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The End of the Beginning
By Frank Granelli

IN THE FIRST article of this portion of *MA's* "From the Ground Up" series I reviewed RTF and ARF aircraft that are suitable for new RC pilots. The second article covered building a generic RTF trainer, using available glow- and electric-powered versions as examples. You can assemble RTF trainers in 20 minutes to an hour, using common hand tools. No adhesives and few building skills are required.

The contents of a typical ARF kit. Most of the hard work is already done for you.

RTF trainers represent a leap forward for beginning modelers. It is possible to get into the air with a quality aircraft in less time than was once required to *unpack* a wood kit. Still, constructing a wood kit has several advantages that RTF pilots miss, one of which is that it allows the pilot to select an upgraded radio system and engine.

Building a wood kit allows the pilot to modify the airframe to increase performance, appearance, and durability. Wood kits allow the modeler to "swap out" heavy parts by making identical parts from lighter wood. Built-up wooden kits are usually 5%-10% lighter than the identical ARF. Less weight makes any sport aircraft fly better.

Constructing a wood kit is also fun and educational. This series will eventually cover how to build a wood-kit aircraft "from the ground up." Every model pilot needs to gain this experience, but constructing a wood kit has two drawbacks: it takes one to two months to complete and requires advanced building skills.

An extra servo, stronger nose gear, a few pieces of wood, and covering material (not shown) are all you need to improve the Hobbistar's handling and durability.

Use 30-minute epoxy to join three wingspar parts. Tack pieces to flat building board or clamp to large combination square.

Surely there must be a compromise between RTFs and wood-kit models. There is, and it is an "ARF."

ARF aircraft require some building skills, but nowhere near those required to complete a wood kit. ARFs come in enough pieces that the builder can make almost as many modifications as he or she can when building a wood kit.

The pilot supplies the radio and engine systems, allowing upgrades. So much work is factory-completed that the average ARF trainer requires just 20-25 hours to go from box to air. Almost the only advantages left for a wood kit are its lighter weight and unique appearance.

There are far more ARFs available than the relatively few RTFs. It is impossible to include every ARF in this installment, as I did in the June issue with the RTFs. Instead, in the next few "From The Ground Up" articles I will cover building and modifying one ARF trainer: Hobbico's Hobbistar 60 Mk III.

This 60-size advanced trainer features a semisymmetrical-airfoil wing, allowing inverted maneuvers. However, the generous wing area and dihedral give the Hobbistar basic-trainer abilities as well.

If you want to learn about many other fine ARF trainers available, you can read about them in *MA's* Sport Aviator online magazine at www.masportaviator.com.

Apply epoxy inside aileron torque-rod hole and along channel. Epoxy strengthens wood around torque rod to prevent flutter. Epoxy in channel fuel-proofs exposed wood.

Note hinge center mark where 3/32-inch hole was drilled in both surfaces. Two pins align hinge during installation. Remove pins just before gluing hinges.

Getting Tacky About Adhesives: ARF construction requires adhesives. These aircraft do not bolt together as RTFs do. A review of adhesives is a good idea before I start gluing tab A into slot 12 and get my six left fingers stuck together.

ARF construction typically employs three types of adhesive.

Two-part epoxy is used where strength is important. Five-minute epoxy is great for parts that require strength but little alignment time, such as aileron-servo mounts. A 12-minute epoxy is best if some alignment time and extra strength are required. This adhesive is used for stabilizer and vertical-fin attachment. Use 30-minute epoxy if maximum strength is required, as when joining wing halves.

There *is* a difference in the final bond strength between the different epoxies when they are used on porous surfaces such as wood. The five-, 12-, and 30-minute epoxies seem to have the same final film strength, but a longer "dry" time (epoxies bond chemically—not through evaporation) results in better adhesive penetration into porous materials. The deeper the penetration, the stronger is the total final bond strength.

For some reason—possibly lower solids content—the typical two-part epoxies in hardware stores do not always have the strength of epoxies that are meant for model construction. Past experience has shown me that the epoxies sold in various hobby outlets are usually best for ARF construction.

The various cyanoacrylate-type adhesives are important in ARF assembly. The thin variety is used for hinge installation, and medium consistencies are used for most other construction steps. A small bottle of cyanoacrylate accelerator is handy for bridging gaps or building reinforcing fillets.

Cyanoacrylate bonds are surface only, making them weaker than epoxy joints. Unlike epoxy, cyanoacrylate does not have much antirotational strength.

Having some old-fashioned yellow aliphatic-resin glue—ol' reliable carpenter's glue—helps construction. Carpenter's glue penetrates like epoxy, forming a strong bond in wood only. It's not as strong as epoxy, but this one-part adhesive is easier to use; no mixing is required. In areas that require strength and alignment time but with room for tack-gluing the pieces in place with thin cyanoacrylate, carpenter's glue is a good alternative.

Aileron is deflected 45°-50° during installation. Larger deflection allows flaperon use but causes unacceptably large 1/16-inch gap between wing's TE and aileron. This must be fixed.

Use trim iron to adhere covering's center first. When affixing two sides, avoid reheating center; it could cause covering to shrink and lift.

Seal top edges of covering with regular covering iron as shown.

If servo remains in place without being held, the opening is too small. Expand opening by sanding, frequently checking fit.

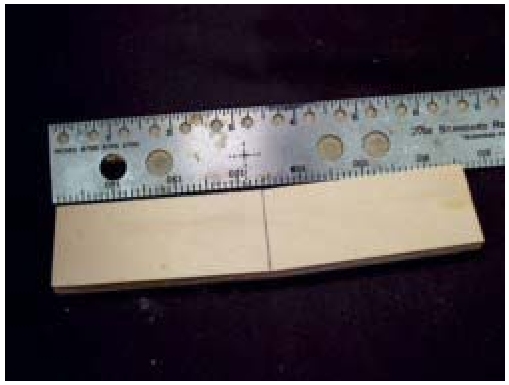
Tools and Building Order: In addition to adhesives, you will need a flat, level work surface that is at least 6 feet long and 2 feet deep. Basic tool requirements include a hobby knife, a supply of sharp No. 11 hobby-knife blades, at least one 1/2-inch-wide hobby chisel-blade knife, epoxy application brushes, 10 clamps (black steel binder clips work well), a combination square, and a hobby iron and trim iron meant for applying plastic film coverings.

Performing a few modifications requires wood, an extra servo, new nose gear, and a few other items I'll outline later.

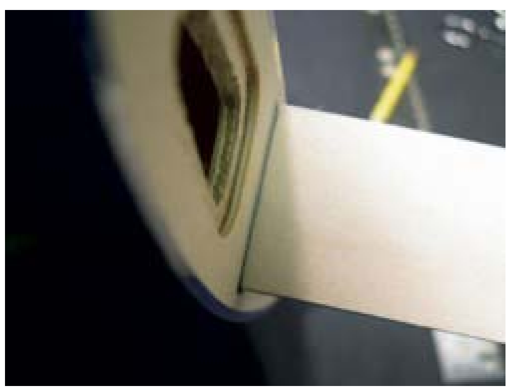
A photo shows the Hobbistar 60 Mk III as it comes out of the box. There are many more parts here than in an RTF kit. The major surfaces are prebuilt and precovered, but who is going to put all these little components in place? Small pieces are taped to the wing and fall off when the tape is removed. That doesn't happen with RTFs!

Yes, RTF models can spoil us. But ARF construction is easier than it looks, and it's more fun than RTF assembly.

A good place to start is the wing. A completed wing is required before you align and mount the tail surfaces onto the fuselage. Mounting one aileron servo and constructing simple aileron control rods is good practice for completing the more complicated triple-servo and control-rod installations that the fuselage requires.



Measure and mark spar's center. It should align with "V" shape. If not, use "V" as center—not your mark.



Centerline should match wing rib from top to bottom. If not, make sure spar is firmly against bottom of spar box and recheck.

Let's start building. As with all modern ARFs, the Hobbistar's photo directions are amazingly complete and contain many helpful tips. But since this article is meant to illustrate ARF assembly, I'll repeat some of them.

Assemble the wooden wing spar. Most ARF wing spars are two to three laminated pieces for extra strength. The Hobbistar uses three pieces. Laminate the pieces together using 30-minute epoxy for maximum strength and clamp in place. The spar assembly is clamped to a large square to ensure that the spar is straight. Getting it aligned and straight is critical for wing-half alignment.

While the spar is curing is a good time to plan wing modifications. As do all ARFs except the Midwest Aerobat, the Hobbistar 60 uses a single servo, mounted in the wing's center-section, for aileron control. That installation is next.

One of the greatest advances in our sport during the last 15 years has been the development of the two-servo aileron control system. I'll cover this installation next month, but I will note any changes required along the way.

The Hobbistar 60 employs Mylar laminate hinges for all control surfaces. Use those; competition experience has proven them to be reliable and durable.

Test-fit the hinges into the aileron and attach to the wing. Mark the center of each hinge on the wing and aileron. Drill a 3/32-inch hole at "hinge center" in the wing's TE and the aileron. This hole allows the thin cyanoacrylate to reach every part of the hinge.

Before attaching the aileron, remove enough wood from around the torque rod at the wing's center-section that it can move approximately 70i in each direction. Place two pins in the center of each hinge to ensure hinge alignment, and insert the hinges back into the aileron.

Put five-minute epoxy *inside* the aileron's torque-rod hole and along its rod channel. Bevel the aileron's rod channel near the hole, making room for the rod's curve as it makes the 90i bend. This allows the aileron to fit tightly against the wing's TE. This is important, as you will see later.

Putting epoxy inside the aileron torque-rod hole reinforces the balsa. Without epoxy, the metal rod gradually crushes the surrounding wood. The aileron then loosens slightly, and you start to hear a vibrating sound called "flutter." The ailerons vibrate rapidly, the servo gears strip, and soon you are flying a rudder-only aircraft. This often is not as much fun as it may appear to be.

Once you have applied the epoxy, attach the aileron to the wing. Do not get epoxy inside the hole where the torque rod exits its TE wing bearings. Putting a small dab of petroleum jelly at this point will prevent a problem.

Press the aileron tightly against the wing. Remove the pins and press again. The TE should fit tightly against the aileron. If you plan to use only the center aileron servo, deflect the aileron 30i in one direction while pushing the aileron's center against the wing. Apply a few drops of *fresh* thin (*only*) cyanoacrylate to the center hinge.

Wait 30 seconds, move to the aileron section near the wing's center, and repeat. Do this for all hinges. Remember to hold the deflection. Turn the wing over and do the same on the other side of each hinge. If you plan to use flaperons, deflect the aileron all the way until its bevel hits the wing's TE. Glue the hinges. Full deflection usually causes a roughly 1/16-inch gap between the wing and the aileron.

Fall Into the Gap: Why so much concern about such a small gap? First, a 1/16-inch hole is huge to an air molecule, and millions of them rush to pass through. As a result, a gap causes air loads to appear, disappear, and reverse direction as aileron deflection and aircraft flight angles change.

A whole book can be written about the effects of control reversal and force/deflection curves. It is beyond the scope of this article, but the result is that aileron flutter is more probable with a large control-surface gap. The airplane is back to flying rudder-only again.

Second, aileron response diminishes. An aileron works by increasing the wing's lift on one side while reducing its lift on its other side. It performs this miracle by deflecting the airstream as it flows over both sides of the wing. If a large amount of air passes through the gap, the aileron does not deflect this air. The less air that is deflected, the slower the aircraft's roll response is to a given aileron input.

In addition, that book on force/deflection curves also tells us that the gap can produce a false aileron effect that acts opposite the real control input. This increases adverse yaw effects.

Third, the wing can experience unequal lift during hard pullouts and maneuvers. If the gap on the left wing is larger than the gap on the right wing, more air passes through the left side, resulting in more lift for the right wing. This usually happens only on hard pullouts and results in a left wing drop.

Fourth, different roll rates, right vs. left, can result if the gap sizes are different; each aileron's effectiveness varies by its gap size and "false aileron" effect.

None of these results are positive. Tests with RC Precision Aerobatics (Pattern) competition aircraft have shown that all of these effects are present even when the gap is so small that it is *nearly invisible.*

If any size gap can be problematic, eliminate it. Heat up your model covering trim iron. Cut a 11/2-inch-wide piece of heat-shrink plastic model covering that is the same length and color as the bottom of the aileron and wing. Fold a sharp crease in the middle.

Deflect the aileron as much as possible and insert the folded covering into the bottom aileron gap. Using the trim iron, adhere the creased area. Do the aileron side followed by the wing side. Trim the excess at the top of the gap, and seal the top edges with a normal covering iron. Voilà! The aileron gap is history.

Sealing all the gaps is a secret that competitive pilots and professional builders have known for many years. Try it on all of your sport aircraft. You may be surprised when that sluggish roller that pulls too hard to one side with hard up-elevator transforms into a respectable aerobatic sport machine with great slow-speed handling.

Lifting overlapping covering and trimming it back strengthens wing's center joint by allowing full wood-to-wood contact.

Twelve- and 30-minute epoxies, mixing cups with epoxy brushes, and low-tack masking tape with elasticity glue will be needed to glue wing halves together.

Stretch the tape while applying it. Tape both sides of the wing. The rear clamp ensures TE alignments.

All Together Now: With mounted ailerons and sealed gaps, it is nearly time to join the wing halves. Trial-fit the servo into each wing half. Lightly sand the wood edges until it fits. Remove the servo.

Find the wing spar you made at the beginning of the building process. Draw a centerline on the spar; it should match the "V" of the spar. Insert the spar in both wing halves. Lightly sand the spar if required, but a snug—not tight—fit is desirable. Keep the sanding to a minimum. The centerline should match the center rib on both sides.

Trial-fit all spar and wing halves together. The wing's LEs and TEs should align with minor hand adjustment. If one LE is more than 1/16 inch forward of the other, the spar was not laminated straight. A new spar will have to be made, so make sure it is straight during construction.

If all pieces line up, separate them for one final step. Using a 1/2-inch chisel blade, gently raise all of the overlapping covering material from inside each wing half's center-section. Use a sharp #11 modeling blade to cut away the excess covering.

Even though the plastic covering is thin, two layers will separate the center wood ribs, weakening the all-important center joint. Covering removal allows full wood-to-wood contact, providing a strong center bond.

A photo shows everything you will need to assemble the wing halves. The blue tape is 3MÕs low-tack Painters Masking Tape. The low tack protects the covering during removal. Since this tape is slightly "stretchy," it applies a pulling force when properly applied.

Do not join the wing halves if flaperons are to be used. If flaperons are *not* in this aircraft's future, use an epoxy brush to liberally coat the inside of each spar box with 30-minute epoxy. Brush epoxy onto all sides of one spar half. Slide it into a spar box until the centerline matches the wing rib. Brush 30- or 12-minute epoxy (your choice) onto the same center rib.

Good advice is to coat the entire center rib *except the outer 1/16-inch edge.* Epoxy will flow to this area when the halves are joined but will not seep out.

The clock is ticking, so this is not a good break time. Brush 30-minute epoxy onto the remaining open spar-box surfaces and onto all sides of the protruding spar. Do not apply epoxy to the uncoated center rib.

Join the wing halves and use short pieces of tape to hold them together. Adhere one side first, and then pull gently on the tape and affix its other side. This pulls the halves together. Apply tape to both sides of the wing. Doing all of this over a piece of waxed paper prevents you from gluing the wing to the building surface.

The metal sanding block is not just for sanding; it is used as a stand to prop up the "high" wing caused by the wing's dihedral. Once the wing is joined, hold half against the surface and slide the stand under the high wing until it just touches the wing's underside. Make sure the stand is perpendicular to the wingspan.

Apply a clamp to the rear of the wing to make sure TEs align. Check the front LEs to make sure they match perfectly. They should at this point. Any mismatch causes a "warped" wing effect that will be difficult to trim away.

Use 12-minute epoxy on the center rib in case there is a slight LE mismatch. It is possible to correct such a misalignment by holding the alignment in place for a short time. I can hold on for the remaining five minutes required for 12-minute epoxy to harden. I can't do that for 30-40 minutes! Once the overlapping covering is removed from the center ribs, 12-minute epoxy has more than enough penetration and bond strength to do the job.

Once the wing cures, install the center aileron servo. Most ARF trainers use a plywood tray to mount the servo. However, the wing's dihedral prevents the tray from seating flat on the wing. Use the chisel blade or a high-speed hobby drill to gently remove some of the center bulge.

If you use the chisel blade, cut only away from yourself and only toward the aileron opening. Keep your other hand away from the chisel's path, in case it should slip from the wood. Trust me on this or make a reservation at your local ER.

Use five-minute epoxy to glue the aileron-servo tray in place. Mount the servo using the screws provided with the radio system. You may have to trim the center ribs to clear the servo's wire.

The stock Hobbistar 60 aileron linkage uses one clevis attached to a nylon torque-rod control horn. The aileron is aligned using two paint-mixing sticks clamped in place, and the control rod's other end is bent to pass through the servo's control arm with the arm centered. The bent section is then held in place by a nylon clip.

This is fine, but experience has shown that the metal end expands the arm hole after roughly 100 flights. Also, the builder must enlarge the control arm's hole to fit the larger rod. If the hole is made even slightly too large, the ailerons will not be firmly held, with the usual bad results I've already mentioned.

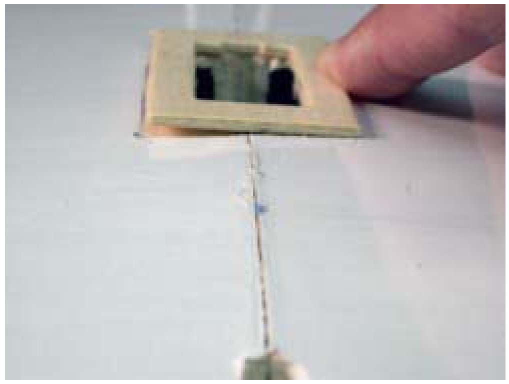
A better linkage system is shown. The control rod is attached to the torque rod's control horn using the standard nylon clevis and then cut in half. Another threaded control rod is connected to the centered servo arm. With the ailerons clamped in neutral, cut the servo's control rod where it meets the first rod. Apply solder flux to both sections and use a Du-Bro solder connector to make the joint. This control system will remain firm and positive during the aircraft's lifetime.

We made several changes to the normal ARF wing construction while building the Hobbistar 60. Some may appear minor while requiring a great deal of work. If so, they are not mandatory and the aircraft performs well without them. However, service life is expanded and flying performance is increased with them. Only you as the pilot can judge their worth.

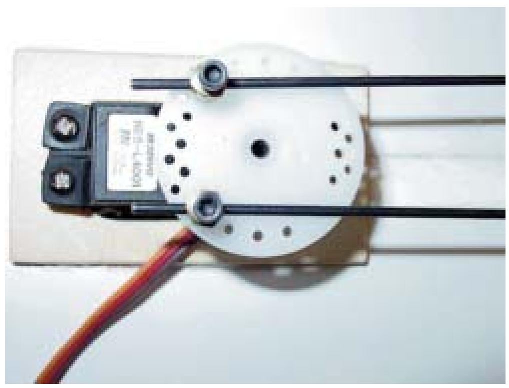
Unless flaperons are going to be used, the wing is finished. Standard construction takes only approximately three hours of work and three more waiting for the epoxy to cure.

You may have noticed a suspicious opening in the wing in a couple of photos. Those are homes for the two aileron control servos required for flaperon use.

Why all the flaperon mentions? Twin aileron servos became useful with the introduction of computer transmitters. Using such a transmitter, a wing in which each aileron is controlled by a separate servo has several advantages.



Right-side linkage is provided in kit but requires expanding servo-arm hole and can enlarge it after extended flying. Twin nylon clevises on left side fit without drilling and never enlarge servo arm's hole.



Some aileron differential can be created using one center servo by mechanically offsetting control-rod connections to arm. But differential is not easily adjusted or trimmed and flaperons are not possible.

Having independent aileron servos allows the pilot to adjust the aileron differential, which is where one aileron moves upward more than the other moves downward. Proper aileron differential improves rolling performance by helping eliminate adverse yaw, which is where the aircraft's nose first moves in the direction *opposite* the intended bank direction when ailerons are applied.

Adverse yaw is most apparent with the flat-bottom wings that are prevalent on basic trainers. Although it is possible to adjust a single servo to provide some aileron differential, that is never as effective as using the transmitter's computer system.

In addition to differential, twin aileron servos allow the ailerons to be used as flaperons, which are ailerons that also deploy downward as flaps. Flaperons slow the aircraft's landing speed while improving low-speed handling.

Flaperons can also be deployed *upward* as spoilers to improve handling in high-wind conditions. Linking the flaperons to elevator input, as in a CL Precision Aerobatics aircraft, also makes for some interesting maneuvers and fun-flying.

With two aileron servos, the control rods connect directly from the servo to the aileron without using torque rods. With sealed gaps and this control system, experiencing flutter is nearly impossible.

Next month I will cover flaperon installation. If you look at one of the photos with a sharp eye, you will spot a groove and a half-moon hole just behind the LE. If rubber bands are not your thing, you will want to learn more about this hole. We will also start fuselage construction next month. ***MA***