Model Aviation's
Sport Aviator
The e-zine for the new model pilot

How to Build an ARF Trainer

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An Almost-Ready-to-Fly Basic (ARF) Trainer differs from the same airplane as a Ready-To-Fly (RTF) version in several important ways. First, ARF Trainers take longer to build, about 15 hours, than the usual RTF trainer's 45 minutes assembly time. A very modest amount of building skill and tools are also required. Most RTF trainers can be assembled using just a screwdriver and wrench. An ARF Trainer usually requires adhesives, and proper airframe alignments. The builder must also buy and install the engine, fuel and radio systems.

Since almost any ARF Trainer is also available in an RTF version, why would a new pilot choose an ARF over an RTF airplane? An even better question is why do so when the RTF version will also probably cost much less than the ARF? Fortunately, there are several good reasons to do so:

- If the worst has happened to your RTF trainer but the radio system and engine survived the uncontrolled air-ground interface, you can just purchase the ARF airframe for a fraction of the cost of another RTF. For example, the Tower Trainer ARF used in this article costs just $80 vs. about $270 for the RTF version.
- Most RTF trainers arrive with very basic radio and engine systems. Almost all RTF trainers include a basic 4-channel computer radio system. The only exceptions are the Hangar 9 Progressive Trainer Systems (PTS) aircraft and the NexSTAR EP which include 5 or 6-channel systems. This limits the pilot's future growth in the sport and usually requires purchasing a more capable radio system in the very near future.
- Like the basic radio systems, RTF glow-powered trainers are often equipped with basic 40-size engines (there are exceptions including the NexSTAR and the PTS trainers which are powered by two great 46-sized engines) which limit the airplane's performance and would probably not be best suited outside the trainer role. That means your second airplane needs a more capable engine.
- Constructing an ARF airplane allows the builder to modify some airframe components to increase durability and to improve flight performance.
- Since the pilot is free to choose the engine and radio systems, it is possible to buy just one advanced radio that will grow with the pilot's increasing skills. This applies to the engine and propeller choices as well.

Photo 1 Photo 2

For this project, we choose the O.S. Max 46 AX engine. Unless you have run this engine in your airplane, it is difficult to understand just what a magnificent engine the AX is for the beginner to operate. Its power is incredible, it is easy to operate and far more reliable than such a powerful engine has any right to be.

The idle is steady at around 2,100 rpm on an APC 11 x 6 in. propeller. That is about 300 rpm less than most 46's can manage. A lower idle speed means easier to manage landing approaches and better touchdowns.

The radio system selected was the Spektrum DX-7 2.4 Ghz with the DS821 Digital Sport servos. The DX-7 is a 7-channel advanced computer control system that will handle the pilot's next 20 airplanes. It even has dual rates on the rudder and 5 programmable mix settings which new pilots don't need to know about right now but will surely need in their first sport aerobatic airplane. For more information on what a 2.4 Ghz radio system is about, read the Sport Aviator articles "2.4 Ghz For The Common Pilot" and "Spread Spektrum - Are You Ready For Full Range?"

Photo 2A

Why Digital servos? Digital servos provide better centering (they return to the exact same neutral point every time) and more precise positioning when deployed than the typical analog servos installed in most RTF trainers. The extra precision increases the pilot's "feel" for the airplane and for what it is doing. Better "centering" means that the airplane always returns to its neutral trim settings every time; making it much easier to fly.

Finally, these Digital servos are stronger; producing 72 oz/in of torque vs. the usual RTF analog servo's ~45 oz/in. The DS 821 is also faster than analog servos at 0.19 seconds for a 60-degree movement vs. the analog's 0.22-0.24 seconds. While all trainers will respond noticeably to the Digital's better centering and strength, the faster servo speed will probably not show up until your first aerobatic airplane. Trainers are just not designed to move quickly enough for the faster speed to communicate itself to the pilot.

Hopefully you are planning to build an ARF trainer because of its advantages and not because you need to replace an RTF trainer that has flown its last. In either case, there are some skills and tools needed and some ways to improve the airplane.

While reviewing this article, keep in mind that the building process is covered in extra detail with some building hints and tips for a better airplane. Some of the modifications are my own ideas but have been proven over decades.

Also, don't let the seeming complexity of this two-part article fool you into thinking that building an ARF trainer is a long, tedious job requiring Master Builder skills. It is not. The whole process takes only 12-15 hours and requires simple modeling tools. It might take you longer to study this article than it will to build the airplane.

The best way to illustrate is to build one, so here goes.

BUILDING THE WING:

Photo 3 Photo 4

While it is bigger than the fuselage, the wing is less complicated and therefore easier to build and align. It is a good place to start. The basic task is to take all the parts in photo 3 and transform them into photo 4.

All RTF wings use an interior metal spar plus an alignment pin to assemble the wings. (For complete information on how an RTF trainer is built, read the Sport Aviator article "How to Assemble Your First RTF Trainer".) The wing halves are held together with a small strap similar to the nylon strap used to hold the main landing gear in place. Eventually, this type of assembly begins to loosen and the airplane loses its easy trim points under stress as the wing flexes a little.

ARF Trainers use a laminated wooden spar that is epoxied in place and the wing halves are also epoxied together. This type of assembly *never* loosens and the wing always remains steady. Durability point one for the ARF over the RTF!

Photo 5

Photo 5 shows almost everything needed to assemble the wing. Note that the wooden spar is in two pieces. Once laminated together with epoxy, the spar will be much stronger than a single plywood piece of the same thickness. **Tip:** The more time an epoxy requires to set up and cure, here 12 minutes for setup and 4 hours to cure, the stronger will be the bond on porous surfaces such as wood. Since the slower “drying” epoxy remains liquid for a longer time, more of the adhesive sinks into the porous wood making an “in depth” bond rather than just a surface joint.


Photo 6 Photo 7

Actually three epoxy brushes will be required to complete the wing, not just the one shown. Two squares and lots of clamps also come in handy. Stresses sometimes build up during manufacturing of the spar pieces resulting in slight warping. **Tip:** When laminating the two pieces together, make sure the gap is towards the lamination’s interior as shown in photo 7. A better, straighter bond usually results this way.

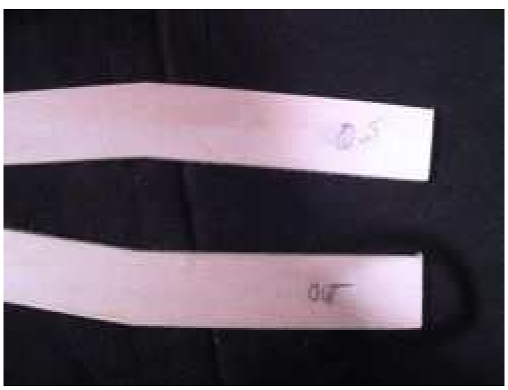
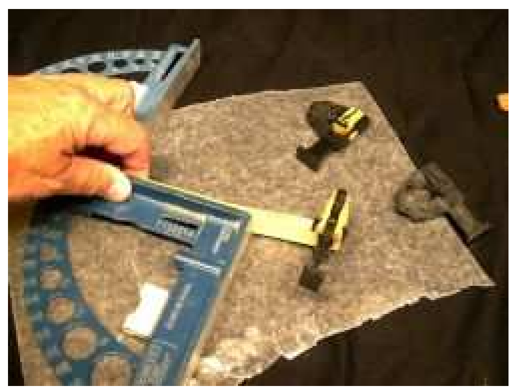

Photo 8 Photo 9

Mark the two pieces as shown in photo 8 to insure a correct lamination. Brush on the 12-minute epoxy onto one piece and join the lamination. Square up the spar as shown. Do this over wax paper to protect the table from the epoxy.


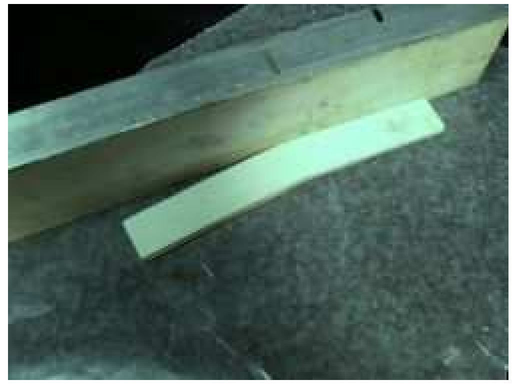

Photo 10 Photo 11

After ensuring that the lamination is perfectly square, clamp it all together. After about 30 minutes, remove the clamps. In many cases, there is a slight, very slight, overlap on one side, maybe two sides? Use a 90-degree sanding block as shown in photo 11 to make everything perfectly even.

Do not remove much material. The idea is to make sure that all sides are flat so that they mate squarely against the wing's spar sockets' top, bottom, edges and sides for maximum strength. A solid mechanical joint is best.


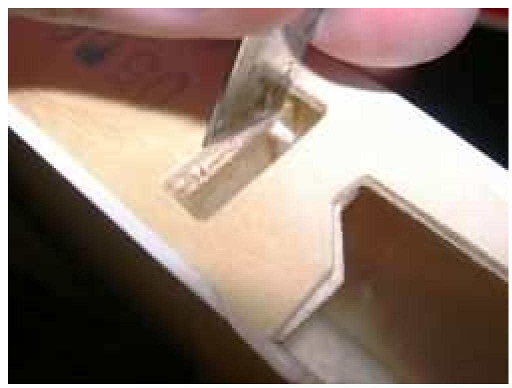

Photo 12 Photo 13

Draw a center line on the laminated spar as shown in photo 12. This will be used to trial fit the wing halves together. Sometimes, the spar pocket is blocked by a little piece of wood (photo 13). Carefully use a razor chisel blade, available at all hobby shops, to remove the extra material. Do not enlarge the socket; just remove the "flash" as shown.


Photo 14 Photo 15

Trial fit the wing spar into each wing half. Make sure that the spar can be inserted into each half so that the center line is slightly inside the root wing rib (photo 14). If the spar/socket fit is too tight, remove a little material from the spar as shown in photo 15. Place the spar on a flat surface and use a sanding block. Do not hand sand without a block as that causes cavitations in the surface that will weaken the glue joint. Test the left wing half first and mark the spar “left” after it fits well into the left side.

Photo 16

Repeat the process for the right wing half. Make sure to fit the unmarked spar side into the right wing. Why? Sometimes the spar pockets differ a little and what will fit one side will often not fit the other without a little sanding. The last thing you want to have happen is to insert the wrong spar side into a tight spar pocket *after* you have applied the epoxy and are rushing to assemble the wing.

After the spar fits nicely, (meaning it has a little drag during insertion but still slides completely into place), into both wing halves, trial fit the wing halves together (photo 17). The center joint should be tight and almost invisible. Don’t worry about the weights and supports in photo 17 for now. They will be explained shortly.

Photo 17 Photo 18

Before joining the wing, it is a good idea to remove the plastic covering that overlaps the center ribs on both wing halves. Do this by prying up the overlap using the razor chisel blade (photo 17). Epoxy does not stick well to the covering. Nor will most adhesives. If the center wing area had several colors, it would have been necessary to gently pry up the covering and bend it back over the wing. Once the wing was joined, the overlap would have been ironed back in place to hide the center joint.

Fortunately, the Tower Hobbies Trainer has an all-white center section. It will be a simple matter to cover the center joint using a strip of white covering, Monokote®, UltraCote® etc or whatever covering material best matches the covering. Therefore, just cut the covering away (photo 18) using a very sharp modeling razor knife.

Some builders prefer to just sand the covering overlap to increase the epoxy's adhesion. This may increase adhesion but does not compensate for the gap caused by butting two thicknesses of covering together. With the overlap covering in place, it is not possible to tightly join the two wooden root ribs together. The covering's thickness causes a space; weakening the joint. Remove the overlap.

Photo 19 Photo 20

Tip: Sometimes a bit of the adhesive from the overlap remains on the wood root. Covering material adhesive is impervious to just about any solvent and so is impossible to remove without damaging the covering. Coverite long ago solved the problem of removing stains and adhesive from plastic coverings. They invented the still little-known wonder of the modeling world: Ironex. Ironex will remove just about anything, even adhesive stains, from plastic coverings without damage. It is impossible to assemble an airplane, or even to tighten the covering, without getting something on the covering. Keep a can of Ironex around, you will be glad you did a hundred times over.

Put a small amount of Ironex on a paper towel and remove any remaining covering adhesive from the center root ribs (photo 19). Finally, lightly sand both root ribs with a large sanding block just to scuff the wood for better adhesion and to insure that both sides are flat (photo 20).

Photo 21 Photo 22

Photo 21 shows everything required to join the wing panels. **Tip:** Use two epoxies to join the wing. Do not use any other adhesive for this task unless you enjoy searching for wing panels and picking up tiny fuselage pieces. Use 30-minute epoxy for the wing spar and pockets. This slow curing epoxy provides maximum strength while allowing plenty of working time. Since the faster curing 5-minute (or 12-minute if this is your first wing) epoxy will hold the wing firmly in place, the 30-minute's long cure time is not a factor.

The brushes are available at all hobby shops and cost about 15 cents each. Do not use a good brush as cleaning epoxy is a job best suited to wizards, not us mere mortals. The small adhesive cups insure that the epoxy is correctly mixed. Use the low-tack tape to protect the covering and trim colors while holding the wing panels tightly together during assembly. The square sanding bar will be used to prop up on wing panel to the proper amount of dihedral. The clamp helps align the trailing edge.

Use a true flat surface, such as the redwood shelf in the photo to insure proper wing alignment. Wax paper protects everything during the assembly. Cut about 20 6-inch strips of tape and keep them handy.

Test fit everything together one last time. Weight one wing panel so that it is flat against the board. Slide the sanding block under the other wing panel until it just touches and supports the raised wing panel. Use a square to make sure the block is perpendicular to the wing (photo 22).

Photo 23 Photo 24

Mix up the 30-minute epoxy in a cup. Do not mix the 5-(12?) minute epoxy yet. **Tip:** Tilt the cup 45 degrees and pour in part A so that it is centered on the cup bottom with the other half dry. Pour at least an ounce in the cup, keeping it tilted. Then pour in an ounce of part B from the center outwards and level the cup. The joint line should be centered in the cup and both levels should be the same height. Now you know you have an equal mix. Being a little bit off may slightly effect the curing time, but the final bond strength will be about the same so this is not extremely critical.

Use a mixing stick (a good excuse as any for eating an ice cream pop) and mix the epoxy. Use a brush and apply the 30-minute epoxy into the spar sockets on both wing panels. Apply epoxy to the socket sides, top, bottom and the far end. Do not put epoxy on the spar itself. Be liberal with the epoxy. Slide the spar into on wing half until the center line you made is aligned with the root rib. remember to follow the labels you created.

Remove any excess adhesive that may slip out around the spar from the root rib. Now, mix up the faster epoxy as previously described. Brush a thin layer of the faster epoxy onto *one* wing root (photo 23). **Tip:** Using a small piece of paper towel, overlap the root edge by about 1/16th inch. Run the towel along the top and bottom edges to remove any epoxy close to the edge (photo 24). Why? When the wing halves are joined, the pressure will squeeze the epoxy towards the edges. The epoxy will fill in the space near the edge but will not escape to ruin the joint’s appearance.

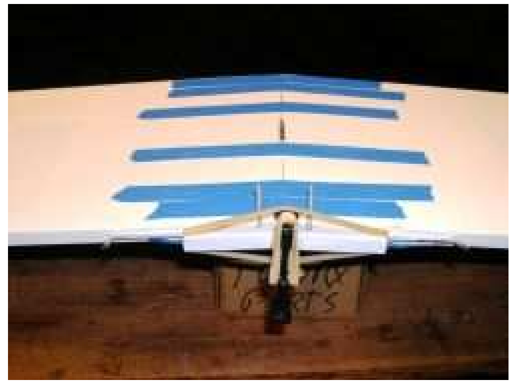

Photo 25 Photo 26

The next step requires concentration to make sure both wing halves are aligned. Wild Bill Hitchcock once said that in a gunfight, “draw and aim slowly; quickly”. The same applies here. Be careful but get everything together and aligned before the fast epoxy sets. Slide the wing panels together just like the last trial fitting. Put a clamp on the trailing edge to align it.

The low tack tape is “stretchable” so stretch it and apply one piece span-wise in the area of the main spar. The tape should be at least 3 inches on each side. Press it firmly in place *while stretching it*. Once released, it will pull both panels together. Apply another piece the same way just in front of the first. Make sure that both halves are aligned; check that both wing bottoms are aligned using your finger.

Put some #64 rubber bands on the trailing edge as shown in photo 26. It is easier to do this without the ailerons installed. If your aircraft’s instruction booklet says to install the ailerons before joining the wing, just skip those instructions. Check the alignment, front and rear, again with you finger. If all is OK, put a piece of tape about every inch or so (photo 25). Keep checking the alignment as you go.

Put a box under the center section and invert the wing. Tape the bottom (photo 26) just as you did the top. Turn the wing back upright. Align it again; then go away for about 20 minutes. This sounds complicated but the whole process is intuitive and takes only about 3 minutes. Just make sure that both wing panels are aligned. Any misalignment will affect the airplane as would a warped wing; requiring aileron trim to correct the resultant rolling tendency.

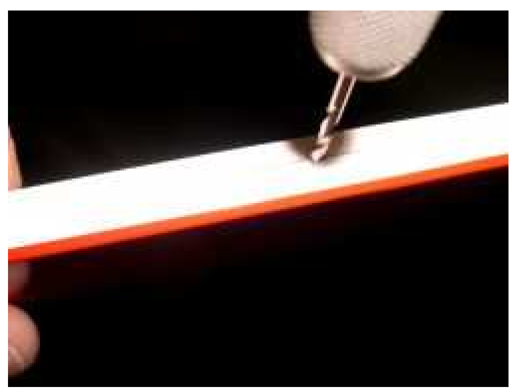

Photo 26A Photo 27

NOW is the time to install the ailerons. The Sport Aviator article, “Installing Mylar Hinges” covers this step in detail. But, as this article is also a “How-To”, the most important details will also be reviewed here. Before installing the hinges, test fit each aileron. Mark the center of each hinge (photo 26A) on both the aileron and wing trailing edge. Note that there is a center gap cut into the hinge. This is for the adhesive to wick inside as far as possible.

The aileron must fit tightly against the trailing edge. Deepen the slot using a hobby razor knife if required. Once the test fit is OK, remove the aileron. Use a hand drill to drill a 3/16th inch hole into the *center* of the hinge slot in both the aileron and wing trailing edge (photo 27). The hole increases the adhesive wicking depth for a stronger installation.

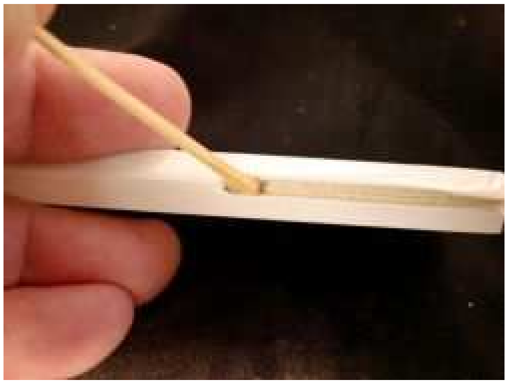

Photo 28 Photo 29

Apply some plastic-safe oil to the wing torque rods where they exit the trailing edge (photo 28). This protects the torque rods from the epoxy applied to the aileron torque rod hole and slot. Use a toothpick to apply some 5-minute epoxy into the aileron hole and along the inset groove (photo 29). Do not skip this step. The epoxy prevents the balsa from expanding away from the rod under continued flight loads. This results in aileron flutter and can be dangerous to your airplane's health and your sanity.

Photo 30 Photo 31

Install the aileron and hinges tightly against the trailing edge. Make sure that the slot is perpendicular to the aileron and trailing edge (photo 30). Deflect the aileron about 40 degrees while holding it tightly against the trailing edge. Starting with the hinge nearest the outside, apply *thin* CAA, thin only, to the hinge (photo 31) while holding everything together. Wait a few seconds, and then do the same to the hinge nearest the torque rod hole. Finally, finish gluing the remaining hinges.

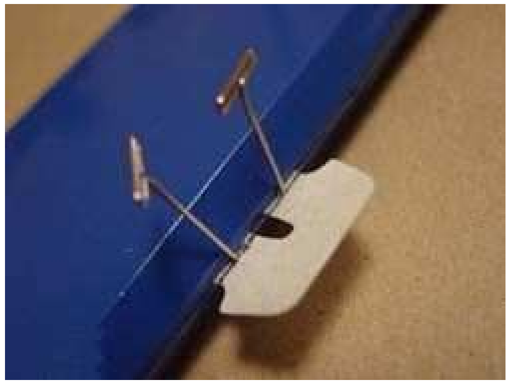

Photo 32

If the factory cut slots are too deep, the hinge may slide too far into either the aileron or the trailing edge. Ideally, half the hinge should be in each side of the slot. If the slot is too deep, you will have to use the pin trick as shown in photo 32. Use two pins at the hinge center. Using only one pin allows the hinge to turn in the slot making for a control surface that is hard to move. Using two pins keeps the hinge perpendicular to the hinge line for best results.

Once the thin CAA has been applied, turn the wing over and apply more adhesive to the hinges from the underside. Be sure to flex the aileron in the opposite direction this time.

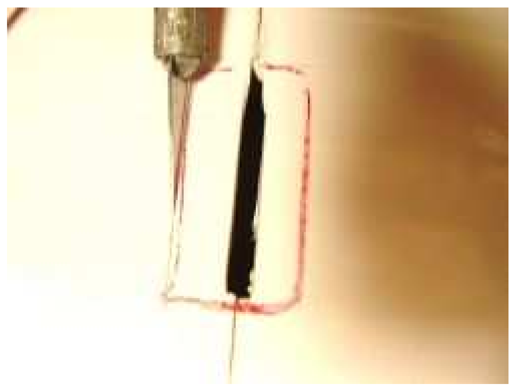

Photo 33 Photo 34

Now that the ailerons have been installed, we need to put something in there to move them on command. A single DS821 digital servo does that job. Some trainers use two servos, one in each wing to motivate the ailerons. This is a superior system because it allows tuning aileron differential to the airplane and allows possible flaperon use. If your trainer has a single aileron servo like the Tower Hobbies airplane here, you might want to install twin aileron servos.

Photo 35

Howe to do this is detailed in the Sport Aviator article "Not Your Stock HobbiStar Part One". However, this can be a difficult task and not really suited to a pilot's first ARF trainer (the HobbiStar MK II ARF used in the article is an Advanced Trainer, not a first airplane). It might be possible to install two servos in the center section but we didn't try that. If it works, we'll put an update here. If this is done, the ailerons will need to have a slightly larger gap (~1/16th inch) from the trailing edge to allow extra downward movement for flaperon use. The larger gap will then need to be sealed using more covering. In general, if your first ARF trainer has just one aileron servo, go with it for now.

Center your servo in the small wing cut out and draw around it on the outside (photos 33 and 34). Use a very sharp hobby razor knife to cut outside the lines. This provides a little "elbow" room for the servo to protect it against vibration.


Photo 36 Photo 37

Most ARF airplanes require that the aileron servo mount be constructed from three pieces – two supports and a small servo tray. The Tower Hobbies Trainer is no different. However, I was very surprised to note that the two tray supports were balsa wood. This is not acceptable in an airplane expected to last more than a hundred flights.

All servo tray supports must be hardwood. Ailerons get a lot of usage. even if the forces involved do not tear the soft balsa apart, prolonged operation will crack the wood and cause the servo tray to fall out. In addition, the hardwood supports provide extra grip area for the servo mounting screws instead of only having the thin plywood (more on this in part two).

However, this is easy to fix and the balsa support comes in handy on this step. Place a small piece of 220 grit wet-or-dry sandpaper tightly against the wing center (photo36). Then rub one of the balsa supports font to back across the sandpaper until it conforms to the wing's dihedral. This creates a usable template.

Cut two pieces of 3/8 inch birch square beams (all hobby shops have them) to the same length as the balsa supports. Then outline the balsa support's center grove onto both hardwood pieces (photo37). Cut the hardwood beams to match the balsa template.

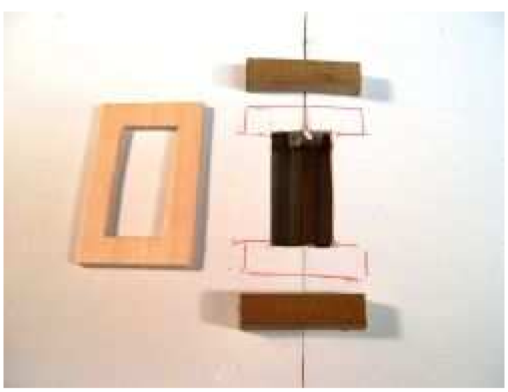
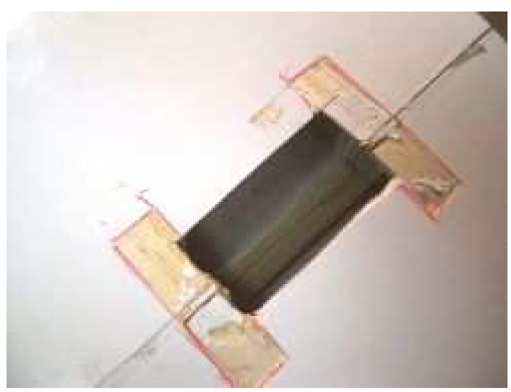

Photo 38 Photo 39

The preferred hardwood mounting system is shown above. Make any fine tuning adjustments needed until both supports fit tightly against the wing's center section.

Outline both supports as shown. Use either a Great Planes hot knife or a sharp hobby razor knife (make sure not to cut into the wood) and remove the covering under the supports (photo 39).

Photo 40 Photo 41

If any covering adhesive remains, remove it with Ironex (photo 40). Note that the adhesive has already been removed from the front support area. Cut out a small section to allow the servo's wire to escape the hole and epoxy the supports in place with 12- minute epoxy.


Photo 42 Photo 43

Apply the epoxy to the support tops and center the servo tray on top (photo42). Put a small weight on top and let everything alone for 20 minutes. Epoxy adhesive forms a stronger bond if it cures under pressure. The weight not only provides the pressure but also forces the adhesive deeper into the wood for an even stronger bond.

Photo 44 Photo 45

While the servo mount is curing, assemble the servo. Insert the rubber grommets as shown in photo 44. Never mount a servo in a glow-powered airplane without the grommets. Vibration will quickly cause servo failure if you do. Insert the brass spacers as shown. **Tip:** Use a nail set to insert the grommets. It saves your fingers for flying.

No matter how you install them, use the brass spacers. They are designed to prevent the grommets from crushing under the servo mounting screw. Once crushed, the grommets provide zero vibration protection and we all know the result.

Photo 46 Photo 47

Install the servo as shown in photo 46. Note the twin cardboard pieces on each side of the servo. These serve as spacers to make sure the servo is not located against one of the side panels. If that were happening, the vibrations would still be directly transmitted to the servo despite the grommets and brass spacers.

Photo 48

The grommets have small ridges that fit *inside* the mount to prevent contact on the front and rear sections. Make sure these small ridges are inside the mount, not on top of it.

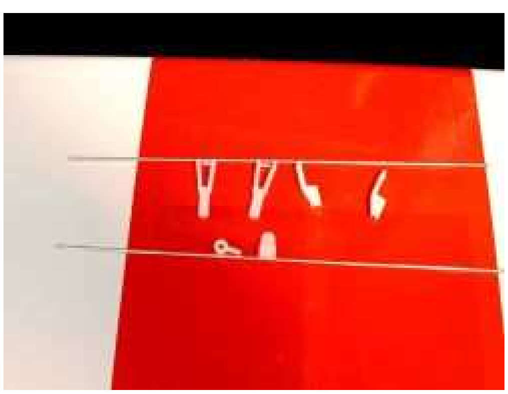

Photo 49 Photo 50

The last step is to install the aileron linkage. All those parts are shown in photo 49. The two small nylon parts nearest the front control rod are screwed onto the vertical aileron torque rods. Screw each down the same amount until the nylon tops are exactly even with the top of the metal torque rods.

Assemble the control rods with the nylon clevises as shown in photo 50. Using a DuBro Clevis Tool makes this job much easier. Install the clevises so that as much treaded rod is left behind the clevis as protrudes from the front of the clevis' treaded base. This allows some adjustment if the servo side hookup is a little off.

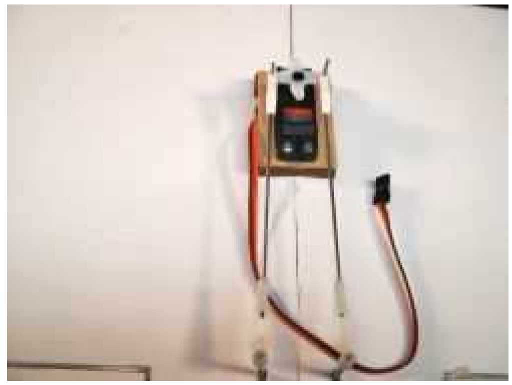

Photo 51 Photo 52

Turn on the radio system. Make sure that the aileron trim tab is centered and that the transmitter's aileron sub-trim is set at zero. Center each aileron (difficult on this airplane as the center trailing edge is thick preventing the aileron to be centered by just clamping it to the wing's trailing edge. Use you eye to center the aileron.

Once everything is centered, connect one of the control rods to the aileron torque rod. Run the control rod to the servo, just under or over the servo output arm. Mark the control rod where it passes by the hole in the output arm (photo 53). repeat for the other aileron.

Remove the control rod and make a 90-degree bend at the mark. It might be necessary to enlarge the servo output arm's holes to fit the wire. Do this slowly and carefully, Make the hole only large enough to permit a tight fit. Too much "slop" will cause trim problems in flight.

Use the locking nylon arms to secure the servo connections as shown in photo 52. If the ailerons are not perfectly centered after install the connecting rods, screw the clevis in or out to center them. Try to avoid using the transmitter sub-trim settings to make corrections. The sub-trims will be used for fine, in-flight adjustments.

Finally, work the ailerons and make sure they move in the proper directions. For a left turn (bank) the pilot side aileron should move upwards while the passenger side aileron moves downward. The reverse is true for a right bank (turn).

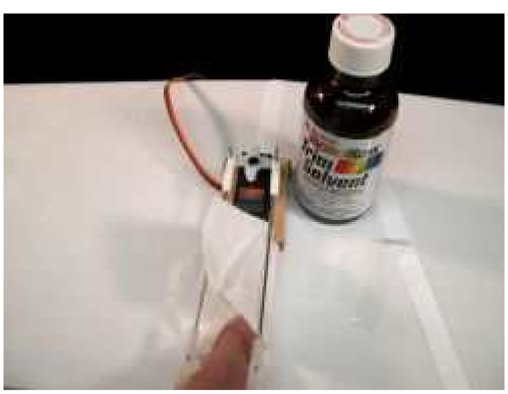

Photo 53 Photo 54

The last step is to seal the wing center section with a 1/2 inch strip of covering. The covering used here is White MonoKote. Small pieces like this are best applied using MonoKote Trim Solvent. The idea is to first adhere the thin strip to the wing with the solvent and then to hit it with a covering iron. Trying to apply it by heat alone often causes the narrow strip to twist and warp.

Place a small amount of adhesive on a paper towel and clean the area to be covered. Then, using the same towel without additional adhesive, rub the adhesive side of the covering to activate the adhesive. Use a very small amount of solvent. The towel should be almost dry to the touch. Apply the covering strip and press into place. If necessary, stretch the covering slightly, very slightly, to go around the compound curves.

Apply the bottom strip first. Then apply the top strip allowing it to overlap the bottom strip front and back. Once all is in place, use a model covering iron to firmly affix everything forever (photo 54).

SUMMARY

Photo 55

The above description uses about 5,400 words and 54 photos (the two glamour shots don't count) to explain the very best way to construct an ARF trainer wing. While the best methods are detailed, not everyone will get them all perfect the first time.

A small mistake here and there is acceptable. But try to avoid them. If you get about 75% there, the airplane will fly OK but short of perfect. Honestly, I would be happy if most of the ARF trainers I am asked to fly made it to 50% right. They still fly but it requires about two hours field time to get them to that stage.

The most important parts to do well (in order of importance) are:

- Align the Wing Halves perfectly
- Secure the aileron hinges top and bottom
- Secure the aileron control rods well.
- Insure that the aileron servo mount is firmly fixed in place.
- Make sure that both ailerons move properly and return to the exact same point after moving.
- Protect the servo against vibration.

Try to do the rest as well if possible. Assemble some tools like a high speed rotary tool, various bits, small screwdrivers, a small two-way appliance level and some more adhesives. Part Two will deal with the fuselage assembly and will be using these tools.

One final note please. This article might make the wing assembly seem tough. It just isn't so. The entire job will take only about 3 hours, usually less. The process is extremely intuitive and mostly just common sense. But when written down in such detail, it looks difficult. It is not. Don't let this article scare you away from ARF trainers.

If you already are flying an RTF trainer, use this building “down” time to construct your ARF replacement. Every experienced RC pilot knows one Great Truth:

You will not lose your first trainer while learning to fly and solo with your instructor. You WILL lose it once you have soloed and are learning about RC piloting on your own. The best replacement plan is to have the identical trainer ready to go. The ARF version, here costing only $80, is the best replacement strategy.

Part Two will require about three weeks, so look for it then.

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