Just Aircraft Highlander

The Just Aircraft Highlander is a modern light sport aircraft usually built as a homebuilt. It is a 2 seater with impressive load carrying and short field performance. Visit justaircraft.com for lots of info and pictures of the real plane.

I am lucky that my local RC club's flying field is within sight of the Just manufacturing facility. I asked the folks at Just if they would mind if I modeled their plane. Not only did they say OK but they gave me a tour of the facility and a 3-view drawing of the plane. Just has a landing strip at their factory which is impressive because it is exactly half as long as our RC field and it is on about a 15° slope with a lake at one end and the factory building at the other.

This article describes a 1/7 scale flying model of the Highlander. The model has a 54" span, 26 oz. flying weight, folding wings, electric power, and balsa / carbon fiber / iron-on covering construction. Control is the basic 4 channels plus flaps.

MODEL INFO		PROTOTYPE INFO	
Wing Span	54 in.	Wing Span	31' 6"
Wing Area	355 sq. in.	Wing Area	120.75 sq. ft.
Weight	26 oz.	Weight	1320 lb
Motor	Himax HC2812-0850, 150W	Motor	Rotax 912S, 100HP
lb/hp	8	lb/hp	13 (8 when lightly loaded)
Battery	Thunder Power 1350mA 3S LiPo	Fuel Capacity	18 or 26 Gallons
Covering	Ultracote	Covering	Heat shrinkable polyester
Wheels	2 1/2" standard; 4" optional	Wheels	19" standard; 29" optional
Scale	1:7	Length	19'
CG	1.69" behind LE	Height	7' 10"
Prop	APC 10 x 4.7 electric	Length Folded	20' 8"
Servos	6 Futaba S3114	Width Folded	7' 11.5"
Speed Control	Castle Thunderbird 18	Number of Seats	2
Receiver	Orange RX 8 chan (Futaba FASST compatible)	Number of Doors	2

General Construction

The files to build the Highlander are available for free download on our club website at oconeeeagles.org. These files are:

Highlander plans.pdf – a full size 36” x 52” construction drawing.
Highlander build notes.pdf – this file.
Highlander patterns.pdf – parts that are more convenient to be printed full size on 8.5” x 11”.

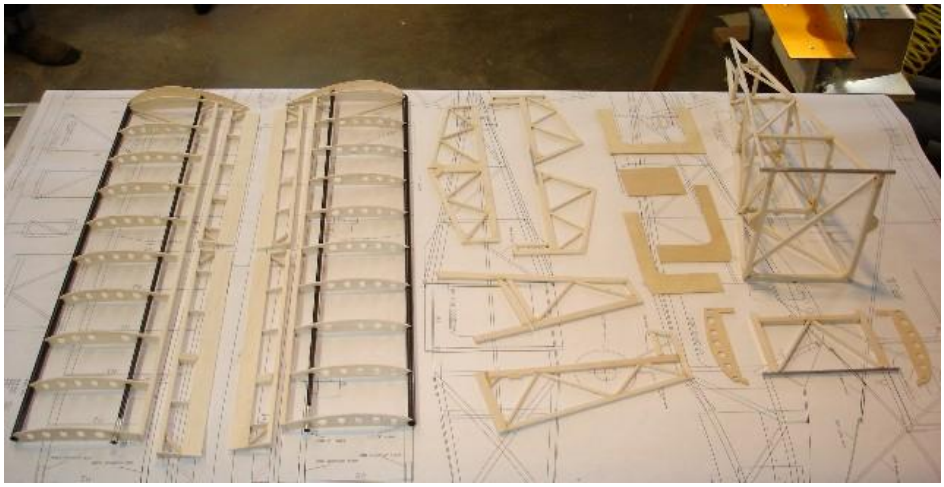
You can get the 36” x 52” drawing printed at a local print shop. To verify that your plans are the correct size, the page format outline should be 35” x 51”.

The drawing makes a few simplifications over an absolutely precise technical drawing; probably the most blatant is that it doesn’t usually use dashed lines to show hidden features.

Most parts are hobby shop stock except the .315” carbon fiber (CF) tube and various thicknesses of aluminum sheet. I got the .315” CF tube from cstsales.com. Unless otherwise specified, material is balsa.

Use a dust mask when sanding CF. Treat it like you would asbestos, for the same reasons.

Wings



Print the rib patterns from the patterns file on a self adhesive sheet (I used Avery Clear Full Sheet Label) and stick the pattern to balsa of the specified thickness. For most parts, I stack 2 layers of wood together with double stick tape to lessen the work and make matching pairs match. Don’t use too much tape with thin balsa, or separating the parts will be tough. Drill the spar holes and the lightening holes before sawing the ribs apart. The location of the spar holes (the ones with crosshairs) should be as accurate as possible, and sized to fit your particular spars. I use a diamond-grit hole saw in a drill press for drilling big holes in thin balsa. Saw the parts out with some margin and sand to final shape.

Glue 1/4” aluminum tubing over the inboard end of the 7/32” CF spar, leaving clearance for the Wing Hinge—Wing to fit into the aluminum tubing. Assemble the wings over the plans. Block up each end of each spar as shown on the plans (see the Wing Construction Detail) to build in washout. I fitted my ribs and spars dry and then flowed thin CA into the joints.

Remove the wings from the plans and sand the outboard ends of the CF tubes at a 45° angle. Glue the R6 ribs to the angled end of the CF.

Add mounting blocks for the servos. If you don't have a radio channel for each flap servo, flip one flap servo over so both flaps will go the same way when you connect the servos with a Y harness, and move the control horn rib in that flap to accommodate the new servo position. Drill holes for the servo mounting screws. I angle these holes so the screws will be accessible from the top of the wing. There are no hatches for the servos, so accessing the servos after the model is completed will require cutting the covering from the wing panel between the ribs over the servo.

Build the flaps and ailerons over the plans. Shape the leading edges to give the required control throws.

Wing Strut Attachment

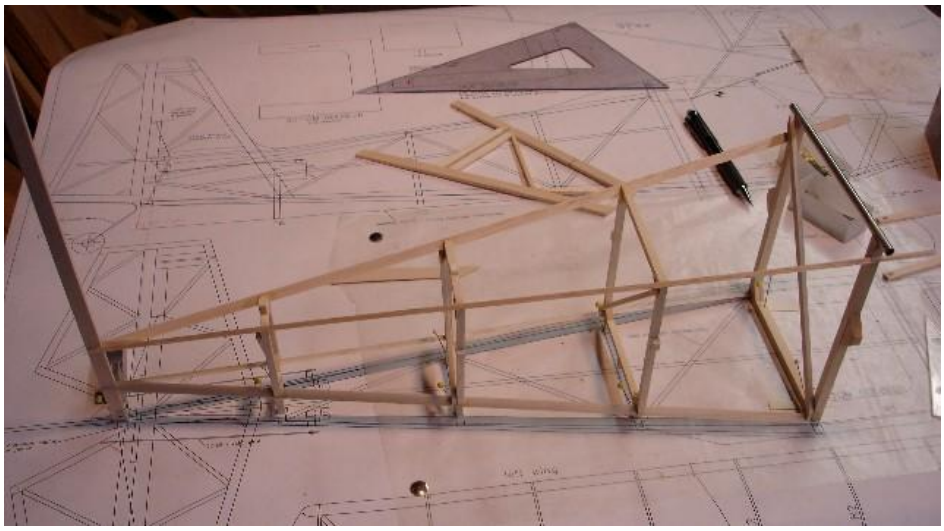
Cut a piece of .025" aluminum .080" wide x about 1.75" long with tin snips. Following the natural curl from the snips, bend this around an appropriately sized drill bit shaft and pinch the free ends together with pliers to form the "tail" for the strut mounting. Trim the tail to about 3/8" long. Open it up enough to slip over the wing spar, with the tail pointing down and toward the fuselage. Build one of these for the fore and one for the aft spar, for each wing. Epoxy these in place at the position specified on the plans.

Horizontal and Vertical Tail

Build the horizontal and vertical tail over the plans. The elevator halves are joined by a piece of 1/8" aluminum tubing.

There are four hardpoints (two in the horizontal tail and two in the vertical tail) for adding a Kevlar thread stabilizer brace. The hardpoints consist of a piece of .031" music wire inserted into a hole drilled from the rear of the part. Poke or drill a pair of cross holes adjacent to the wire to allow the Kevlar thread to wrap around the wire during final assembly. The real Highlander has a second stabilizer brace near the leading edge of the tail surfaces—this could be modeled but is not shown on the plans.

Fuselage



Build the formers F2 – F6 over the plans. Size the 45° gaps at the corners to fit a 1/8" stringer. Note that the legs on F4, F5, & F6 will be broken off after the fuselage is removed from the plan.

Stand F3 – F6 in place over the plan. Stand the vertical tail in place over the plan. Sand 1/8" x 1/4" stringers to fit the vertical tail. Glue the four stringers into the corner notches of F3 – F6 and to the vertical tail, keeping everybody square.

Add the diagonal bracing to the fuselage top and sides (the bottom is done later).

Cut out the Bottom Doubler and two Side Doublers. Glue the left and right Side Doublers to F3, with the plywood curl trying to curl inward toward the nose. Glue 1/4" x 1/4" bottom stringers to the side doublers.

Glue F2 to the Side Doublers and glue the R1's to F2 and F3. Make sure the bottoms of R1 are parallel to the building surface, and make sure the aluminum tubes at the tops of F3 and F2 are parallel to each other and to the building surface.

Build the bottom half of F2 in place: Glue 1/4" x 1/4" vertical members between the fuselage bottom and F2. Glue a 1/4" x 1/4" bottom cross member between these vertical members. Add 1/8" x 1/4" side to side diagonal bracing (see the drawing front view).

Over the side plans, build one left and one right Nose Subassembly. Sand a radius on the Nose Subassemblies where they meet the Side Doublers to allow the Side Doublers to bend inward. Glue the Nose Subassemblies to the Side Doublers, bending the front of the nose subassemblies inward before the glue dries.

Cut out F1 and drill it to fit your motor mount. Glue F1 to the nose assembly and reinforce the glue joints with 1/4" triangle stock. Glue a diagonal brace to the bottom of the top horizontal nose pieces.

Remove the fuselage from the plan. Snap off the temporary legs on F4 – F6. Add the bottom diagonal bracing. Add the spacer to the bottom of F3.

File a notch in the bottom stringers and Side Doublers to receive the Strut Hinge—Fuse. Glue on the Bottom Doubler.

Glue 1/8” x 1/8” stringers from F3 to the tail on both sides, and from F4 to the tail on the top. On the bottom, glue 1/8” x 1/4” stringers from F3 to the tail, from F2 to F3, and forward of F2; this last stringer needs a cross piece to hold it’s front end.

Glue a piece of 3/4” x 1/8” balsa to the bottom cross spars of F3 and F2 for the receiver and battery mount. Extend this as far forward as you can for more CG adjustment range. Use triangle stock reinforcement in the glue areas to support the weight of the battery.

Cut out cowl formers C1, C2, and C3 to the shape in the patterns file, and glue them on. Cut out the cowl top C4 to the shape in the patterns file. Wet C4 until it will bend over the cowl formers, then tape it in place. When dry, glue it in place and trim to shape.

Add 1/8” x 1/4” door frame to the rear and bottom of the door area. Taper these where they meet R1 and the Side Doubler.

Turtledeck

Cut out the Turtledeck Sides to the shape in the patterns file. Glue triangle stock to the bottom edge to make the sides fit against the 45° top stringers. Add front and rear cross pieces and gussets. Add 1/4” x 1/4” catches to fit under the F3 top cross piece.

Build a Turtledeck Latch as shown. The front bearing block is the top cross piece of F4. Glue the turtledeck latch to the F4 top cross piece and the top stringer. Drill a hole in the turtledeck rear cross piece to accept the latch.

Wing Hinges, Strut Hinges, and Wing Sockets

Print the hinge patterns in the pattern file on a self adhesive sheet like we did for the ribs, and stick the patterns to .040” aluminum. Drill the hinge holes as clearance holes for the barrel of a 2-56 T nut—probably 1/8”. Then saw the parts apart with some margin and sand or file to final shape.

Size the Wing Hinge—Wing to fit inside the aluminum tube over the rear wing spar. Size the Wing Hinge—Fuse to fit inside the aluminum tube in F3. Offset the wing hinges up and down so the wing tube and the fuselage tube are vertically aligned (see the Wing Hinge at Aft Strut Detail). Make hardwood spacers to fill the space between the hinge and the inside of the tubing.

Size the Strut Hinge—Wing to fit inside the fore and aft strut tubes. Bend the strut attachment prongs up to match the strut angle.

For the hinge pins, break the spurs off a 2-56 T nut. File the barrel of the T nut to be just a bit longer than the thickness of the two hinge pieces. Put the T nut through the hinge pieces and put in a screw. Leave the screw removable for now, but during final assembly make the screw permanent either by buggering the threads on the screw end or by adding CA to the threads. I did both; it would be bad to loose this screw in flight. If you want to remove the wing after final assembly, you’ll have to twist off the screw and make a new hinge pin for re-assembly.

For the front spar socket, glue a piece of 7/32” brass tubing inside the front spar with 5/16” exposed past the root rib. Double the tubing with a 5/16” piece of 1/4” brass tubing over the exposed end. When the glue is dry, chamfer the front spar socket tubes so the joint can easily be made.

Space the wing root rib 3/8” from the fuselage root rib and epoxy the wing hinges in place. Rotate the wing hinges so the wing hinge pin lines up with the strut hinge pin.

Place the plane upside down with the wing laying on a flat surface. Place a 3/8” spacer under the fuselage R1 ribs with the wingtips still against the surface to set the dihedral. Make sure the leading edge

of the wing is straight and perpendicular to the fuselage (make sure the wingtip to tail measurements match from left to right). Then cross drill the socket tubes to accept an .042" x 1" hitch pin to hold the wing in position. Drill so the hitch pin is inserted from the front.

Leave the wing in this alignment for the next step.

Wing Struts

Bend the tail of the Wing Strut Attachment to point toward the strut hinge by placing a piece of 1/8" brass tubing over it as a bending handle and guide.

While the wing is still in alignment from the previous step, cut the fore and aft CF wing strut tubes to fit. The inside of the fore strut tube will fit over the Wing Strut Attachment. The aft strut tube butts end to end against the Wing Strut Attachment. Cut a piece of 5/32" aluminum tubing to slip over this joint to reinforce it. Don't glue the struts till final assembly.

Radio Gear

Mount the receiver and battery to the mounting platform using Velcro. Leave room to shift the battery to adjust the CG.

Mount the motor to the firewall. Mount the speed control where convenient. Mine is Velcro'd to the Side Doubler.

All 6 servos need extensions. Depending on the number of channels and programming flexibility of your radio, you may need Y connectors for the aileron servos and/or the flap servos. Five channels would be the minimum radio, and seven would let you avoid both Y connectors.

Landing Gear

Make LG Brackets by folding .062” aluminum around .078” music wire as shown in the drawing.

I have never had success getting music wire to stay soldered so I made this landing gear with all the solder joints to brass tube. This is the Tubing Tree in the plans. Cut 3 pieces of brass tube which just fit over the landing gear wires and silver solder as shown in the plan.

Place the LG Brackets and Tubing Tree over .078” music wire and bend the wire to fit the Main LG Strut in the drawing. The lower bend holds the Tubing Tree in position.

Bend .062” music wire to fit the Back LG Strut in the drawing. Size the loop to clear a #4 screw. I had to heat the wire with a propane torch to bend the loop without breaking. Slip the wire into the Tubing Tree and bend the end to hold it in place.

Bend .031” music wire to fit the Bungee Strut in the drawing. Slip the wire into the Tubing Tree and bend the end to hold it in place.

Place a #2 washer on the landing gear as the inner wheel thrust bearing. Put the wheels in position and hold with wheel collars. I used a piece of nylon pushrod for a bushing between the wheel and the axle, but this will depend on your wheels.

Add a rubber band as shown in the drawing. This should be a pretty stiff rubber band, and if it bends the wheels past horizontal when not on the ground, this is prototypical.

Bend the tail wheel bracket from .047” music wire as shown in the drawing. Install the tail wheel to the bracket and secure with a wheel collar.

Covering

I covered my model with Ultra Cote, but a lighter weight material could be used. The frame is strong enough to hold Ultra Cote shrunk with an iron, but I would avoid using a heat gun for fear of distorting the structure.

The wing servo installation requires a particular covering order: Cover the bottom of the wing and shrink the covering. Cut slots for the wing servo arms. Install the wing servos and run the servo wires. Then finish covering the wing.

Similarly on the tail servos: Cover the bottom and sides of the fuselage and shrink the covering. Cut the slots for the servo arms and install the servos. Then finish covering the fuselage.

Glue the tail wheel landing gear to the rudder and add some fiberglass reinforcement to the joint before covering.

Cover the other parts.

The decal in the photo was homemade on an ink jet printer.

Windshield & Doors

Cut the windshield, doors, and turtledeck skylight from .015" clear polycarbonate to the shapes in the pattern file. Cut the doors so the natural curl of the polycarbonate stock (if present) will tend to hold the middle of the door against the fuselage when the door is secured at the top and bottom edges. This curl will be opposite on the left and right doors.

Lightly crease the doors to bend out in the middle.

Cold form (bend) the windshield so the bend at the windshield edge does not put so much strain on the glue joint.

Install the windshield with canopy glue at the tops of F3 and R1 and the front sides of F2. I held mine in place with transparent tape while the glue dries, taping the rear of the windshield skylight to F3 and the front sides of the windshield to F2, and the tape is still in place. I originally tried just the tape, but the skylight is a stressed member and the tape failed.

The doors open by hinging upward. Using transparent tape, tape the top edge of the door to R1. Add small patches of Velcro at the bottom edge of the door and door frame to hold the door closed. Add another small patch of Velcro at the bottom edge of the door and the wing leading edge to hold the door open.

Glue the turtledeck skylight to the turtledeck with canopy glue.

Cowl

I formed the cowl with 2 layers of Tyvek envelope material and fiberglass resin. The form was made by adding Styrofoam blocks to the front and bottom of the fuselage and sanding to shape. Then the nose was covered with a balloon. I used the special latex balloons like you get in the family planning section of the drugstore. These come with mold release compound already applied, and they don't neck down at the opening. Apply the Tyvek or fiberglass and resin. Then stretch on another balloon.

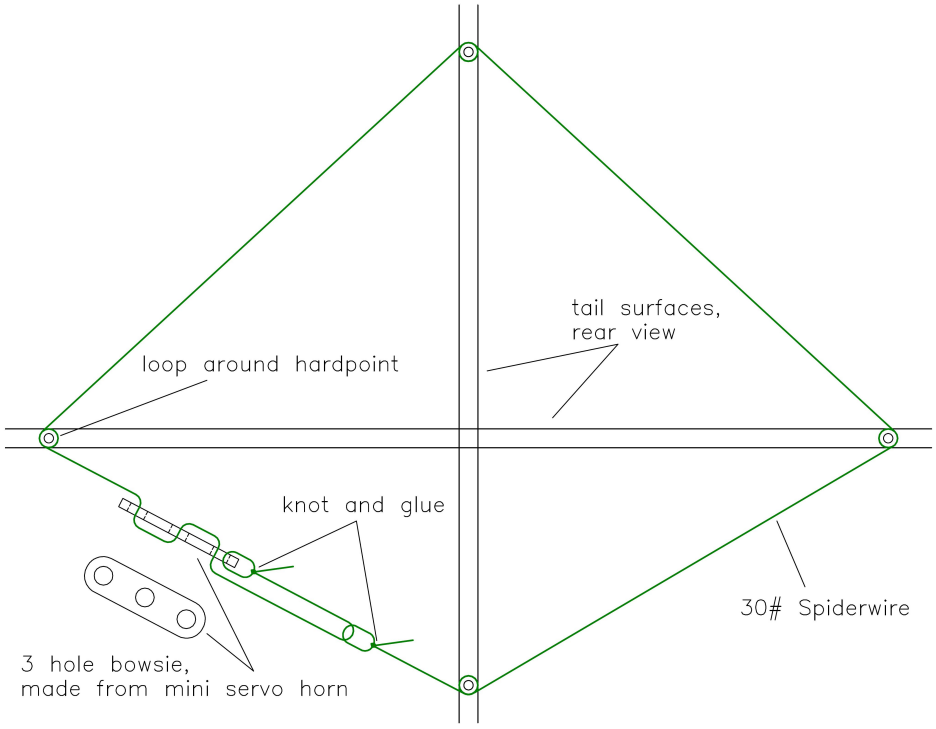
After the resin dries, a shot of compressed air will help get all this off the nose of your plane. Then finish the cowl. I covered mine with covering (as opposed to paint) but trapped air bubbles mar the finish.

Final Assembly

Attach the wings to the fuselage. Glue the wing struts in place.

Notch the vertical tail so the elevator will go up and down. Glue on the horizontal tail.

Tie on the stabilizer brace. I used 30 lb. Spiderwire fishing line (which we can't call Kevlar because it's the wrong brand). Loop the line once around each of the 4 hardpoints installed in the tail. I used a 3-hole piece of miniature servo horn as a bowsie (tightening device) to keep the line taught, and I added a speck of CA to the bowsie to keep it from slipping under load. You may need to thread your line through more or fewer bowsie holes to get the friction right for your setup.



BOWSIE RIGGING

Mount the control surfaces, control horns, and linkages. Install the landing gear using #4 hardware. Install the cowl, prop, turtledeck, etc.

The battery is put in through an open door. This position is not ideal for keeping out of the prop arc when connecting the battery, but it can be done.

CG & Control Throws

Shift the battery to set the CG to 1.69" behind the leading edge.

I copied my control throws from the Just build manual. This gives plenty of control authority.

Rudder	28° left, 28° right
Elevator	28° up, 28° down
Aileron	30° up, 30° down
Flap	40° down

Folding the Wings

To fold the wings: raise the flaps, remove the turtledeck, pull the hitch pins, and fold back the wings—same as the prototype Highlander.

Binding in the wing sockets can be relieved by judiciously bending the F2 aluminum tube end using a piece of brass tubing as a handle.

Flying

It's not super aerobatic, but the model is a blast to fly. It will take off in about two plane lengths with half flaps. It does not quite have the power for unlimited vertical, but will climb at a steep but slow rate that looks just like a Highlander. Flight times are about 15 minutes on a 1350mA battery.

It requires a lot of right rudder in a steep climb. If this is not what you want, build it with a couple of degrees of right thrust in the motor mount.

While it will fly in some wind, the model is too light and too slow to handle wind well. At least crosswind landings are no problem—just point it into the wind and land across the runway.

Takeoffs and landings are easy with or without flaps. I usually use no more than half flaps on takeoff.

Ground handling is very good. There is very little nose-over tendency, even in high grass. If the grass is too high, it just won't go (that's when you should consider swapping to 4" wheels to become a real bush plane). If your thumbs are familiar with taildraggers, there are no ground loop problems. The bungee cord landing gear is reasonably strong, but I have had to straighten it a few times. Go to a larger diameter Main LG Strut and tail gear if this is an issue, but there will be a weight penalty.

Aileron rolls and inverted flight are awkward, and it won't do a snap. Loops, hammerhead turns, and spins are good. But short takeoffs, steep landings with full flaps, slips to landing, and slow flybys (in other words, flying like a Highlander)—that's what it excels at.

I would like to hear from anyone who builds the model or has feedback on the plans.

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Walhalla, SC
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Revisions

R1 5/24/11. Initial release

R2 6/5/11. Radio Gear—moved speed control.
Windshield & Doors—glued on windshield.
Final Assembly—added Bowsie Rigging diagram.