elevator deflection is equal in the center and at its maximum endpoints, Erik used a set of carbon rods taped to each elevator half as a pointer.



Be very careful to always check for correct control-surface directions before the airplane leaves your shop.



Erik and Mike used a CRC deflection gauge to ensure the desired (and equal) amount of deflection on both sides.

to right and up and down. It's nice to have two gauges for matching ailerons. Before you adjust throw, match the neutral and endpoints for the ailerons. I make these adjustments at maximum deflection or 100% travel. Then as you adjust the total throws or rate settings, the control surfaces should stay in sync.

To make sure the elevators are in sync, Erik likes to use a 24-inch length of carbon tubing taped to each elevator half as a pointer. The carbon rod is stiff and does not flex at this long length, so it stays accurate. Line up the elevators at the counterbalances to make sure they're level, then tape the tubes to the surface so that they point directly to each other when centered. Erik used a toothpick in the end of each tube for further accuracy.

Move the surfaces slowly and watch for differences along the length of travel; some offset as the elevators move is normal. The pointers are so long that a fairly large gap of, say, a half inch only reflects a minute offset, so don't get too worried unless the differences are huge. With the transmitter you can now adjust the endpoints to match perfectly at the extremes of each throw, and you are assured of even elevator adjustment.

For the beginning setup and initial flight testing, set the ailerons to 15° of throw each way and the elevators to 20° each way. To set the rudder, you must turn the fuselage on its side with the wings and stabilizers removed from the airplane. Initially set the rudder to 35° each way. After you get comfortable with the model, readjust all of the deflections and settings to suit your flying style.

The Dead Zone: Before we get into the setup for 3-D, let's discuss flying with huge throws and some of the things to understand before you try flying with 3-D throws the first time. With a little bit of exponential, or "expo," and some experience, this Extra can be flown with any amount of control throw. I fly mine on full maximum 3-D rate all the time. That includes takeoff, landing, and everything in between. The only time I switch out of 3-D is to fly a precision flight where I want more exacting control of the airplane.

For a while I was starting to think that the model couldn't be induced to snap with elevator alone and that anyone could fly it in 3-D mode, but I was brought back to reality when I let a friend fly the airplane. My friend was an experienced pilot who I trusted completely, but he had never flown an airplane set up for 3-D.

At first when I handed him the transmitter set to precision rates, he had a ball doing rolling loops, knife-edge circles, and multiple snaps; you name it, and he was doing it! He became comfortable with the airplane and started to try some of the 3-D stuff that he had seen me do. "You can't do those things in low rate," I said. "I'll switch to 3-D for you." I hit the switch, and the smile on his face started to relax; he was beginning to look worried.

Suddenly just controlling the airplane through a loop was difficult, and he snapped the model without provocation within a couple of seconds. "Shut it off!" he yelled, and I hit the switch back to low rate. That episode made me realize that, without knowing it, I had become used to flying the Extra in a manner that worked with extreme surface deflection, but the model could still be a handful to pilots who are just learning 3-D.

Don't get caught in the trap. Some of you may read the preceding account and think to yourself, I'll just tone it down a bit by

Defying the Limits

Learning to fly 3-D maneuvers is fun and satisfying, and the Project Extra model is a great aircraft with which to learn 3-D. Another advantage is to gather information to help you get started. If you'd like to learn more about high-alpha flight, 3-D maneuvers, aircraft preparation, equipment, and setup, Robin's View Productions has released a video called *Defying the Limits*, featuring world-renowned 3-D and precision pilot Jason Shulman. I developed and filmed the video.

Defying the Limits is available on DVD with convenient searchable chapters. For more information or to order the video, contact Robin's View Productions at (610) 746-0106. MA

—Mike Hurley

reducing the control throw and work up to more throw as I get comfortable. That's exactly what can get you into *more* trouble.

The secret to entering and exiting 3-D is to have the pitch authority to power past a stalled attitude and hold it with massive surfaces, deflection, and a powerful propeller blast. If you tone it down by lowering the surface deflection and try the maneuver, the airplane won't have the required pitch authority and will stall. I call the lowered surface deflection "the dead zone." The dead zone is too low for 3-D and too high for precision control. The dead zone will get you into trouble in a hurry.

Flying 3-D: When flying the model, remember that you need to be committed to getting into and out of a high-alpha (HA) attitude. It's important to have enough airspeed or power to transition into a high angle of attack. I've noticed that people get into trouble when they move too slowly into the transition or don't use enough elevator deflection or engine power.

I'm not saying you need to perform 3-D maneuvers with a higher airspeed, but if the speed is low you must use the power from your engine to move the airplane's tail into position. Indeed you can slow the model to a stall as long as you keep inducing the power needed to keep the tail below the airplane. At that point you can transition into a hover with no forward airspeed. Inversely, you can transition into HA with power off if you maintain the airspeed to pop your model into position, but once in position you need to power up to hold altitude.

Learning to fly into and out of HA safely is the beginning of learning to fly 3-D; it's not hard to do, but it takes a little finesse. If you're not getting it quite right, the aircraft will let you know with a nice wing drop or an all-out snap.

My recommendation, even if you're experienced, is to start slow and use the rate switch. Have enough expo dialed in to keep the airplane controllable, and only switch into 3-D mode to execute a specific 3-D maneuver, then switch back to low rate to fly out. Set your elevator to 45° for 3-D deflection. The dead zone for the elevator is 27-37°; try to avoid those settings. For the ailerons, you can 3-D nicely at 25-30° deflection, and the rudder should be 45°. There is no dead zone for the rudder or ailerons.

Remember that these rates can get you into trouble fast and are not recommended for beginning pilots. If you have to significantly reduce the travel on your radio from 100% to get the ailerons down to 30° of deflection, I recommend moving the control-rod mounting position on the servo arm inboard toward the output shaft until you get

the desired deflection with the radio programmed to 100%.

Exponential: Expo is a program on most computer radios that allows you to adjust a nonlinearity of the stick movement relative to the servo arm output. In most cases pilots use expo to soften the feel of the stick around the neutral position, especially when there is a lot of surface deflection. To create a softer feel you are moving a portion of the servo travel to a different area of the stick deflection—in this case, farther out in the travel. So the servo moves less near the center of the stick position and exponentially moves more as the stick moves toward full travel.

Here's a funny fact that shows a need for standardization. With a JR radio you want to dial in positive expo for a softer neutral area, but a negative value is needed with Futaba. Be sure to read your owner's manual! Because I can't climb into your shoes, I cannot give you a positive starting point for setting expo on this airplane. You will need to do it for yourself. The trick is to set a value and try it. Change one setting at a time and find the value that works best for you.

Following is what I have set on my Extra at max 3-D deflection: aileron, +50%; elevator, +55%; and rudder +30%. I have expo for precision too, but it's slightly different; aileron is +30%, elevator is +30%, and rudder is +40%.

You can see that my rudder expo is higher for precision than for 3-D. That's to try to smooth out any rudder wobble while flying precision maneuvers. You can really effect some big changes with expo that can gain big advantages by smoothing out your flying around the center of the stick while allowing a large amount of control deflection right at your fingers if you need it. There's also the possibility of too much of a good thing, so be careful and don't numb out the center of your radio's stick completely. Once you're comfortable with the airplane, give it a try and don't be afraid to experiment.

Balance: The center of gravity (CG) located

on the plans is conservative, at approximately 32% of the chord at the mean aerodynamic center (MAC). I fly my airplane at this forward position, and it works great for 3-D and precision flying. It's safe to locate the CG anywhere between F3 and the forward edge of the wing tube socket. I feel that, within limits, CG location can be a personal preference. Many of the top pilots fly with a forward CG for precision and move the CG aft for freestyle.

Some people believe that you must have a rear-biased CG to perform any 3-D maneuvers; that simply is not true. In some 3-D maneuvers a rearward CG will slightly enhance the model's performance, but in most other flight attitudes the performance will suffer. I prefer to lose a tiny amount of 3-D performance to keep the rest of the aircraft's integrity intact, yet with practice I'm able to perform any 3-D maneuver.

Trimming: Decidedly, trimming your airplane for neutral flight is the difference between a model that flies well and one that you fight to keep on track. Trimming a model properly is also one of the most overlooked steps in readying it for competition. Hey, it flies pretty well right off the blocks, so why spend so much time on a few minor changes? It does take a bit of time to get everything right. I've spent almost 100 flights getting one of my competition airplanes to where I wanted it. No, it wasn't a problem airplane; on the contrary, it was fantastic, and that's why I knew it had so much potential to be close to perfect.

Some of the things you want to look for are the ability to fly precision up- and down-lines, 45s, and loops without the need for stick input. There are many good trimming procedures and charts available that can take you step by step through the procedure, and I would most likely be doing you a disservice if I tried to make a condensed version here, so take a look online. You can download a chart from the National Society of Radio Controlled Aerobatics at www.nsrca.org/trimA.htm. While you're at it, take a look at the Web site; these are the people who lead the way in precision aerobatics.

Common Mixes: Most Scale Aerobatics (SA) airplanes have some form of unwanted coupling to the rudder. In an ideal scenario, rudder movement would impart yaw only, but with many Scale aircraft the rudder will also effect some roll and/or some pitch. Those are things we do not want for precision flying, so it's a common practice to create a mix to trim those attributes out. After you're comfortable with how the airplane flies, you can start to add these trimming mixes.

For the rudder coupling, check the trim by flying the airplane in knife edge. Set the mix by flying at an even medium speed with only enough rudder to sustain level knife-edge flight. Many of today's computer radios have special mixes just for this trimming procedure. I believe that all of JR's computer radios from the 662 up to the 10X have this specific feature.

The rudder is always the master channel. Aileron will be slaved for roll, and elevator will be slaved for pitch. The amount of mix depends on your model and a variety of dynamic forces that can change, such as atmospheric density, balance, airspeed, servo power, and so on. So no matter how well you dial in the mix, it will never be 100% foolproof, and your model will more than likely be somewhat different from the next flier's.

It's also quite common for the mix for left rudder to be slightly different from the mix for right rudder, so you will have to trim those tendencies out one step at a time. Our Extra does not have any roll coupling, but Scale aerobatic airplanes will commonly have a 2-4% mix. This model does tuck slightly, so I have 10% up-elevator mixed for left and right rudder. That number would decrease with a more rearward balance. To be conservative, start with approximately 5% up if it tucks to the gear or down if it pulls to the canopy, and decide from that point if you need more or less mix.

I like to put my mix on a switch so it can be defeated if necessary. The switch could be useful when performing rolling maneuvers such as a slow roll or a rolling circle, where you are flying through the maneuver with all of the controls in sync,

but (to be honest!) I leave the switch on all the time.

More Mixes: Other mixes that are common to SA aircraft are a throttle curve and aileron differential. I don't use either of them with my airplane, but I thought it prudent to touch on them here.

A throttle curve is used to make the engine power feel more linear through the entire range of stick motion. Since carburetor butterfly position does not usually translate to engine rpm, most of the change in power comes at the lower end of the stick movement. You can set a curve to give you a more even feel. Some people use this for torque rolling if the throttle is too touchy at the hovering rpm range. I had throttle curves in all of my models when I flew at sea level, but since moving to the high altitude in Colorado I've taken the curves back out.

Aileron differential is a means to even out the drag on each wing of the aircraft while rolling. If one aileron has more drag than the other it can cause the airplane to yaw off line as it rolls, giving you a wobble. Normally the down aileron creates more drag than the up side, giving us what is commonly known as adverse yaw. Most differential programs work well at adjusting the down aileron for either roll direction. Actually seeing this happen can be tricky, so often it comes down to extensive experimentation until you get a roll that looks good.

Before computer radios, pilots and designers used to adjust differential by changing the location of the aileron hinge line! Can you imagine the work involved in doing that for each adjustment? You can also see the importance of starting with properly set aileron deflection. The key to making intelligent adjustments is knowing what you have to start with. Our Extra has an axial roll, so I have no differential programmed into the airplane.

Ready to Fly! If all is going well and

you've followed Project Extra through the building process, you're probably just putting the last drops of Loctite on your bolts and checking throw directions one final time before you head out to the field for the first flights with your new airplane.

Who would have ever imagined five years ago when I started to dream about the type of Scale aerobatic model I wanted for myself that it would turn into a major project I would be able to share with the whole modeling community? It has been my hope that you come away from reading this series with new knowledge or ideas about your own modeling experiences. And if you come away from it with a new airplane, that's so much the better!

It's been incredibly gratifying to read so many letters and E-mails from AMA members who have followed and enjoyed the series, and it's been equally gratifying to be able to forge ahead essentially with a blank sheet and help the *MA* staff create a model for future Web-based construction articles and start the ball rolling for an information database that will spread to all aspects of the hobby.

The entire process of bringing this airplane to you and documenting it as the construction progressed would not have been possible without Erik Richard's tireless effort and perfectionism. When we started this project for *Model Aviation*, Erik's wife Angela was newly expecting their first child. Erik's daughter Julia is a year old now! Throughout it all, Erik's commitment to the project has been unwavering.

Oh, don't think for a minute that he's going to have time to spend at home with his family now. We have plenty more ideas and projects ready to get started on, and we can stay busy for a long, long time ... MA

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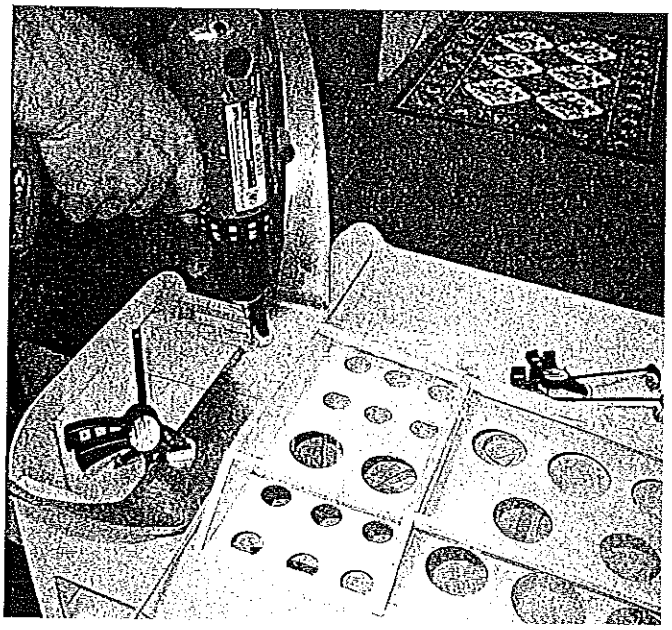
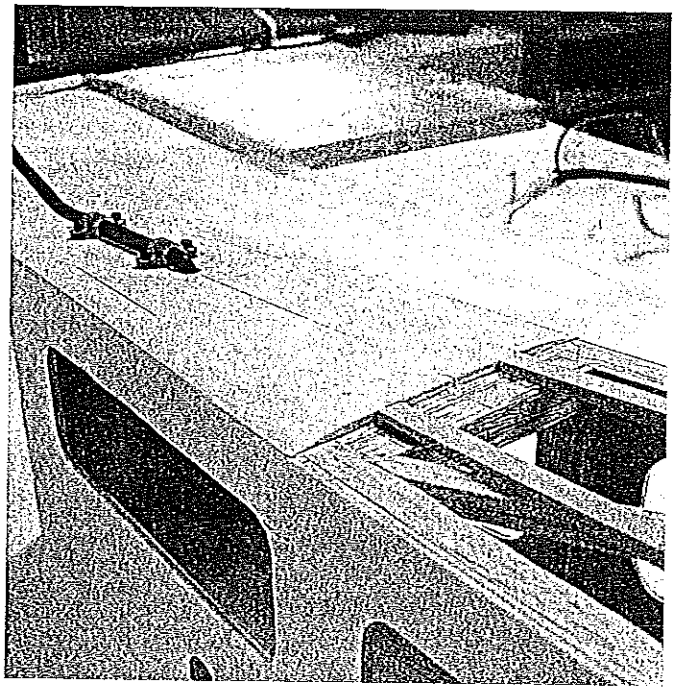
Project Extra



The landing gear is held in place with two aluminum angle brackets that transfer landing forces to the motor-box plates.



The tail-wheel mounting plate and finished rear stringer area shows the mounting details of the Haigh Style bracket.

35% Extra 300L Specifications and Equipment

Wingspan: 106 inches

Length: 96 inches

Wing area: 2,060 square inches

Wing loading as tested: 30.75 ounces/square foot

Weight: 26-28 pounds

Engine: Desert Aircraft DA-100

Propeller: Mejzlik hollow carbon-fiber 28 x 10

Spinner: Tru-Turn 4.5-inch-diameter Ultimate

Canopy, cowl, cuffs, pants: Aeroglass Hurley 35% Extra

Radio: JR 10X

Receiver: JR 955 dual conversion

Servos (control surfaces): JR DS8411 digital

Servo (throttle): JR DS8231 digital

Servo matching: JR MatchBox

Switches: JR HD charge switches

Servo extensions: JR 22-gauge gold silicone twisted

Servo arms: SWB Manufacturing 1.25-inch aluminum

Linkages: Nelson linkages (formerly Rocket City), HD ¼-inch ball ends, K&S aluminum tube tapped with 4-40 ends

Control horns: Nelson (Rocket City) super swivel clevis control horns

Rudder linkage: Nelson pull-pull system

Batteries: Three 6.0-volt Sanyo 2700 mAh NiMH

Covering: MonoKote

Fuel tank: Du-Bro 32-ounce with SWB aluminum stopper cap

Fuel line: Tygon ⅛-inch inside diameter

Wing tube: 0.049 inch 1.5- x 36-inch aluminum

Stabilizer tube: 0.035 inch ⅝- x 16-inch aluminum

Landing gear: TNT 33% Extra 300 aluminum

Axles: Du-Bro 3⁄16 inch

Wheels: 3.5-inch-diameter Sullivan Skylite

Tail wheel: Large Ohio Superstar Haigh Style

EXTRA 300 LX

MIKE HURLEY