

## Blackbird XC.3

*As mentioned in a previous column, we're hard at work on our third Blackbird XC. This will be the eighth Blackbird to come off our building board. As usual, we've incorporated many modifications to the original design besides the enlarged size. This column will describe all of the various changes to be incorporated in this rendition and share some of the highlights of the construction process. The second installment will cover completion of construction and test flying.*

Our experience with Dave Jones' Blackbird planform goes back nearly twenty years. We've always found it to be relatively easy to build, stable and maneuverable in flight, and, in spite of its total lack of exotic materials, capable of full power "pedal to the metal" winch launches which end in thrilling zooms to great altitudes.

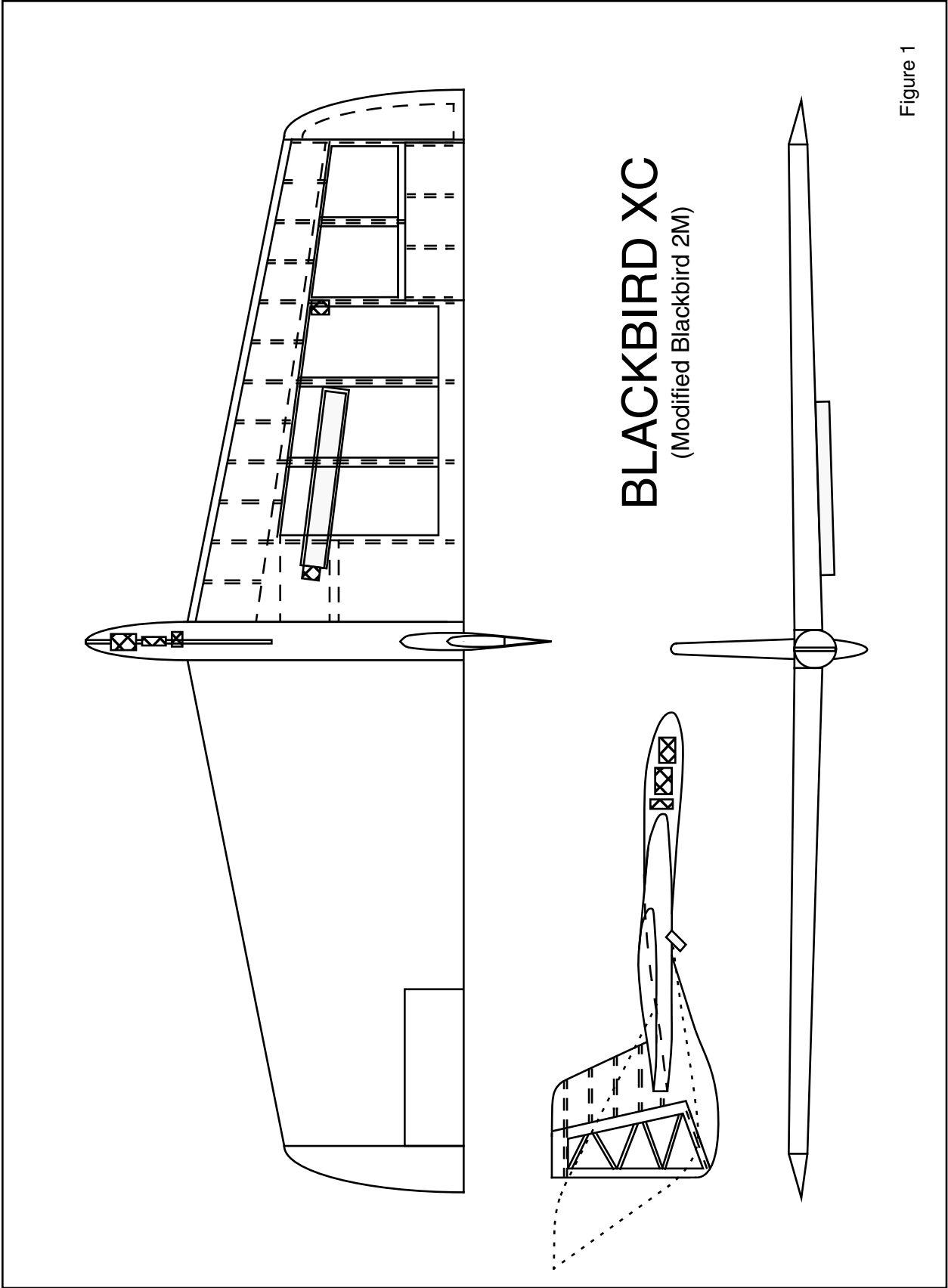
The Blackbird XC has a span of 107 inches and an area of 2300 square inches. The last one we built weighs 162 ounces for a wing loading of just over ten oz/ft<sup>2</sup> and is an incredible flying machine. Due to its size, it cruises sedately through the sky between thermals. Once in rising air, the low aspect ratio of the planform and the light wing loading make climbing fairly easy. All of the sheeting on this aircraft, with the exception of the fin, is 3/32 inch balsa. The Blackbird XC now under construction will be sheeted with 1/16 inch balsa throughout, not only reducing the overall weight of the sheeting, but also decreasing the amount of lead placed in the nose. As an example of this weight saving, each wing for the last version weighs 48 ounces, the new wings will likely weigh between 32 and 36 ounces. The projected flying weight should therefore be well under 162 ounces, and we anticipate a wing loading of under 9 oz/ft<sup>2</sup>.

We're using Hitec HS-605BB servos throughout — one for each elevon, one for each flap, and a fifth for the rudder. These servos are close to the size of a standard servo and come equipped with dual ball bearings and helical gears. This servo can put out 77 oz.in. of torque at 0.16 sec./60 degrees on 4.8 volts. These "high torque" servos were recommended by John Packer, the manager of Hobbytown in Parkland WA, and we're extremely pleased with them.

### Vertical fin and rudder

After putting rudders on our two meter Blackbirds and finding a noticeable improvement in handling, we decided to add a moveable rudder during construction of this XC machine. This dictated a redesign of the fin so that the hinge line would not be swept back so severely. The leading edge of the wing is swept back ten degrees, and we swept back the leading edge of the fin 20 degrees. Since the hinge line is located at 50% of the local chord, it sweeps back at ten degrees. Additionally, the moveable rudder will be of open frame construction with diagonal ribs rather than fully sheeted. This should save some weight compared to the same surfaces fully sheeted. The included 3-view (Figure 1) shows the old fin planform and the redesigned fin and rudder assembly.

Because of the large chord and expected flight speeds, we wanted an airfoil of about 10% thickness. We also wanted an airfoil with a small deadband around neutral. The S 8020 seemed to



meet our needs, despite some recent notes which state the deadband is slightly larger than originally measured.

Because of the modified fuselage shape, the already large sub fin was made deeper. We also wanted to make sure that upon landing the wing would be driven to below its zero lift angle of attack.

### Airfoil

Our previous versions of the Blackbird have used the CJ-3309, the CJ-25<sup>2</sup>09, and the BW 05 02 09 sections. These airfoils differ from each other in significant ways.

The CJ-3309 has a flat lower surface from the leading edge radius back to the point where the reflex starts at 75% chord. Building a warp free wing on a flat surface is therefore automatic.

The CJ-25<sup>2</sup>09 has what's commonly called a "Phillips' entry." The lower surface curves upward from 25% chord forward to the leading edge radius. This reduces the camber from three percent to two and a half percent. Flight speeds appear to be slightly faster with this airfoil than when using the CJ-3309. Launch height is greater because of the lower drag, allowing higher zooms, and climbing ability in a thermal is not noticeably affected.

The third section, the BW 05 02 09, has no flat portions on either the upper or lower surface, making a construction jig of some sort a necessity. We really like this airfoil because of its low drag and reduced reflex. The CG location is in exactly the same spot as the version with the CJ-25<sup>2</sup>09 section, but the natural oscillations in pitch which appear when flying straight ahead for long periods are slower and of lesser magnitude. The performance improvement over the CJ-25<sup>2</sup>09 is remarkable. Energy retention during zooms off the winch are consistently higher, cruising between thermals is noticeably faster, and the aircraft is more quiet.

Despite the more convoluted construction methodology, we chose the BW 05 02 09 for this aircraft.

### Flaps

The topic of flaps on planks was a subject of our correspondence with Dave Jones, designer of the Blackbird 2M. While such flaps cannot be used to improve thermal climb, they can be during winch launches to improve initial climbout and for glide path control during landing. The generalized "rules" for flaps on plank planforms are as follows: location of the leading edge of the flap at 40% of the local chord; approximately 5% of the wing area; deflection of 45 degrees should be sufficient.

The flaps are 18 inches long and three inches wide. They consist of 1/16 inch balsa exterior and interior sheeting, and 1/8 square spruce diagonal ribs. The control horns are mounted on plywood triangles which fit into the corner under the servo output wheel. The flaps are lightweight and torsionally rigid. We used standard nylon pinned hinges, five per flap. Our Dremel was mounted on a router base and just enough balsa was removed for the hinge to be flush with the flap and

wing sheeting exterior surfaces. We then cut 1/64 inch plywood into the shape of an aerodynamic strut and used that to cover the exposed surface of the hinge.

We're using Hitec HS-605BB servos throughout — one for each elevon, one for each flap, and one for the rudder. These servos are close to standard size, have dual ball bearings and helical gears, and can put out 77 oz.in. of torque at 0.16 sec./60 degrees on 4.8 volts. The flap control system utilizes a short pushrod with ball links at each end. The servo wheel is set so that throttle trim (low speed) adjusts the closing position, and when the flap is fully deflected there is no pressure against the gear train. See Figure 2 and the flap servo photo.

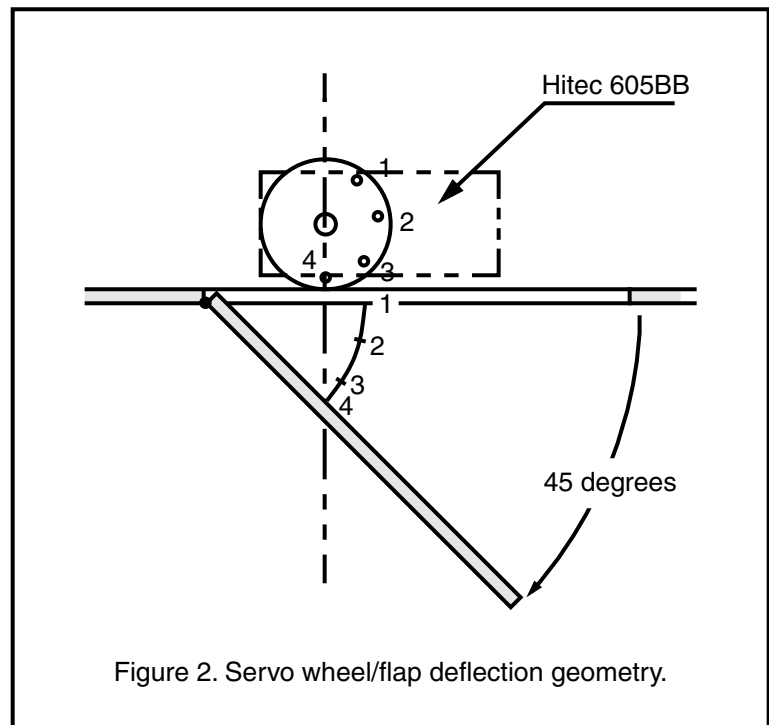


Figure 2. Servo wheel/flap deflection geometry.

We settled on a Y-harness for the flap servos. This allows us to use the throttle channel for controlling flap deflection, the aileron and elevator channels for the elevons, and the rudder channel for the rudder. The flap servos were mounted in mirrored positions in the wings, so one servo had to be modified for reversed direction of rotation. Our original plan was to use a Hitec seven channel receiver and mixing options on the transmitter, a JR PCM 10. This channel utilization allows us to use our FMA M5 with additional protective foam surrounding it, and our JR Century 7 transmitter should the need arise.

### Fuselage

The Blackbird 2M per plan fuselage construction consists of 1/8 inch plywood sides which match the wing root profile from the high point to the trailing edge. From the high point forward, the fuselage side view is similar to the airfoil. The rectangular cross section at the high point gradually blends into a solid nose of roughly circular cross section as the plywood sides bend inward. The internal volume is incredible. A four cell 1600 mAh sub-C battery pack forward, receiver behind. Without a rudder servo installed, there's more than enough room in front of the spar for two Ace thermal sniffers.

We desired a fuselage with a cylindrical cross-section from the nose to the intersection of the wing at the expense of internal volume. Our original thought was to construct a central keel and a slip-on nosecone. We sketched out the side view in full size, then drew in circular cross-sections



from the nose to the high point of the wing root. In looking at our creation, it became obvious that a slip on nosecone would not be possible because of the fuselage curves as seen in the side view. Our decision was to retain a central keel and form large balsa sides of balsa block.

Fuselage construction began with the keel. Two pieces of 1/16 inch plywood were glued together to form the 1/8 inch thick main portion. This part of the keel is mounted to the main spar wing rod at the rear and to a 5/8 inch dowel near the wing leading edge. The dowel is a lightweight method of establishing a good carrythrough between the keel and the wing roots and acts to prevent crushing if the wings happen to swing forward on a rough landing. Additional rims of 1/16 plywood were glued to both sides of the keel. More about those rims in a bit.

A few of our last construction projects have utilized large carved and hollowed blocks. We're getting to be pretty good at the shaping process and had a large balsa block of the correct dimensions to work on. Blocks were first run through a jig saw to give the rough profile, then tack glued to both sides of the completed keel. An X-Acto carving blade, a freshly sharpened low angle plane, a razor plane and carbide sanding bars were used to get the fuselage to match circular templates fabricated from credit cards.

After external shaping, the blocks were popped off the keel. Holes were drilled around the perimeter of the keel to serve as holders for several mounting/alignment pins. The nose blocks were then reattached with wide masking tape and the holes in the keel used to guide the drilling of matching holes into the nose blocks. The nose blocks were removed and hollowed using a Dremel and a carbide grinding tool. The holes for the pins were coated with thin CA and then cleared by hand using a matching drill bit.

The keel is quite sturdy by itself. It's very much stronger with the side blocks attached, and we're sure the strength will increase further with the additional layer of fiberglass which will encase the entire fuselage structure.

### Other modifications and details

The spruce spars are tapered in width from 3/4 inch at the root to 3/8 inch at the tip. This is wider at the root and more narrow at the tip than scaling the spar caps as indicated on the two meter plans, where the width should be constant for the entire length of the spar. The spar webbing is also heavier at the root and more light at the tip than would be indicated by the two meter plans. As mentioned before, the completed wing has no carbon or Kevlar, yet is strong enough to withstand full power contest winch launches with a barely noticeable flex at the root.

As is now our usual practice, the elevon servos are located in the wing behind the spar and directly in front of the inner edge of the elevon. This allows a direct linkage between the servo output arm and the servo control horn. Additionally, the Frise type elevon has been eliminated. This version will once again use simple fabric hinges at the lower surface.

The rudder servo is mounted vertically on the keel directly in front of the leading edge of the wing. The pushrod cable consists of 1/16 inch music wire through a yellow ridged NyRod which

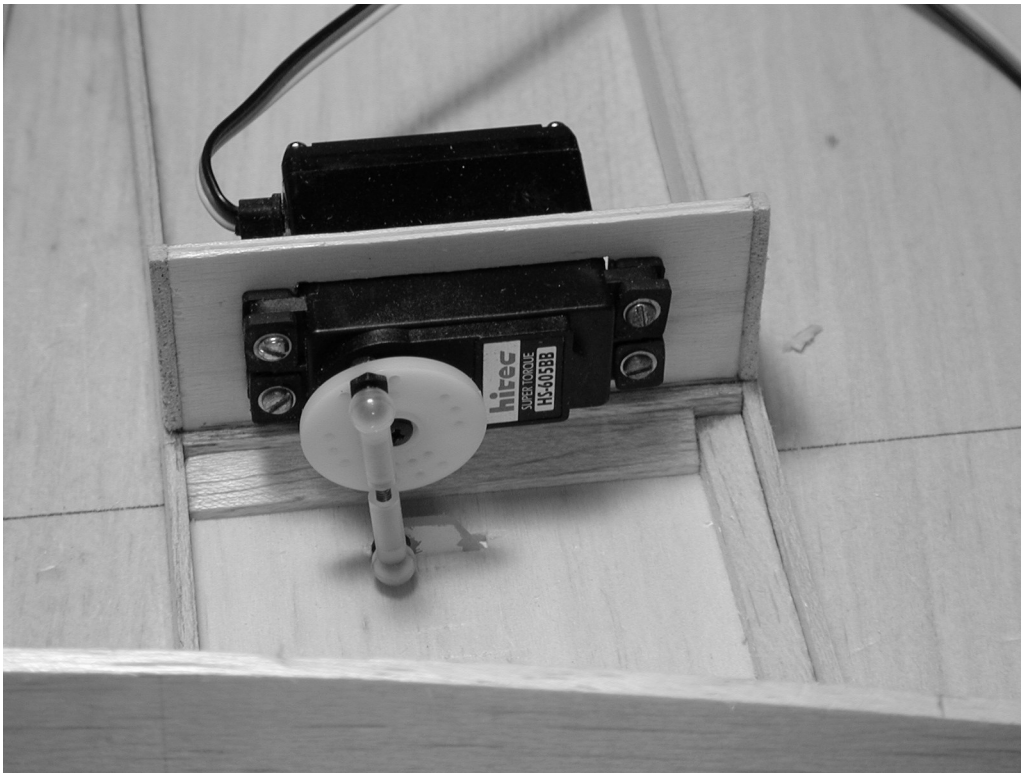
goes through a red NyRod. This pushrod goes below the 5/8 inch dowel which traverses the fuselage in the forward part of the wing.

In the past, we've run the antenna along the leading edge of one wing. In this version, the antenna is routed behind the rudder servo, down the right side of the fuselage and up the fin.

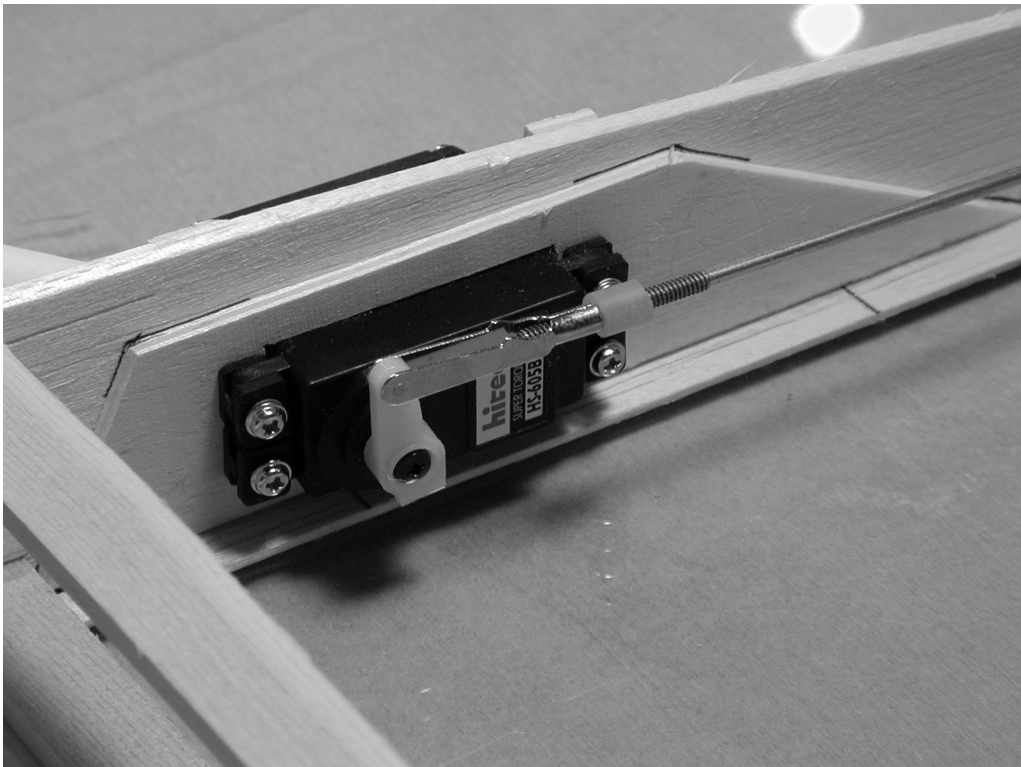
The rudder servo is connected directly to the receiver with a shortened cable while the flap and elevon servos require cable extensions within the fuselage. The elevon servos also require 24 inch cable extensions within the wing. All servo cables are cut to minimum length and twisted to inhibit spurious noise being introduced into the signal paths.

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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>.



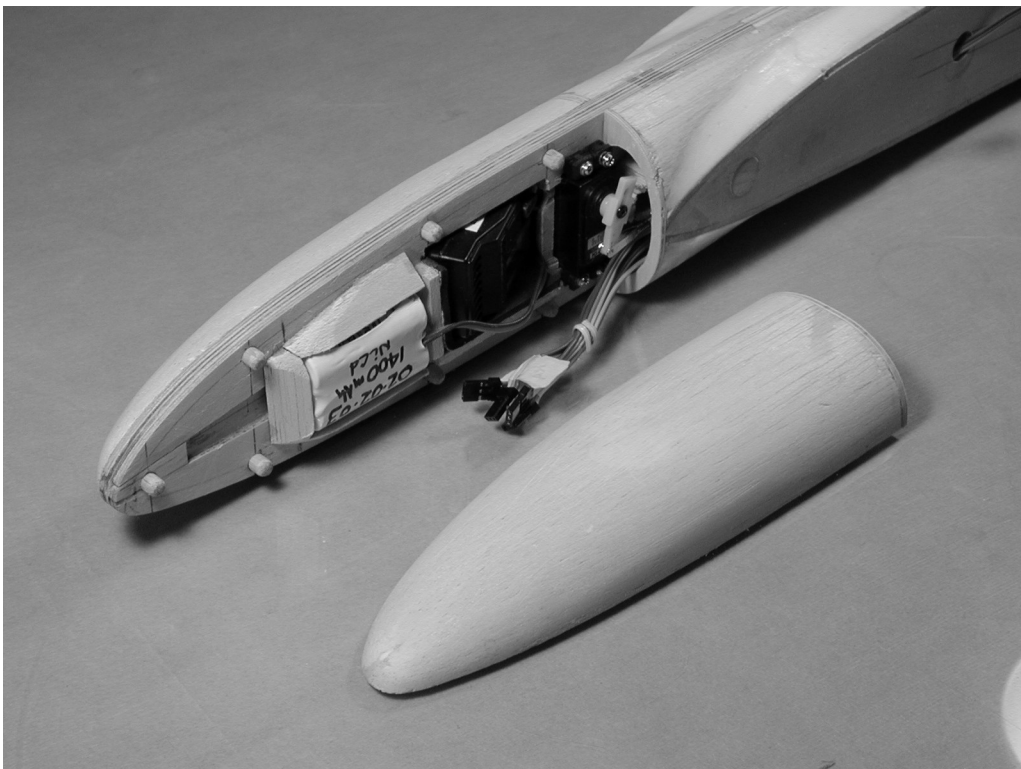
The flap servo mounting and pushrod system.  
The hinged edge of the flap is toward the left.



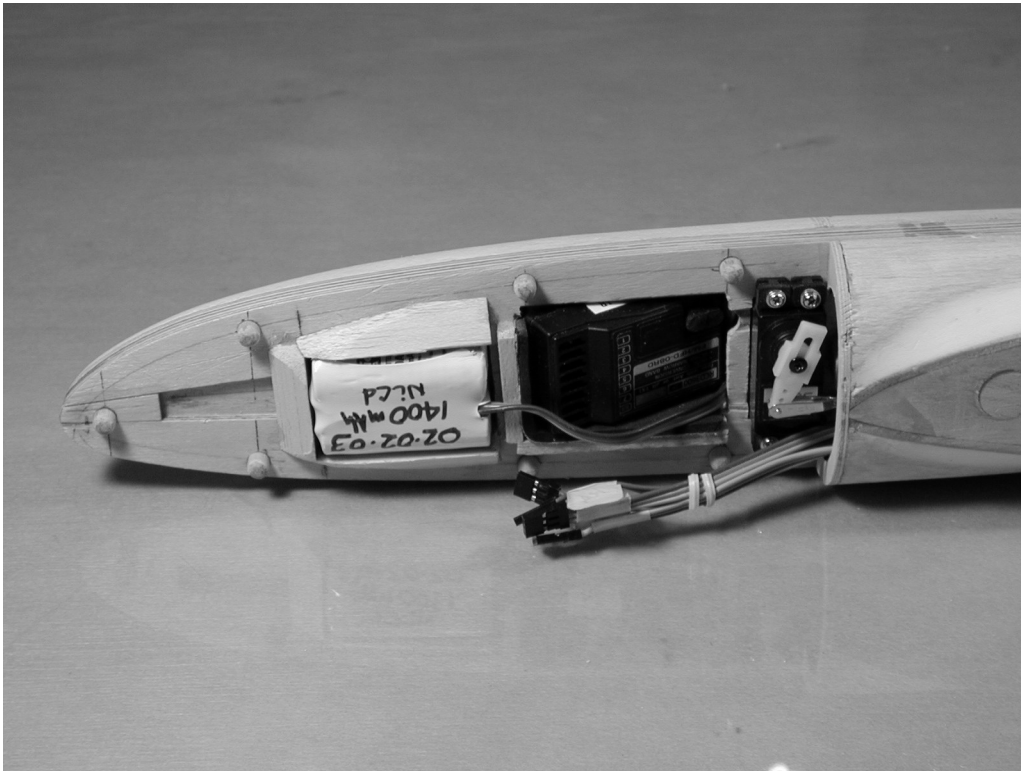
The elevon servo is mounted right behind the main spar. Notice the high strength clevis and pushrod. The Hitec HS-605BB servo puts out 77 oz.in. of torque, so the system has to be of more robust construction than the usual.



The complete flap and driving servo system. Each flap is 18 inches long and three inches wide. The leading edge sheeting is not yet in place. A rolled paper tube acts as a conduit for the elvon servo cable.



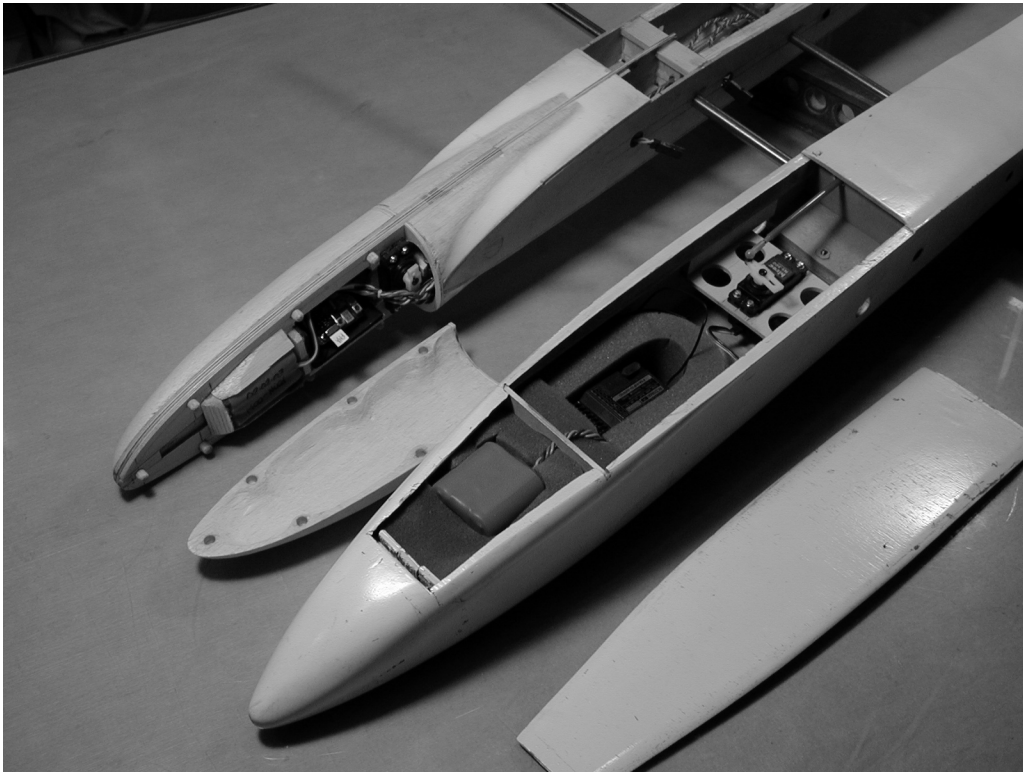
View of the left front of the fuselage nose. 1400 MaH battery pack, Hitec seven channel receiver, and vertically mounted rudder servo. Still plenty of room in the forward nose for lead ballast to adjust CG location.



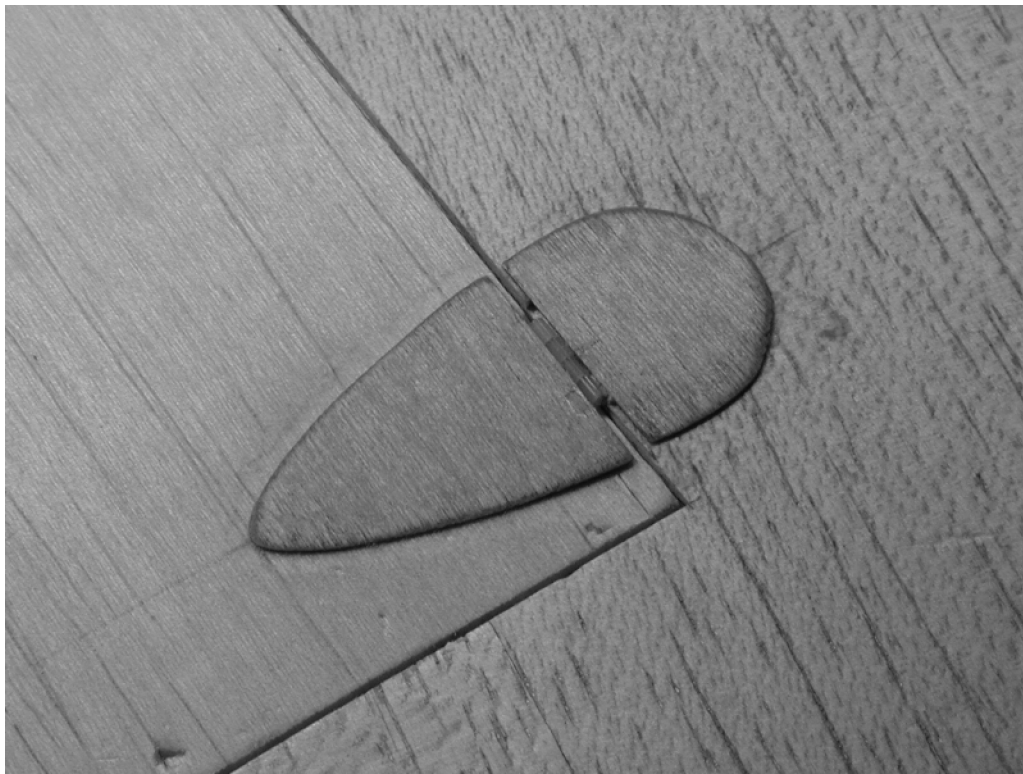
Another view of the forward fuselage showing the location of the various electronic items. The receiver location was framed for the Hitec seven channel, but the FMA M5 will be used with lots of room for protective foam.



The fuselage nose with side blocks in place. The area in the region of the wing spar is still open. Fiberglass and resin are still to be applied.



A visual comparison of the Blackbird XC.2 (front) and Blackbird XC.3 (rear). The new XC.3 has less internal volume, but is far superior from an aerodynamic perspective. The steel wing rods are inserted into both fuselages, so wing placement is parallel.



The flap hinges are inset into the 1/16 inch balsa sheeting, then covered with 1/64 inch plywood. The plywood covers were faired with sandpaper before being gluing in place.