Blackbird XC.3, Part 2

Construction of our Blackbird XC is complete and test flying was successful. Read all about!

The framework

Several pictures of the airframe in various stages of construction were included in the last installment.. A couple of photos of the completed airframe are included in this installment.

Several construction points deserve additional explanation.

Flaps: The flaps are constructed of 1/8th inch square spruce sticks on 1/16th balsa sheet. The outside rectangular frame is just slightly smaller than the balsa framed opening in the bottom of the wing. The flap “ribs” are placed diagonally to provide torsional resistance and prevent warping. A plywood mounting plate was added at the inner end to serve as a mounting point for the control horn. The completed truss framework was then covered on both sides with 1/16th inch balsa sheet.

The method we used for hinging the flaps is rather unique. The bottoms of the wings were turned upward and the flaps put in final position. The hinges were then placed evenly across the front of the flap and their outlines traced. Using the traced outlines as a guide, a Dremel tool with a router base was used to cut away the flap and wing material to the depth of the hinge.

Very small quantities of thin oil were applied to the bearing surfaces of each hinge and the pin removed. The lightly oiled hinges were then strung together with a single piece of music wire.

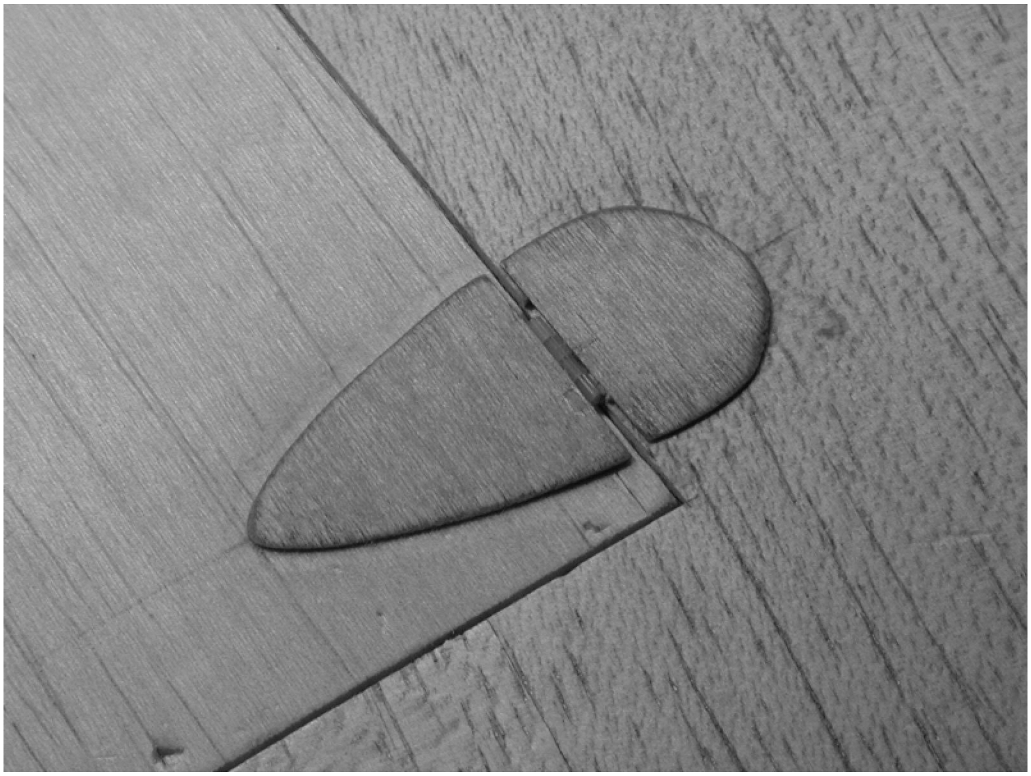
With the flap still in place within its cavity, the hinges were arranged in their shallow wells. The point of a #11 X-Acto blade was used to hold one side of the hinge in place while thin CA was run around the outline. This permanently fixed one half of the hinge. All of the flap side hinges were glued in first while the music wire kept them all in line and the oil kept extraneous glue from sticking to thehinge bearing area. The process was then carried out on the other half of each hinge. Once completed, the hinges were in a straight line and fixed to both the flap and the wing.

To cover the bare faces of the hinges, we used 1/64th inch plywood cut to a rounded airfoil shape using scissors and a couple of aluminum templates. Thick CA was then applied to each hinge half and the appropriate plywood cap glued on - round at the wing, tapered at the flap. The final step was to run thin CA around the perimeter of each hinge cover.

After removing the music wire guide and covering both the interior and exterior flap surfaces, the original hinge pins were reinserted and fixed in place by pushing the extended end into a cut slot. The result is relatively clean from an aerodynamic perspective, and sufficiently solid to withstand both the power of the servo and the expected air loads.

The one thing we now wish we’d done was to go around each of the plywood caps with some spackle to smooth the plywood-balsa interface. As it is, the covering does not fully attach to the wing surface around the perimeter of the cap. No big deal, but in retrospect...

Construction jigs: Since the wing itself has a straight taper, jigs for setting up the wing are simple, despite the fact there’s no flat area on the lower surface of the BW 05 02 09 airfoil. Trailing edge stock serves this purpose extremely well.



Flap hinge in place, 1/64th inch plywood covering applied.

Trailing edge stock was also during the framing of the vertical fin and rudder for the same reason.

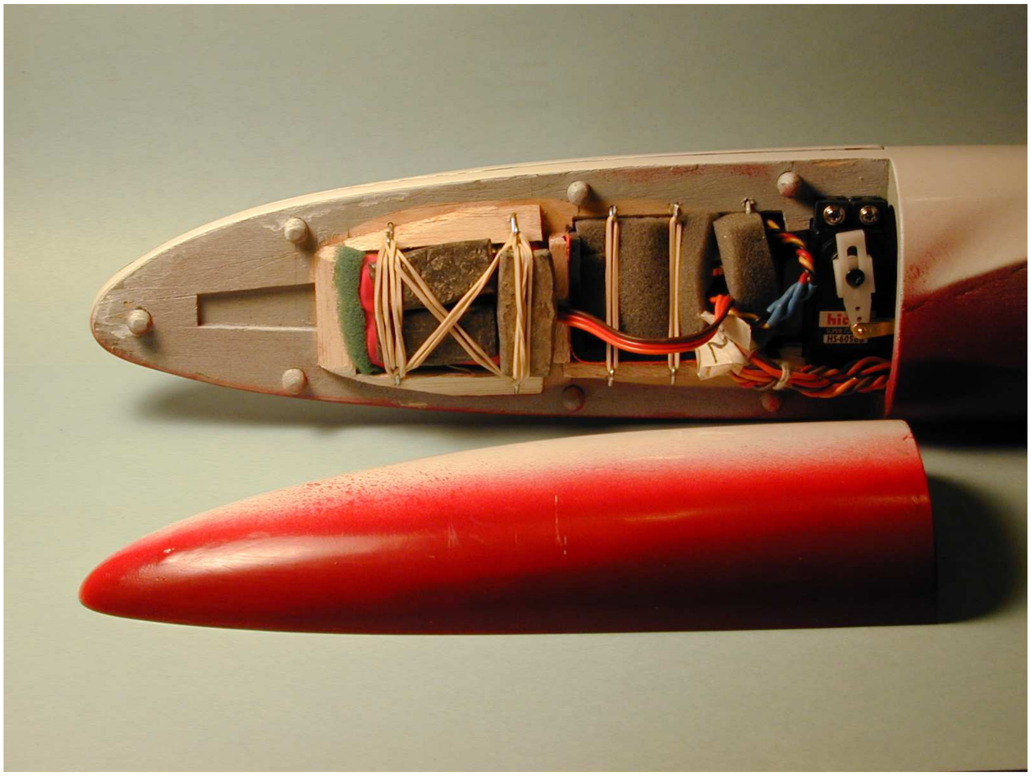
Spar webbing: Another thing we did differently involved the spar webbing. In the past we've carefully cut the plywood and balsa webbing and glued it into the space between the spars. This time we glued the spar webbing to the rear face of the spar caps beginning with the first open bay. The spar webbing in the first bay, were the wing rods receptacles are located, retains the interior webbing equivalent to the original Blackbird 2M plans.

Installing radio gear

We had originally chosen the Hitec receiver for this aircraft, but from the start were not convinced this was the best way to go. After reversing one of the flap servos and being able to use a Y-connector to drive both servos from the throttle channel, we gravitated toward using the FMA Direct M5 because of it smaller size and the confined area in the nose pod. This worked out extremely well. The receiver is well padded in a configured piece of foam, held in place with some small rubber bands. See the included photo. Four of the five available channels are used - flaps are on throttle, there's one elevon on aileron, the other on elevator, and the rudder servo is run off the fourth (rudder) channel.

The battery complement, a four cell 1400 mAh NiCd pack, is held in place with small bands as well.

Servo cables, as mentioned previously, are run through the wing in conduits, and all are twisted to avoid picking up extraneous signals.



Nose cone removed, the layout of the radio gear can be seen: battery pack, with attached lead slugs, M5 receiver encased in foam, and rudder servo.

Our JR PCM 10 was programmed for V-tail with aileron to rudder mixing and flaps on the throttle stick.

Covering

The Blackbird XC we've been flying for many years was finally in need of recovering, so we purchased 25 foot rolls of Ultracoat in red and white. This seems like an awful lot of covering, but we used a bit more than a third of each roll covering that airplane. With sufficient material left over, it was only natural to use the same colors on this new XC machine.

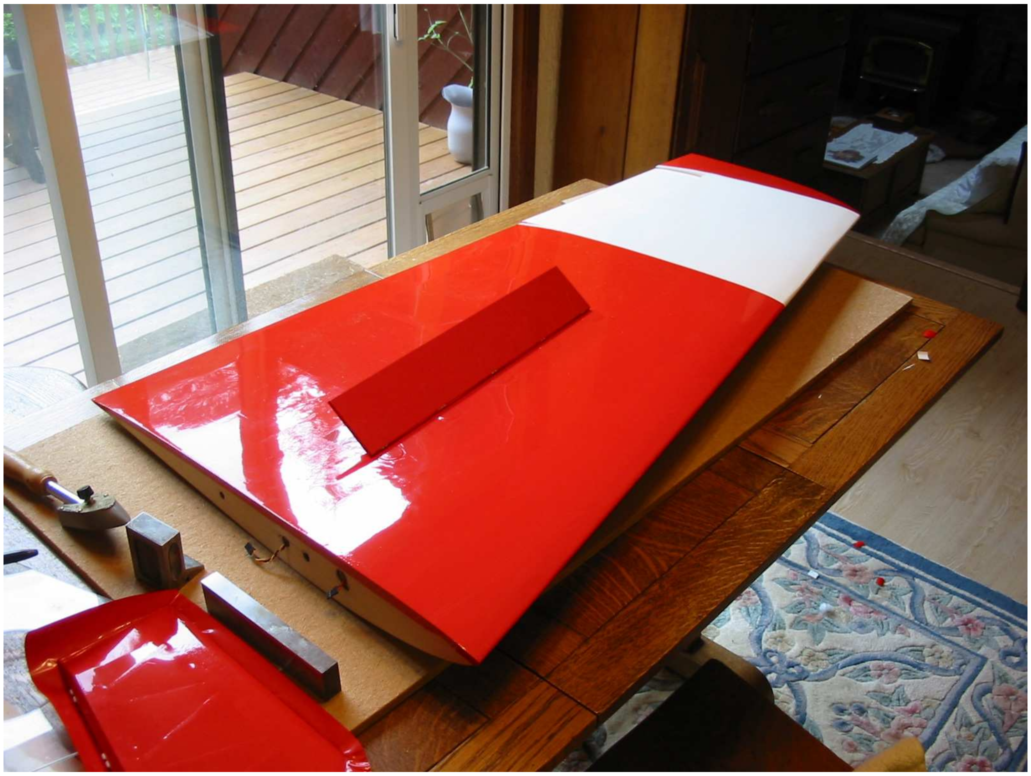
Asymmetry remains and intriguing scheme for us, and we rapidly decided upon a contrasting band around the right elevon area. The final pattern consists of a red band over the top of the wing and a white band along the bottom. This gives a little bit of contrast at altitude without making the covering process too complicated. Separation bands of 3/8th inch width were applied afterward.

Jim Pruitt has been wanting to get back into modeling after a rather lengthy respite, and volunteered to help with the covering job. A couple of his photos, taken during the several hours it took to get most of the covering accomplished, are included. Nearly thirty five square feet of covering later, the job was done.

To make sure the flaps closed securely, we induced a 1/8th inch twist during the covering process. The slight twist forces the outer portion to seat first and the servo brings the flap to the fully closed position. The inner portion is held in place by the servo, and the outer portion by the imparted

This photo shows the elevon servo and associated linkage, plus the rudder structure.
The flap servo is between the root and first outboard ribs, under the sheeting.

The 1/64th plywood flap hinge covers can be seen in this bottom view. The holes on either side of the fuselage are just big enough for thumb and finger.



The lower surface of the right wing showing. The assymetry of the final color scheme can be seen i the white banding around the elevon. The flaps are in position, but the hinges are not connected.

twist. This method is used on full size aircraft, so we anticipated it would work in this application as well.

Balancing

Aaron Coffey's Panknin spreadsheet, available on our web site, was used to determine the location of the neutral point (NP) and the static margin. The leading edge of the wing is swept back at ten degrees, so the quarter chord sweep is 7.5 degrees. The root chord is 27 inches and the tip chord is 17 inches. The spreadsheet shows an area of 2354 square inches (16.3 square feet) for these planform dimensions. In reality, due to the shape of the wing tips, the area is 2325 square inches (16.15 square feet) and the area is a bit further rearward than the simple trapezoidal shape used by the spreadsheet. Still, the latter is somewhat of a safety issue, as the spreadsheet places the NP slightly forward of where it actually is located. The spreadsheet shows the NP as being ten inches back from the apex of the leading edge. A static margin of 5% (0.05) places the CG an inch forward of the NP, nine inches from the leading edge apex. We marked the NP and 5% static margin CG on the bottom of the fuselage using a fine felt tip marker.

The balsa blocks which form the nose were previously hollowed out, leaving quite a bit of room for lead. We made dams of aluminum sheet and used wooden dowels stuck in the mounting pin holes to support them. The nose blocks were supported on wet rags while molten lead was poured into the dammed cavities. About 0.4 pounds went into each side. Once hardened, the nose blocks were rigged at 45 degree angle and more lead was poured in until level with the original pouring. This filled the nose blocks back to the location of the triangle stock in front of the battery compartment. The included photo shows the finished product, a half pound of lead in each side.

Molten lead was poured into the hollowed sides as described in the text. There are still some small cavities which can be filled with lead, reducing the amount attached further to the rear.

Additional flattened lead pieces were placed on either side of the battery pack, held in place with the rubber bands.

After adding all that weight, the CG turned out to be a half inch in front of the marked NP. This is equivalent to a static margin of 0.025 or 2.5%. This is a small static margin based on our previous experience. The one thing which kept coming to mind, however, is the lower positive pitching moment of the BW 05 02 09 airfoil compared to the CJ $25^2$09. With less downforce at the rear, a more rearward CG is possible. More about this in the next section.

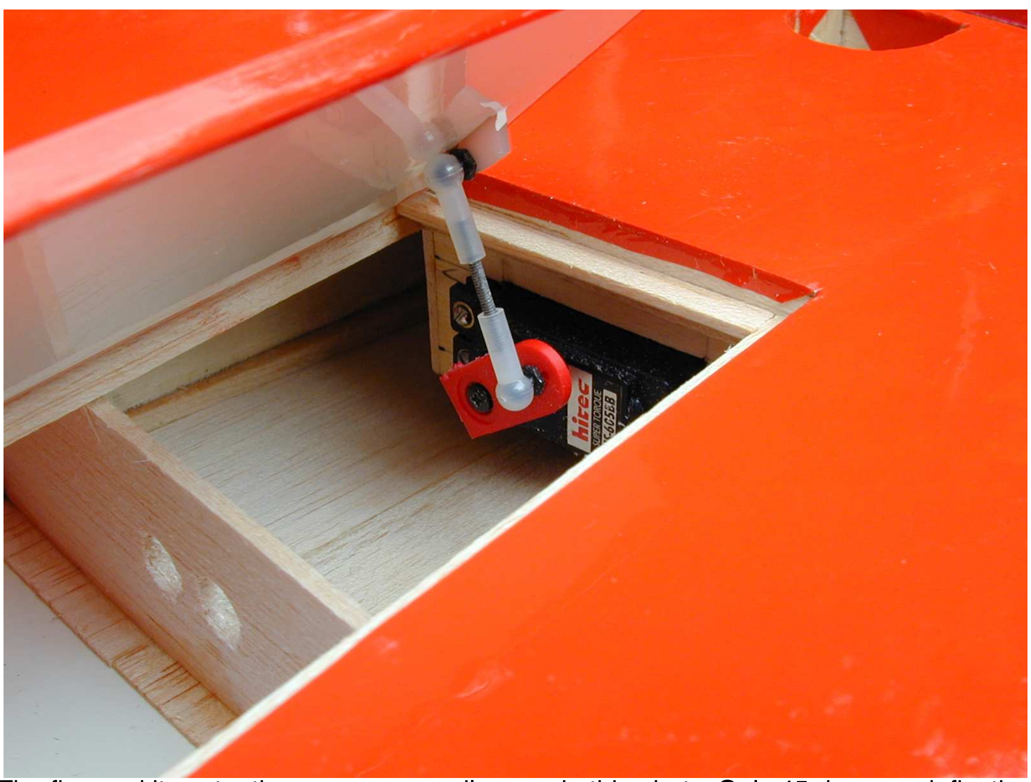
With all of the lead in the nose, the overall weight came out to be eight pounds five and half ounces. This compares very favorably with the ten pound eight ounce weight of the last Blackbird XC. The wing loading for the completed aircraft is just 8.25 ounces per square foot.

Test flying

First, it's necessary to realize that this is an incredibly large airplane - the total wing area is just a few square inches short of the FAI maximum. Getting the airplane up to flying speed poses big difficulties, as can be imagined. Luckily, the wind was blowing at 60 Acres when we went out for test flying.

We talked Doug Brusig into handling the transmitter while Bill, Blackbird overhead, ran across the field at top speed. Several trials, nearly releasing the aircraft in order to feel for pitch instability, resulted in no untoward tendencies being observed. A push forward on the fourth attempt and the Blackbird XC was traveling out in a flat glide with some barely visible elevon

Granddaughter Anna, age 3½, steadies the newly covered airframe. The root chord is 27 inches, the tip chord 17 inches. The completed aircraft spans 107 inches.



The flap and its actuating servo are easily seen in this photo. Only 45 degrees deflection is necessary. The flaps clear the ground due to the shape of the fuselage and the ventral fin.

Bill and the brand new Blackbird XC after its second flight. Granddaughter Alyssa took time out from flying her two meter Highlander to help test fly the new bird. She really enjoyed steering the giant through the sky.

deflections from Doug's hands on the transmitter sticks. It appeared that the 2.5% static margin was right on.

The tow hook is a quarter inch in front of the 5% static margin CG, three quarters of an inch in front of the 2.5% spot. This seemed like a good place to start, so the Blackbird was hooked up to the winch line. Tension was built up and the aircraft was thrown straight ahead. The Blackbird immediately rotated into a steep climb. Rapidly pulsing the pedal was sufficient to maintain the climb to release. Once off the line, no trim was required for continued straight and level flight. The mixed rudder was sufficient to get well coordinated turns from the right stick alone. There wasn't much thermal activity, but the Blackbird XC turns majestically and cruises through the sky just as one would expect from such a large aircraft.

The one thing we wanted to test was the aircraft reaction to flap deflection. Slowly lowering the flaps initiated a nose up motion, so they were quickly retracted. We were expecting no pitch change at all, so now must work on getting the transmitter to mix throttle position to elevator in the proper proportion. The tow hook needs to be moved back as well, and we anticipate its final position will be a quarter inch in front of the final CG location.

Despite the flap deflection adversely affecting pitch, the Blackbird XC performs exceptionally well,. It's docile enough that Alyssa, our seven year old granddaughter who is still perfecting her flying skills with her Highlander, took over the controls for a while on the third flight. She really liked steering the giant around the sky.

We're looking forward to flying the Blackbird XC throughout the coming summer and for many years to come.

A few days after this article was submitted for publication in *RC Soaring Digest*, we had the opportunity to go out flying with it again. This gave us the opportunity to make the minor changes we outlined at the end of the original article.

The 2.5% static margin has not been changed, but the tow hook has been moved back to apoint a quarter inch in front of the CG. This gives a good steep climb without any tendency to pop off.

We finally settled on a flap-to-elevator mix of 75%. This setting thoroughly inhibits any pitch change as the flaps are deflected or retracted. Putting the flaps down 45 degrees slows the aircraft a small amount, steepens the glide angle , and dramatically improves its steadiness in turbulent air. The remaining down elevator deflection, although small, is sufficient to maintain full control during landing approaches.

As is common with this design, you can take advantage of small bubbles of lift by flying straight through them. The nose rises as the aircraft climbs. Once you see the climb slowing, a touch of down elevator levels it resumes straight ahead flight at the higher altitude. If substantial lift is found, it can be banked steeply and brought around quickly to center the thermal.

The Seattle Area Soaring Society sponsors an open flying session each Wednesday night while daylight savings time is in effect. In all, twelve SASS members, plus a few others, have had their turn at the controls on Wednesday evenings. The Blackbird XC is truly a joy to fly, a sentiment shared by an increasing number of SASS members.