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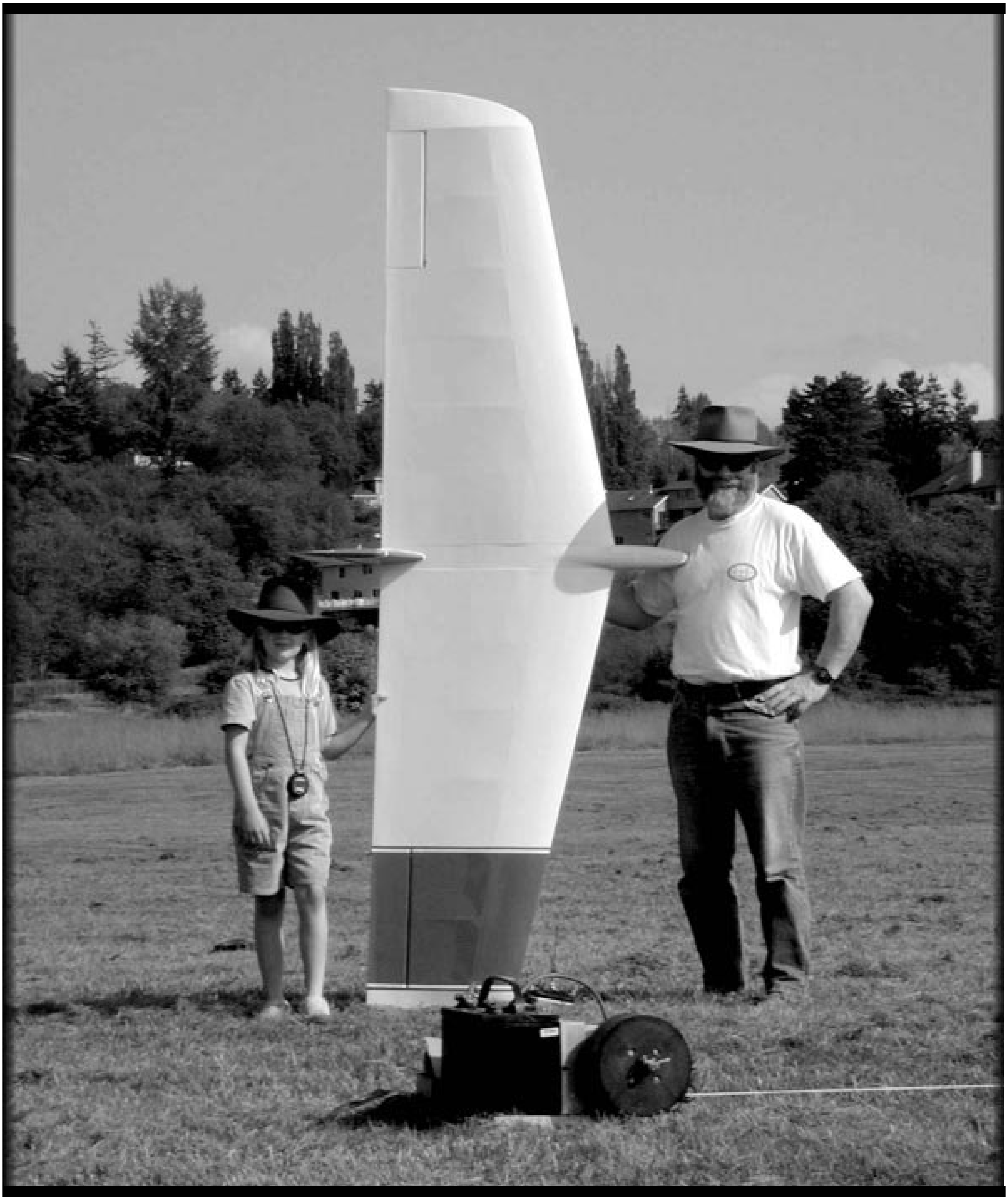

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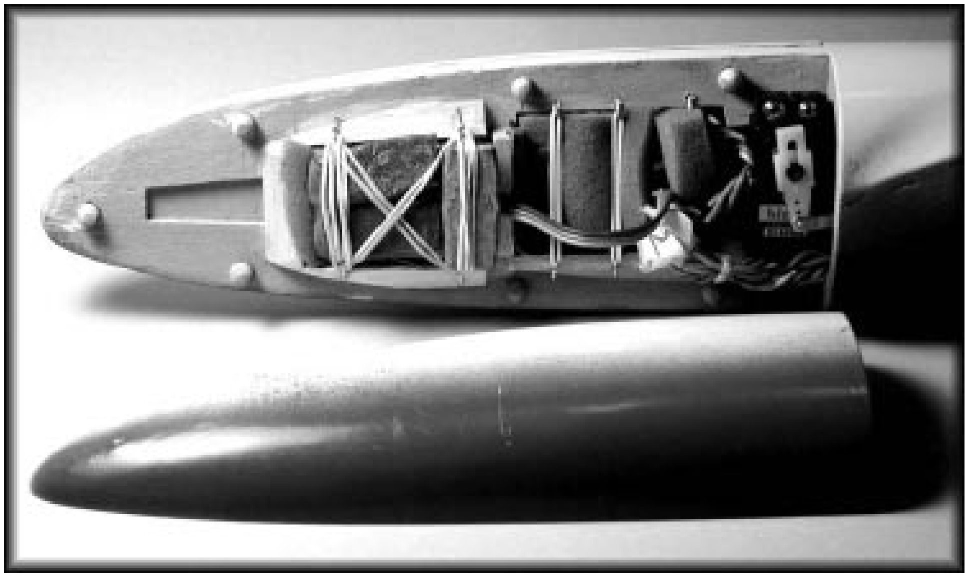
Blackbird XC.3

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



Side view of the nose of the completed fuselage. The lead nose weights closely follow the contour of the keel and the triangle stock right in front of the battery pack. Lead sheet is also placed on both sides of the battery pack. The receiver is placed in foam between the battery pack and the rudder servo.

The framework

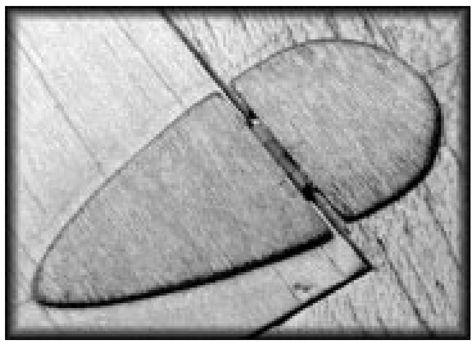
Several pictures of the airframe in various stages of construction were included in the last installment. A few photos of the completed airframe are included in this installment.

Several construction points deserve additional explanation.

Flaps: The flaps are constructed of 1/8th inch square spruce sticks glued to 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 short control horn. The upper surface of the truss framework was then covered 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 within their wells. 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.



A typical flap hinge. The nylon hinge is inset into the balsa sheet covering the wing and flap, and 1/64th inch contoured plywood plates are then glued over the hinges to support the Ultracoat covering material.

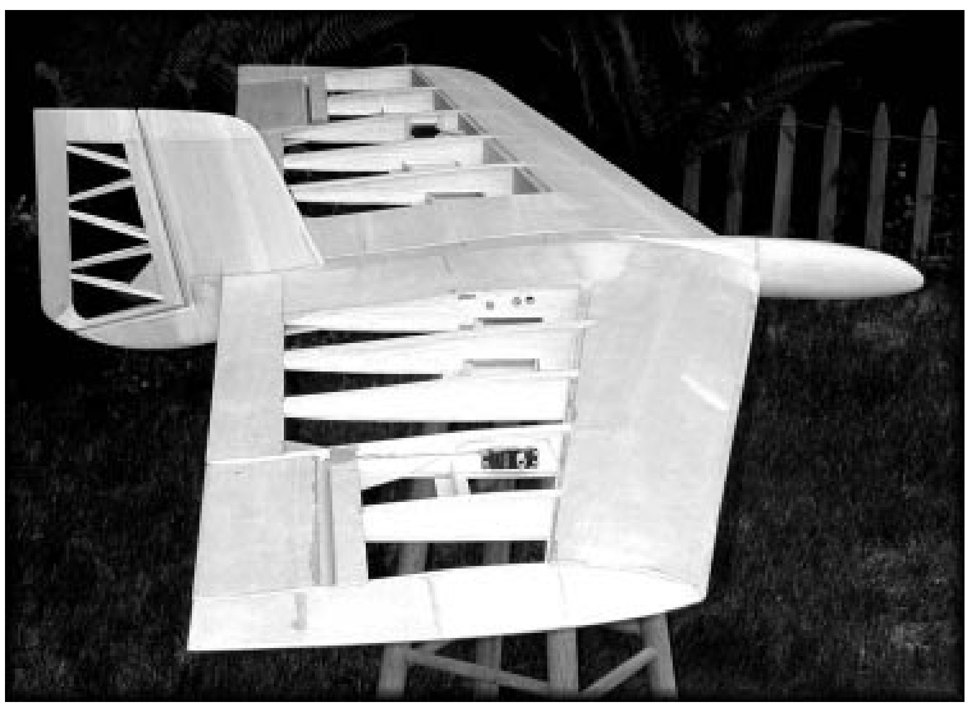
(R) Molten lead was poured into the nose through use of aluminum dams and tipping the sides at 45 degrees. Each side holds slightly more than a half pound.

With the flap still in place within its cavity, the hinges were arranged in their shallow depressions. 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 the hinge 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 rigidly fixed to both the flap and the wing.

A closeup of the flap servo location which provides an idea of how the control system operates. Full flap deflection is 45 degrees.

Granddaughter Anna, age three and half, steadies the completed airframe for the camera. The flap structure is obvious in this view.

(Below) Side perspective of the complete airframe. The elevon servo can be easily seen, the flap servo is under the wing root sheeting. The reflex of the airfoil is evident in the curvature of the lower surface.



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 and the wing bottom, 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.

Trailing edge stock was also used 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, where the


Underside of the Blackbird XC with flaps fully deflected. Granddaughter Anna, age three and a half, provides some scale.

wing rods receptacles are located, retains the interior webbing equivalent to the original Blackbird 2M plans.

Trailing edge webbing: Using 1/16th inch balsa sheeting certainly brought the overall weight down, but it also caused minor structural difficulties in some areas. The major problem appeared at the front of the trailing edge sheeting. Despite the curved surface, the sheeting tended to bend too easily in our estimation. Our solution was to add a vertical web of 1/16th balsa sheeting inside the leading edge, fully spanning the upper and lower sheeting between adjacent ribs. This created a triangular "box" which substantially stiffened the area with very little weight penalty.

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 arrangement worked out extremely well. The receiver is well padded in a configured piece of foam, held in place with 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. Our JR PCM 10 transmitter was programmed for V-tail with rudder to aileron mixing and flaps on the throttle stick.

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

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

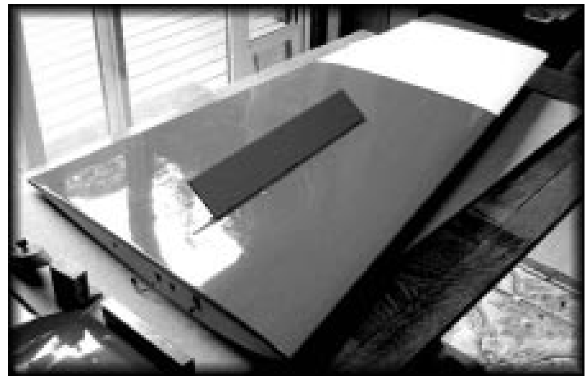
Covering

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 some time ago. 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 an 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, a Bremerton resident, has been wanting to get back into modeling after a rather lengthy respite and has been following the Blackbird XC construction process from the start. Jim 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.

The right wing, bottom covering in place, ready for the upper surface covering to be applied. Notice the interior framing of the flap bay.



Bottom of the right wing after the covering was applied. The flap recess has not been cut out yet, so the hinges are not connected. Each flap is over fifty square inches in area, so substantial servo power is required.

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

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 (16.35 square feet) for these planform dimensions. In reality, due to the shape of the wing tips, the area is 2300 square inches (16 square feet) and the area is a bit further rearward than the simple trapezoidal shape used by the spreadsheet. The spreadsheet shows the NP as being ten inches back from the apex of the leading edge, slightly forward of where it is actually located, so there is a small safety factor built into the computations. A static margin of 5% (0.05) places the CG 1.1 inch forward of the NP, 8.9 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 ample 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 a 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. 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 slightly more than a half inch in front of the marked NP. This is equivalent to a static margin of 0.025 or 2.5%. Based on previous experience, this is a small static margin. 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 which we used on the last Blackbird XC. With less downforce at the rear, a more rearward CG is possible. We just had to make sure the CG was in front of the computed neutral point. More about how this worked out in the next section.

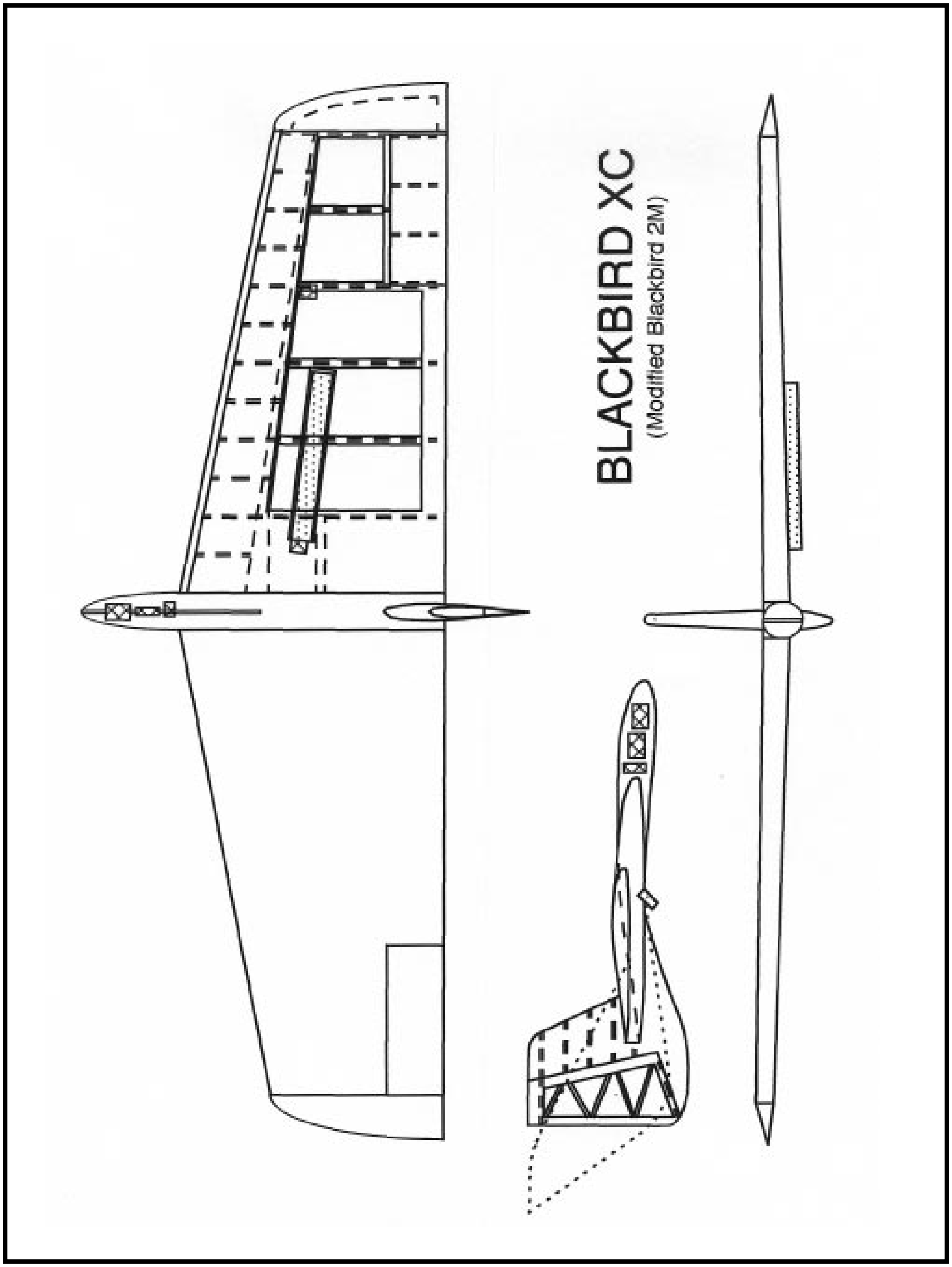
With all of the lead in the nose, the overall weight came out to be eight pounds five and half ounces, well below the eleven pound FAI maximum. This also compares very favorably with the ten pound eight ounce weight of the last Blackbird XC. The wing loading for the completed aircraft is just eight and a third ounces per square foot, very low for an aircraft of this size.

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 deflections from Doug's hands on the transmitter sticks. It appeared from the results of the single hand launch that the 2.5% static margin was going to be right on.

The tow hook was initially placed 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 gracefully and cruises through the sky in an overtly majestic manner.



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 or so 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 gentle giant around the open blue sky.

We're looking forward to flying the Blackbird XC all Summer and for many years to come.

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Suggestions for future columns can always be sent to us at either P.O. Box 975, Olalla WA 98359-0975 or <bsquared@appleisp.net>.

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