CRUSADER II (Reprinted from the November 1988 issue of RCM) #1030

By Steven J. Ellzey

Leave an aerospace engineer alone with enough balsa wood in a warm dry place long enough and strange things are likely to come out, or at least that seemed to be the opinion of most people at the flying field when the Crusader II first showed up. To date, it has been called everything from an Air-Florida Concord to a violation of the ABM Treaty. In reality, it is just a good flying sport airplane that looks just a little bit different. Okay, it looks a whole lot different, however, it is a good flier.

The Crusader II was designed to be a very maneuverable airplane with good stability. The combination of the coupled canard and elevons, a fairly light wing loading, and the vortex generating system gives the Crusader II lots of control power in almost any attitude you can put it in. This allows for a bit of freewheeling abandon while flying. Since the airplane has a fairly light wing loading, low speed flight is very smooth and landings can be very easy.

All of my prototypes used a tuned pipe which runs through the nacelle on the bottom of the fuselage. The pipe is not really needed since the plane is light enough to fly very well without it. But, if you want the full barnstorming performance the Crusader II can deliver, go with a pipe. You may need to modify the nacelle to accommodate the size of your exhaust system. If your pipe is larger than the one I used, you may need to make the nacelle larger. On the other hand, if you use a Magic Muffler, or something similar, you may want to make the nacelle smaller or even leave it off altogether, especially if you use a standard muffler with an upright engine.

If you have never used retracts before, now is a good time to start. Since the wing is built in one piece, it is very easy to install the main gears and hook them up. Since the top of the fuselage is removable, the nosegear installation is a snap. You will notice on the plans that the main gear is a Goldberg Twin-gear, not the tri-gear. This is necessary because the Center of Gravity is too far forward for the tri-gear to fit in the wing. I found this out the hard way on the first Crusader II. With the tri-gear mains as far forward in the wing as they would go, the wheels were still several inches behind the C.G. which made for anything but pretty take-offs and landings. Use the Goldberg retractable Nose Gear up front.

Well, if you are ready to fly something that will do what you tell it to do when you tell it to do it, break out the balsa wood and the knives and start building.

CONSTRUCTION

Wing:

Start the wing by cutting out all of the ribs and their doublers. Rib 2 is the busiest of the ribs, it has a 1/16" plywood doubler from the leading edge to the main spar, a 1/4" balsa doubler from the main spar to the sub-spar which has a control cable housing running through it for the rudder. The two sub-ribs which form the cutout for the prop and the stand-off ribs which form the cutout for the vertical fins and the sub-fins are also part of rib 2. Laminate all of rib 2 together, except for the stand-off rib, making sure that the control cable housing is installed first. Rib 3 should have its plywood doubler glued on at this time, also. Next, cut the main spars from 1/8" x 3/8" spruce and splice them together in the center with 1/16" plywood; remember that the plywood goes on the top of the lower spar and on the bottom of the upper spar. Pin the lower spar over the plans and glue the ribs in place; you will need to trim the notch for the spar in the ribs to match the sweep of the spar. Make sure at this point that the number 1 and 2 ribs are in straight. Glue the 1/8" balsa shear webs in place, grain vertical. Trim the shear webs flush with the spar notch in the ribs and then glue in the upper spar. The leading and trailing edges are made from 1/4" sq. balsa, the trailing edge runs from the center of the wing to the number 6 rib, and the leading edge runs from rib 2 to rib 6. Make sure that the leading and trailing edge of the ribs are trimmed to the proper angle, to match the sweep, and then glue on the leading and trailing edges.

After everything has dried, sand the leading edge flush with rib 1 and 2 and glue a piece of 1/4" balsa across the front of the wing. Now glue in the sub-spar and the number 1 sub-ribs. Next glue the number 2 stand-off rib in place, making sure that there is a 1/4" gap between it and the 1/4" doubler. After this has dried, sand the leading and trailing edges to match the contour of the ribs.

Cut the landing gear mounts out of 1/4" plywood and fasten the retracts to them. With the gear as far outboard as it will go, epoxy in the gear mounts and the 1/8" x 3/8" spruce braces.

The bottom of the wing is now ready to be sheeted. Cut out the leading and trailing edge jigs and pin them down to the plans so that they overlap the leading and trailing edge by 1/8". Glue several sheets of 3/32" balsa edge to edge to get the proper width. In order to get the sheeting to go down properly, it will be necessary to cut a small V in the sheeting at the center of the leading edge. Lay the sheeting over the jigs and test-fit the wing to it. Push the spar down to the building surface and check to see that the sheeting is touching all of the ribs; anywhere it does not touch a rib try placing a small piece of soft foam under the sheeting at that point to push the sheeting up to the rib. You will need to make an H-shaped cut in the sheeting for the prop cutout. A chordwise cut is made along the inside edge of rib 2 from the main spar to the sub-spar and a spanwise cut is made to connect the center of the first cuts. After this, it should be possible to pull the flaps you have created up to the sub-ribs. After you are happy that everything will go together properly, glue the wing structure to the sheeting with the retracts in place. Put plenty of weight on the spar to make sure that it is pushed down to the building surface and use plenty of pins to hold the leading and trailing edges to the building jigs. After the glue dries, trim the sheeting flush with the leading and trailing edges.

Now we will cut out the openings for the retracts. First, an access door will need to be cut out; it should be about 2½" spanwise and 1¾" chordwise. Hold on to pieces you cut out for they will make nice covers for this cutout. Place the wheel on the axle and slide both inward until the wheel is 1/8" from rib 1. With the wheel in place, form a wheel well from 1/16" balsa and glue it in place, making sure to leave some room behind the wheel to allow for springing back of the strut with time. Using 1/16" balsa, build up a well around the strut. Once this has dried, cut out the wing sheeting that is inside of the wells.

As advertised, the retracts are easy to hook up. First, glue in the servo rails and install the retract servo. You will need to cut a few holes in rib 1 and 2 for the pushrods; after that, just follow the directions that come with the Goldberg retracts for the proper pushrod shapes. After you are happy with the operation of the main gear, sheet the top of the wheel and strut well.

The 1/16" shear webs that go between the wing skins are there to help reduce the chance of the wing being damaged due to handling and to keep the skins from bowing while being sanded, plus they do make the wing stronger; thus the little weight

they cost I feel is well worth it. After the shear webs have been glued in place, install the cable housing for the elevons, a tube for the antenna, and remove the sheeting between rib 2 and the stand-off rib.

The wing should now be ready for the upper sheeting. Prepare the upper sheeting like you did the lower sheeting. Now remove about a 2" strip from the center of the sheeting from the spar forward and very carefully drill two holes for the rudder control cable housing. Once you are happy with the fit of the sheeting, place the wing on the jigs and glue the sheeting in place. Make sure to use plenty of weight distributed on the wing and use plenty of pins to hold the sheeting to the leading and trailing edges, and the leading and trailing edges to the jigs. When the glue has dried, trim the sheeting flush with the leading and trailing edge and with rib 6. Also, trim the sheeting flush with the trailing edge of rib 1 and the leading edge of the sub-ribs.

Glue a balsa block to each tip that is large enough to form the tip from, then carve and sand the block to shape. The leading edge should now be sanded to shape; notice that it transitions from a sharp edge at rib 2 to a round edge at the tip. Glue a piece of 1/4" sq. to the leading and trailing edges of the prop cutout and sand these to shape.

From 3/32" sheeting cut four pieces to the shape of the elevon. Glue a piece of 1/4" sq. to the leading edge of two of these. Using a sanding block, sand both the 1/4" sq. and the trailing edge of the 3/32" sheet. The sheeting will be sanded to a sharp edge and the 1/4" sq. will be sanded so that when one of the other 3/32" sheets is placed on top it will be the same thickness of the trailing edge of the wing. Now glue on the elevon ribs, just make them over-sized and then sand them to shape once they are in place, then glue on the top sheet. Sand a proper bevel on the leading edge and sand the trailing edge down to about 1/32 of an inch.

Fuselage:

Start the fuselage by cutting the side out from 1/8" balsa and the doublers from 1/16" plywood. Glue the aft doubler in place, then glue the 3/8" triangular pieces in place at the bottom edge. Locate the 5/32" hole for the canard pivot on the forward doubler and drill this before gluing this doubler in place; after the doubler is in place, drill through the balsa fuselage side also. Cut the bulkheads out of 1/8" balsa, and the firewall and nosegear/canard bulkhead from 1/4" plywood. Pin one of the fuselage sides down and shim up the nose 1/2 of an inch. Glue all the bulkheads in place except for the nosegear/canard bulkhead and epoxy on the firewall. Make sure that the fuselage side is pinned down to the building surface at F2. When the glue has dried, glue on the other fuselage side. When this has dried, glue in the 1/4" x 1/8" balsa braces on the edge of each bulkhead.

The canard pivot is made from Du-Bro nosegear hardware. Drill the nosegear/canard bulkhead for the pivot blocks screws and the nosegear retract, notice that the nosegear is on the right edge of the bulkhead. This is done to give room for the steering arm. The retract itself is spaced 1/2 an inch off of the bulkhead with four pieces of 1/4" plywood. With the retract and the pivot blocks in place and the axle on the strut at the right length, put the bulkhead in place and then insert a piece of 5/32" music wire through the fuselage into the pivot blocks and back out the other side, then set the fuselage upright on the building surface and block the axle up 1". You will need to make a hole in the bottom of F2 to clear the strut. With the bulkhead in this position, epoxy it in.

The top of the fuselage is made of 3/32" balsa which is rolled in to a 3" diameter cylinder. You will probably find it necessary to glue two sheets together to get the proper width. Once this is done, wet the wood and roll it around a cylinder about 3" in diameter (I used several cans of spray paint), and let it set to the side to dry. Cut from 1/8" balsa the straight sides of the top, notice from the cross sections that the top edge of this piece is beveled. Mark the position of the top of the bulkheads on these pieces for the aft section of the top and then glue top bulkhead pieces in place for the aft section. Glue the 1/32" plywood alignment tabs in place aft of bulkhead 2, every other one attaches to the fuselage and the others attach to the upper fuselage. Put the upper aft fuselage in place, then pin the second upper piece or F2 in place and glue the side pieces to it, being careful not to glue the forward and aft sections together. Now glue in the upper piece of F1. Remove the forward section and then cut a 23.5" length of the pre-rolled 3/32" balsa, and with the aft upper section in place, glue the sheeting on. This is done in this manner to prevent the upper fuselage from warping. When the glue is dry, remove the aft section and sheet the forward section in the same manner. When everything is dry, sand the rolled sheeting flush with the sides and with F2, then with both sections in place, glue the two F2's together.

The upper fuselage is held down in two places, just behind F2 and F5. Section A-A shows how the upper portion of the hold-down is made. It is just two pieces of 1/4" balsa glued together and sanded to match the curvature of the rolled sheeting, these are glued in with a piece of 1/16" plywood glued to the bottom. The aft hold-down is glued to the firewall. The best way to attach it is to put the top on, turn the fuselage upside-down, then lay the 1/4" plywood hold-down on top of the 1/16" plywood piece, then epoxy it to the firewall. The forward hold-down is held in place by a 1/16" piece of plywood glued to F2. After the hold-downs are in place, drill through the fuselage top down in to the 1/4" plywood with a 1/16" drill; then, using your fingers, drill the hole big enough for the head of a #2 wood screw in the balsa.

The bottom of the fuselage is sheeted with 1/8" balsa with the grain running the length of the fuselage. Before gluing this sheet on, cut an opening for the nosegear in it.

With the upper fuselage in place, make sure that all of the sheeting is sanded flush with F1 and the firewall. Remove the upper fuselage and glue a balsa block to the nose and rough shape the nose.

Now it is time to fit the wing and the fuselage together. Trim the wing sheeting on top flush with rib 1 back to the main spar. Cut some holes in F4 for the control cables and trim the 1/16" plywood fuselage doublers to clear the control cables and the retract pushrods and servo mounts. Now, push the fuselage doublers into the wing so the bottom of the firewall is touching the upper wing skin, then draw a line around the back of the fuselage on the wing. Remove the fuselage and cut away the wing skin inside the line. When you reassemble the wing and fuselage, the bottom of the firewall should touch the main spar. When you are happy with the fit of the wing and fuselage, epoxy the plywood doublers to the number 1 ribs, and the bottom of the firewall to the main spar. After this has cured, epoxy in the 1/4" sq. plywood braces up against the firewall and the plywood doublers.

Now is as good as any time to hook up the nosegear to the retract servo, this is a long run so you will need to brace the rod to prevent it from bending in several places. Build a well around the gear out of 1/16" balsa. If you want to get a little sporty you can add a nosegear door. The plans show how I have done it. The idea is for the strut to pull up on the piece of music wire on the way up which, in turn, pulls the door up; when the door goes past center, the music wire should force the door closed. The shape of the wire shown is only a starting point, you will probably need to play with it a little to make it work.

Leading Edge Extensions (LEX):

Cut from 1/8" balsa the LEX rib, which is glued to the side of the fuselage in front of the wing with the bottom of the rib 3/32 of an inch above the bottom of the fuselage. Next, on a piece of 1/8" balsa, trace the outline of the leading edge. Draw another

line 3/32 of an inch inside of this line and cut this out. Glue this piece, centered, on the leading edge. Out of 3/32" balsa cut out the LEX sheeting and glue it in place such that it is up against the two 1/8" pieces. With the top and bottom in place there should be a gap between the free edges. From 1/32" plywood cut out the LEX edge. Glue a 1/4" balsa strip to each side of the plywood. Now, keeping the plywood edge centered between the 3/32" sheeting, glue the edge in place. When dry, sand the edge down to the plywood.

You will notice that the wing and the LEX meet at an angle, this is smoothed out by puttying that junction along with the junction between the bottom of the wing and the fuselage.

There is a fillet between the wing/LEX and the fuselage. Cut a piece of 1/4" triangle stock to length and point its ends, then glue it in place in the wing/LEX corner. Now, use putty to create a smooth radius fillet (I use micro-balloons and resin).

Nacelle:

The purpose of the nacelle is to house the exhaust system. If you plan to use a muffler on an upright engine you can skip this section, however, it should be possible to put the muffler in the nacelle.

The first thing you need to do is to determine what angle your engine needs to sit at. This angle should put the end of the exhaust header on the centerline of the plane. After determining this angle, drill the firewall to accept the engine mount at this angle. Now remove whatever wing skin you need to clear the cylinder head and the header, then, using 1/16" balsa, form a passage around the cylinder head and header.

From 1/8" balsa cut out the nacelle sides. Notice on the plans where the bend lines are on the nacelle sides; on the inside, cut about halfway through on these lines. Draw two lines, each 1" off of the centerline, or however wide the nacelle needs to be for your pipe, on the bottom of the fuselage and wing from the back of the nose wheel well to the prop cutout. Glue the side in place from the vertical bend line back, so that the outside edge of the side is on the line. Then pull the front of the nacelle sides towards each other so that they are 1" apart, then glue the front of the side pieces down. If you look at the nacelle from the front you will notice that the inlet does not look square, so pull the lower edges of the inlet together until it looks square, then run some super glue into the bend lines to hold the proper shape.

For the nacelle cover, cut from 1/8" balsa the temporary formers and two strips 1/4 of an inch wide and the length of the nacelle; these strips will be the sides of the cover. Tack glue the formers to the sides. From 1/4" balsa cut two strips 13/16" wide and the length of the nacelle, sand the edge so that it will butt up against the 1/8" side when it is put in place. When this is ready, glue the 1/4" balsa to the 1/8" side and tack glue it to the formers. Now set the cover in place and cut off the ends at the vertical bend line. Sand the end of the pieces you just cut off so that they will match the angle of the inlet, then glue them back on. Sand the bottom of the cover flat, mark a point 6 inches back and sheet the bottom from this mark back with 1/4" balsa. Sand the front of the cover flat at an angle so that you have a sharp edge at the front, then sheet the front with 1/8" balsa. Now sand the cover to a round cross section, then remove the formers.

Glue the 1/32" plywood alignment tab to the nacelle side, then recess the 1/4" x 1/2" x 1/32" plywood plates into the cover side. Then with the cover in place, drill through both the plates and the alignment tab for #2 flathead screws.

At this time build up a small fillet where the nacelle meets the bottom of the fuselage/wing.

Install the engine and pipe at this time and install a tuned pipe mount (Dave Brown Products makes one that works well here). Cut a 2" length of 1/2" brass tubing and drill a hole in the center of it that the tip of your pipe will go into, then drill a 1/2" hole in the side of the nacelle just at the end of the pipe for the brass exhaust tube.

Canard and Tail:

From 1/16" balsa cut out the canard skins and ribs. Glue the 1/4" balsa spar and sub-spar in place, then put this assembly on the canard jigs like you did the wing. Glue the ribs in place, then sand the sub-spar to match the contour of the ribs, then glue the upper skin in place. Glue the 1/4" balsa leading and trailing edges in place along with the 1/8" balsa tip and sand to shape.

The vertical fins and the sub-fins are made of 1/4" balsa with the grain running vertical. Make sure to include the tab on each of these that goes into the wing notch next to rib 2.

Engine Cowl:

The engine cowl is built out of 1/4" balsa. Start by cutting out the sides and sanding the top edge to the angle shown on the plans, then cut out the top pieces and sand their center edge to the proper angle. Then glue the top and side pieces together. Epoxy a 1¾" x 2¾" x 1/32" plywood plate to the inside center of the cowl. Sand a 10" length of 1" x 1/4" balsa to a triangular shape, then use this to line the inside back edge of the cowl (blunt edge back), and then sand the cowl to shape. With the engine mount in place drill a hole for a #3 wood screw through the top of the cowl and into the engine mount. With the engine in place, mark the bottom edge of the cowl right next to the glow plug, then make a hole large enough for an alligator clip to reach the glow plug.

Canopy:

The canopy is made from an 8" Sig canopy. To shape the bottom of the canopy, wrap a piece of sandpaper around the nose and then move the canopy back and forth on it. Next, wrap a piece of 1/16" balsa around the nose under the canopy and trace the outline of the canopy on it and cut it out. Trim this piece so that the canopy will fit over it. Depending on how you plan to finish the canopy floor, you can glue it on now or wait until after you have painted the rest of the plane.

Finishing:

Unless I have forgotten something, most of the building is finished, so sand everything smooth. Seal and prime the airplane by whatever method works best for you (I used clear lacquer and talc cut down with lacquer thinner over tissue). Hinge and pin the control surfaces, then epoxy the vertical and sub-fins in place. Use some putty to build up a small fillet around the fin/wing junctions. The plane should now be ready to paint.

Once you are finished painting, the canard will be installed. Cut a 6" length of 5/32" music wire and cut several notches in the outer inch of both ends for epoxy to grab ahold of. Install the rod in the fuselage and tighten the setscrews on the steering arm and the wheel collar. Push a fair amount of epoxy into the hole in the canard and put a little on one end of the rod then push the canard in place leaving a 1/32" gap between the canard and the fuselage. When the epoxy has cured repeat the process for the other side making sure that it is aligned with the first.

The radio installation is fairly easy. The rudder servo should go up against the leading edge of the wing in the center of the fuselage with the throttle just in front of it and off to the right. You will need to mount a Du-Bro V-tail mixer to the aileron servo output arm. The aileron servo is mounted in the center of the fuselage just ahead of F3. The elevator/canard servo should be mounted so that the output arm is on the same level as the output of the mixer and off to one side, so that the center

of whichever arm moves aft when you pull back on the stick is in line with the mixer. Connect one of the inner holes in the elevator/canard output arm to the center of the mixer and one of the outer holes, on the same side, to the canard. Set the control throws to those shown on the plans. Initially, set the elevons up about 1/8 of an inch and set the canard to zero. When you pull back on the stick (up elevator) the trailing edge of the canard should go down, and the trailing edge of the elevons should go up. Put the receiver and the battery wherever you need to in order to make the model balance. Now, if you will just install a fuel tank, glue the canopy in place, and make sure that the engine and pipe are fastened in tight, you should be ready to fly.

Flying:

The Crusader II handles very nicely at all speeds, and with the gear sucked up, and with a hot engine, it is capable of rather high speeds.

With two pitch control surfaces it is possible to trim the plane in several ways, however, I recommend the following. With the throttle set around half-power, trim for level flight, then slowly increase power; the nose will probably pitch down. If so, trim some up in the elevons (trailing edge up) and some down in the canard (trailing edge up). Should the plane pitch up, reverse the procedure. Doing this, it should be possible to set the plane up so that it will fly level for a wide range of power settings.

Landing can be very easy, unless you try to land like you would with a conventional plane. The Crusader II likes to land at a fairly high angle of attack, in fact, its approach angle of attack is about as high as most airplane's angle of attack at landing. To set up a landing when you turn on final, start to bring the nose up a little and let the speed drop a little, you may want to carry a little power on approach, but this is a matter of flying style. When you are about 3 feet off of the ground start adding a little power and raise the nose higher, at this point the airspeed should be fairly low and the model will settle down for a nice nose high landing (the angle of attack at landing can be as high as 20 degrees).

One area that some care should be taken is in cross wind take-offs. The Crusader II will tend to weather vane until you have enough speed for the rudders to take hold, and if you have the rudders cranked over hard at low speed when they do take hold, the airplane will try to turn sideways. If you do take off in a cross wind, try starting from the upwind edge of the runway and pointed slightly across; this will allow the model to build up some speed while it is weather vaning and by the time the rudders take hold, you should be pointed down the middle of the runway.

You should find the Crusader II to be a fun and smooth flying model capable of very quick maneuvers. Should you build one I hope you enjoy flying a piece of hi-tech hardware. □

CRUSADER II
Designed By:
Steven J. Ellzey
TYPE AIRCRAFT
Sport-Delta Canard
WINGSPAN
38 Inches
WING AREA
550 Sq. In.
WING CHORD
Root 22"; Tip 7.75"
WING LOCATION
Low Wing
AIRFOIL
Symmetrical
WING PLANFORM
Cranked/Cropped Delta
DIHEDRAL EACH TIP
0 Inches
LEADING EDGE EXT. AREA
58.4 Sq. In.
CANARD SPAN
13.25"
CANARD CHORD
3 Inches (Avg.)
CANARD AREA
32.4 Sq. In.
CANARD LOCATION
Mid Fuselage
CANARD AIRFOIL
Symmetrical

TOTAL AIRCRAFT LIFT. AREA
640.8 Sq. In.
O.A. AIRCRAFT LENGTH
47.5 Inches
FUSELAGE LENGTH
36 Inches
RADIO COMPARTMENT SIZE
(L) 30" x (W) 2.5" x (H) 3"
VERTICAL FIN HEIGHT
13" including Sub Fin
VERTICAL FIN WIDTH
9.6 Inches
VERTICAL FIN AREA
76 Sq. In. Each
REC. ENGINE SIZE
.40 Cu. In.
FUEL TANK SIZE
10 Oz.
LANDING GEAR
Tricycle Retracts
REC. NO. OF CHANNELS
5
CONTROL FUNCTIONS
Elevon/Canard, Rud., Throt., Retr.
BASIC MATERIALS USED IN CONSTRUCTION
Fuselage ..... Balsa, Ply
Wing ..... Balsa, Spruce, Ply
Empennage ..... Balsa
Takeoff Gross Wt. 90 Ounces (5 Lb. 10 Oz.)
Wing Loading ..... 23.6 Oz./Sq. Ft.
Lifting Surface Loading ..... 20.2 Oz./Sq. Ft.