

## Grim Reaper XL Building Instructions by CRASHTESTHOBBY.COM

The Grim Reaper XL is one of the toughest FPV planes on the planet. It is designed to fly at a wide speed range with more room to carry FPV equipment. We have used the same techniques to build the Grim Reaper XL as we use for our combat planes. It has an amazing glide. It can carry more weight than the smaller planes. It is cut from solid EPP foam that doesn't crush. It has EPP elevons that are strong. It has bidirectional reinforced Extreme Tape hinges and laminate to make it strong while protecting the battery and radio. The plane is designed to use low cost motors, ESCs, servos and batteries. You need one of these!!!! It's time to fly without worrying about breaking your plane.



**Please watch the videos on how to build our flying wings.** The videos show technique and will give you more information than can be provided in written instructions alone. We recommend that you build and laminate the plane before you install the radio and FPV gear. This makes the plane easier to build and easier to service and repair.

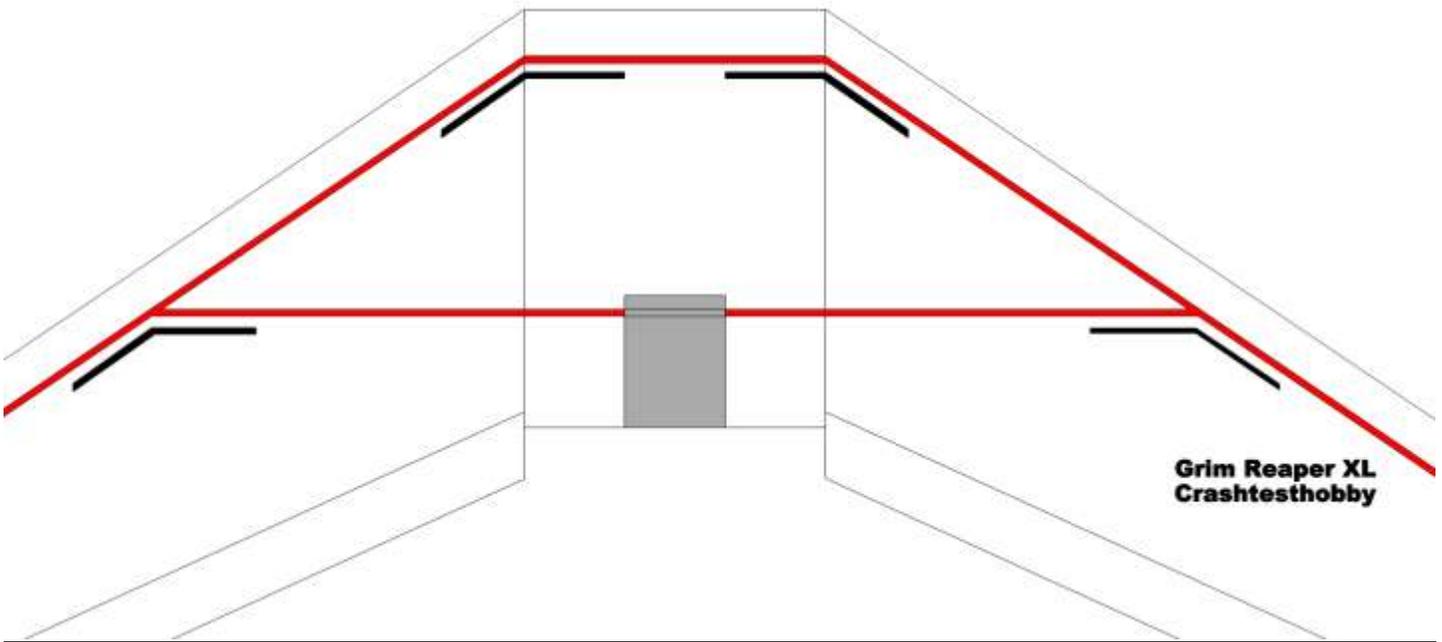
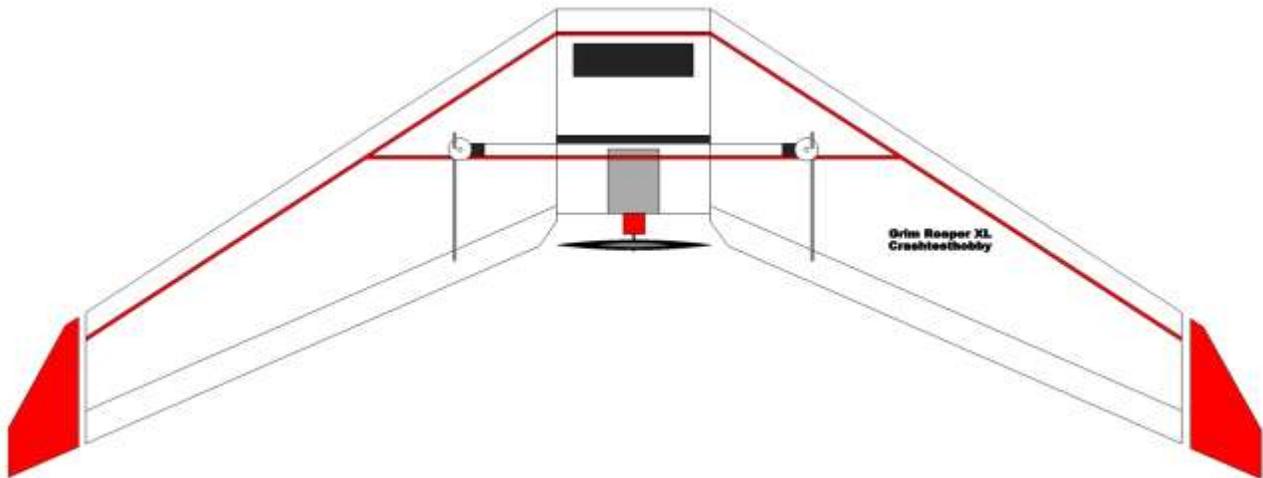
### **Specifications**

- a) Center of gravity is back 9" from nose of plane if using the 9" extension.
- b) Flying wings will not fly well nose or tail heavy.
- c) Flying wings tend to build tail heavy so you will need to keep the batteries and radio far forward.
- d) Front spars are back 1.5" (4 cm) from the leading edge of wing on both right/left/center and on the top/bottom of the wing.
- e) Center spars are back 9" (23 cm) from nose of plane on both the top and bottom of the wing.
- f) Spars are tied together with wire joiners and reinforced Scotch Extreme Tape over the top to prevent separation.
- g) Elevon throws 3/8" (1 cm) up/down. Use hole close to center of servo and hole at top of elevon horn for best leverage.
- h) Target flying weight 50-80 oz (1500-2400 gm). Lighter always flies better.
- i) 3530-1400 KV motor recommended with 9x6 propeller. (Some flyers are using the 3536-1800 KV with a 9x6 prop)
- j) Use a 40 amp ESC with the 3530-1400 KV motor and a 80+ amp ESC with 3536-1800 KV motor.
- k) 4000-12,000 mAh 3S lipo batteries mounted flat in the wing to decrease drag.
- l) Standard sized servos recommended for any motor capable of over 20 amps.
- m) Speed range 15-90 mph depending on finished weight with suggested motors and standard build.

### **Equipment needed**

- a) Low-temperature hot glue gun and low-temp rated glue
- b) Thin CA glue
- c) (OPTIONAL) Gorilla Glue (preferably white), or "Goop" brand glue
- d) #8 x 3/4" screws to attach motor mount to Formica (2-56 bolts and nuts may also be used) 4 needed
- e) Scotch Extreme Tape (2" bidirectional) available at office supply shipping departments and on Amazon.com
- f) Metal straight edge that won't melt or cut when used as a guide for the soldering iron or razor blade
- g) Soldering iron with 5/16" wheel collar to set cutting depth
- h) Pliers for cutting pushrod to length
- i) New razor blade to cut slit for shock cord
- j) Small Philips head screwdriver to push shock cord into slit
- k) Electric drill and bits for attaching motor mount to Formica plate.
- l) Iron for applying laminate (hobby iron is preferable, but clothing iron may be used)
- m) Velcro strips

This is the finished plane showing spar location, radio cutouts and fins.



## **REAPER XL BUILDING INSTRUCTIONS**

### **2. The images above show the finished location of spars, motor, radio and fin installation.**

- Clean the cut fibers off cores by rubbing two pieces of EPP together or using a disposable razor and shaving the EPP foam.
- Glue the three core sections together as shown. We prefer hot glue but Goop or Gorilla glue can also be used.
- Do not glue the ailerons. They will be attached later.
- The illustration above shows a 3536-1400 KV motor and a 9x6 prop. (Some use a 3536-1800 KV motor for more power.)
- The spars and Formica plates are installed the same on both the top and bottom of the wing.
- The front spars are back 1.5" from the leading edge of the wing and across the extension in the middle.

- g) The center spars are installed across the center of the wing, marking the CG, back 9" from the nose of the plane.

Use soldering iron to cut slots for spars.



Use a metal straight edge as guide.



Lightly sand spars so glue will stick.



### Install the spars

- Cut the spar slots with a soldering iron and a metal straight edge.
- Cut the tip of a soldering iron off to 1/4" or slide a 5/16" wheel collar on the shaft of the soldering iron to set the depth.
- 6" angle reinforcing wires are bent to fit in the spar slots to keep the spars from separating in an accident.
- Enlarge the slot slightly where the wire will be installed to give spars room to lay flat over the wires.
- Put the reinforcing angle wires in the slots at the angles.
- Lightly sand the spars to help the glue bond with the spar. (black spars shown for photos, kits usually have white spars.)
- Hot glue the spars in the slots making sure they are well secured to the angle wires.
- Trim spars even with the end of the wing.

Bend angle wires and put in slots.



Glue spars in place.



Secure spars till glue cools or sets.



### The Formica plates attach the motor mount to the spar system across the center of the plane.

- Formica plates are glued on both the top and bottom in the back center of wing directly over each other.
- The motor mount will be installed after the plane is laminated on the bottom of the wing.

Glue the Formica motor mount in place



Secure it till glue cools or sets.



Cut spars to length.



### The shock cord keeps the plane from tearing between the elevons in a forward impact. Even with the motor cut out on the bigger planes the shock cord keeps the trailing edge from tearing and gives longer life to the plane.

- Cut a 3/8" deep slit around the perimeter of the wing with a brand new razor blade to get the best cut.
- Push the shock cord in the slit with a small Phillips screwdriver and tie securely at the nose of the plane.
- Glue shock cord in place with thin CA glue. (Some builders wet the shock cord and use Gorilla glue in the slit.)

Cut slit around wing for shock cord.



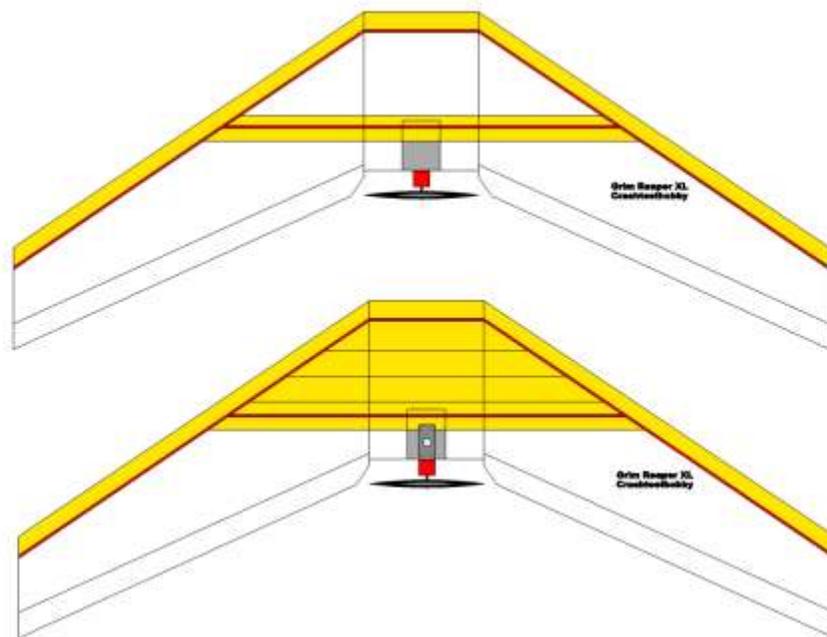
Stretch out shock cord.



Press shock cord into place.



Your plane is made strong by a combination of EPP foam, top and bottom fiberglass spars, reinforced angle wires, shock cord and super strong UV shielded laminate



CA glue shock cord in place.



Aply E-tape as shown above.



Wrap leading edge from spar to spar.



**3. The top image above shows the reinforced tape pattern for the top of the wing.**

- a) We recommend "Scotch Extreme Tape" because Extreme Tape will stick without a spray adhesive.
- b) It should be tight enough to give strength but not so tight it warps the wing.
- c) A strip of Extreme Tape should be over every spar and the formica motor mount to increase plane strength.
- d) Wrap Extreme Tape around top leading edge of wing from tip to tip from the spar forward.
- e) The tape is **YELLOW** in the picture. Foam is **WHITE** and spars are colored **RED** for identification.

**4. The bottom image shows the bottom of the wing and the reinforced tape pattern.**

- Extreme Tape across center of wing directly over the spar.
- This will reinforce the bottom of the battery and radio boxes cut in the top later.
- Put strips of Extreme tape from the bottom spar forward.
- Wrap 2" Extreme tape around bottom leading edge of wing. Wrap from tip to tip along the leading edge of the wing from the spar forward.

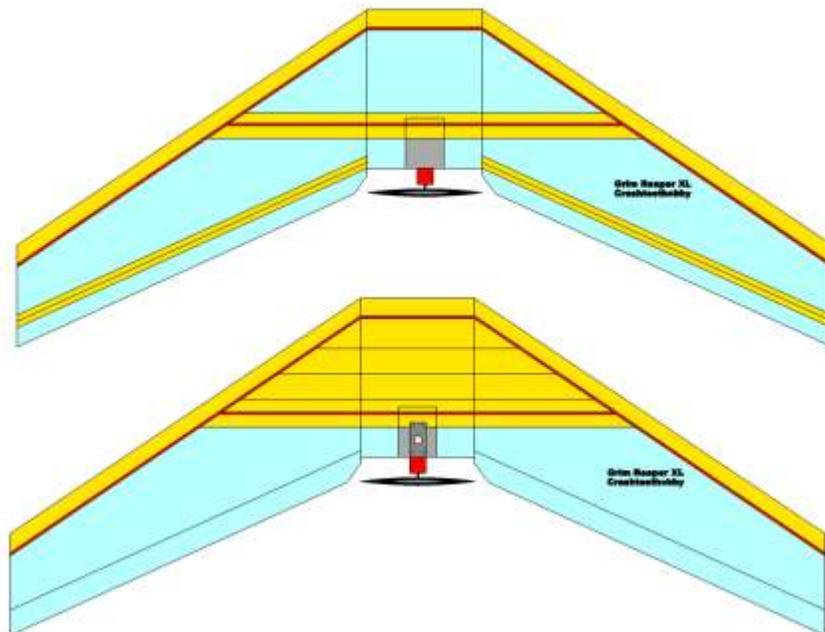
**ALL REINFORCED TAPE MUST BE COVERED WITH LAMINATE TO PROTECT FROM UV RAYS THAT DESTROY ITS ADHESIVE.**

Laminate wing starting with long stroke through middle of wing. Work from center out. Seal the edges.



#### Laminating the wing.

- If you are painting the wing, paint before you laminate. If you are putting colored tape on, laminate first.
  - Your iron should be hot enough for the laminate to stick but not so hot the laminate shrinks and wrinkles.
  - Start with an iron temperature of about 170 degrees or just enough a scrap will stick to your box.
  - Closely watch the foam. If it is changing shape your iron is too hot.
  - Keep a wet rag around to cool the iron if it seems to be getting too hot.
  - Put a single layer of laminate on top and bottom of wing over foam and tape
  - Cut laminate pieces that will cover 1/2 of one side of the wing with a 2" overlap.
  - Lay the laminate flat on the wing with the rough side against the foam
  - Start with a long single stroke down the middle of the wing trying not to leave wrinkles.
  - Work from this line and iron towards the edges avoiding wrinkles or too much heat.
- Wrap the edges and ends to get a great look.



**5. In the images above** The BLUE color represents the clear laminate we include in the kit which is ironed onto the core over

the foam and tape. Although the tape is still shown yellow you will need to put laminate over the tape to protect it from UV rays that will break down the adhesive and rot the tape in a matter of a few hours in the sun without protection. The Scotch Extreme Tape is not yellow but is almost as white as the foam and will stay white if protected with the laminate. The laminate we include in the kit does NOT need a spray adhesive to get it to stick. We hinge the elevon with a strip of the reinforced tape.

Lay out laminate for elevons.

Use low temp on iron to attach laminate.

Trim and seal laminate on ends of elevons.



**Laminate the elevons with 3 layers of laminate to make them stiff and strong**

- a) Test the temperature your iron with a scrap of laminate on the cardboard box.
- b) If your iron is too hot you will wrinkle the laminate and warp the elevons.
- c) The laminate should stick and slightly shrink but the iron should not be so hot it changes the shape of the foam.
- d) This is more important on the elevons that are thinner so more sensitive to the heat
- e) **Iron 3 layers of laminate on the EPP elevons.**
- f) Be careful not to warp the elevons during lamination.
- g) Place one of the elevons under one edge of the laminate, so that the rough side of the laminate is facing the EPP foam.
- h) Wrap the laminate end up over the elevon and make sure the elevon is straight before ironing.
- i) Use your iron to stick the laminate to the foam. Begin at the center and work your way outward to avoid wrinkles.
- j) If you start to get wrinkles you can put each layer of laminate on one at a time.
- k) Fold the laminate over and continue ironing until the elevon is completely covered with 3 layers of laminate.
- l) Check the elevon frequently to make sure it is straight and not warping.
- m) Cut the extra laminate on the ends of the elevon to fold over neatly. Iron the laminate around the ends of the elevon. Repeat process with other elevon.
- n) The heat and laminate shrinkage can warp the foam.
- o) If needed, re-heat and straighten the elevon, then hold it flat while it cools.
- p) The elevons will be much stiffer when they are hinged to the back of the wing.

Extreme Tape Hinge.

Split tape to 1" wide.

Put tape strip down elevon.



Tape goes on top pointed edge.



Attach elevon to wing.



Fold elevon over and put tape on bottom.



Cut laminate strips 2" wide.



Iron them over the E-Tape to shield it.



Fold elevon down and iron hinge line.



### Hinging the elevon

- a) The Extreme Tape has bidirectional reinforced fibers making a strong hinge line.
- b) The E-Tape hinge line will also need a layer of laminate to protect it from UV light.
- c) Position your elevons so the hinge line (sharp angle on the elevon) is level with the top of the wing
- d) Tape the top side of the wing first.
- e) Cut strips of the Scotch Extreme Tape 1" wide by sticking the tape to a piece of glass or Formica and using a new razor blade and metal straight edge.
- f) Leave a 1/16" gap between the elevon and the wing core.
- g) Put the tape the entire length of the elevon.
- h) Fold the elevon up over the wing and put a 1" strip of E-Tape on the bottom of the hinge line.
- i) Iron 2" wide laminate strips over tape on both the top and bottom of the hinge line to protect from UV light.**
- j) The hinge will not lay flat until you iron it in both the flexed up and flexed down positions.
- k) Look down the elevon and make sure it lays flat and is not warped.

### Add some color to your plane.

- a) In the pictures below you will see colored 2" packing tape available from many suppliers.
- b) Ultracoat or Holographic tape can also be used.
- c) Choose a design where the top and bottom are different.
- d) Choose colors that stand out against both a cloudy sky and a blue sky.
- e) Don't add a lot of weight with excessive or double layer laminate.

### MOTOR – We recommend the 3530-1400 KV motor with 9X6 propeller.

- a) Some flyers like the bigger 3536-1800 KV motor with an 8x6 or 9x6 prop.
- b) Use 3mm bolts to mount the 3530 motor body to the back of the motor mount bracket.
- c) With the wing upside-down, place the motor mount on the Formica plate, and mark where the holes will be drilled
- d) Drill pilot holes through the Formica plates and plane.
- e) Screw the bracket to the Formica plate using #8 x 1/2 " metal screws
- f) You can also bolt though both the top and bottom Formica plates by using longer 2-56 bolts with lock nuts, being careful not to over-tighten and crack the Formica. You can leave the motor mounted to the bracket to properly measure the Center of Gravity later, but remove the prop for safety purposes.

Choose a motor based on the kind of flying you want to do.

Drill the mounting plate for #8 screws.



Screw the motor mount in place.

Mark the fins on top edge of wing for mounting tape.



Use soldering iron or razor blade to cut 1" slit.

Goop Glue end of wing to secure fin.



Tape fin in place and allow glue to dry.

Adjust CG with radio in place. Adjust as needed.



### Installing the fins

- a) Hold the fins in place against the ends of each wing top, and make a 1" (2.5cm) mark in the center of the fin, where it meets the top of the wing, then use your razor blade to cut out that 1" (2.5cm) slot in the fin.

- b) Shape the front and top of the fin as desired.
- c) Use Goop (or Shoe Goo) to glue the fins to the ends of the wings, with the slit just above the top of the wing.
- d) Place a 2" (5cm) wide strip of Extreme Tape along the entire bottom of the fin, wrapping around to the bottom of the wing. Allow the glue to dry.
- e) Cut a 1" (2.5cm) wide strip of Extreme Tape and feed it through the slit in the fin, so that the tape attaches to both the top and bottom of the wing, around the bottom portion of the fin.

**Center of Gravity is important**

- a) With the motor and fins in place set all the electronics you plan to use on the top of the wing and see how it balances.
- b) Move the parts around if needed to get the plane balanced.
- c) Mark the location of the components.
- d) Increasing battery size is a better choice than adding lead but sometimes a little lead in the nose is the best option if you don't have the right battery or you don't have enough room for a bigger battery.
- e) With the center spar on the CG, anything ahead of the spar will move the CG forward and anything behind the CG will move it back.
- f) Most flying wings tend to be tail heavy so you usually can be generous with your battery size to help balance the wing.
- g) The CG is close to 23% of total wing area including elevons. This means 77% of the wing and the motor are behind the CG.

**Installing the electronics.**

- a) Pre- test the motor, batteries, ESCS, receivers and servos that you plan to install to know everything is working.
- b) Look at the length of the wires between the battery and ESC and the ESC and the receiver. This often will influence where you will install the radio.
- c) Spread your servos wide enough apart so that the servo arms will have a good angle to the horns on the elevons. The servos will need to be 12"-20" apart. Make sure the servo electrical wires will reach before you cut your holes. (You may need to use a servo extension or two depending on your servos.)
- d) Move the battery forward or back to get the CG at 9" back.
- e) Install the servos.
- f) The radio slot can be cut deep and wide enough to allow you to put the ESC and receiver on their side in the slot or you can cut separate compartments for the battery, ESC and receiver and connect them with razor blade slits for the wires to be pressed into the foam. Put clear shipping tape or laminate over any slit or slot with wires.
- g) The wing is stronger if you don't leave any empty space in the wing so cut out compartments that fit parts tightly.
- h) Once all components are installed hot glue the servos securely in place with only glue around the sides and not under the servo so you can remove it later if needed without damaging the plane.
- i) You can use Velcro straps to secure the battery, ESC and receiver as needed. In some cases I have used clear tape to secure the radio but make sure the ESC has adequate ventilation so it doesn't overheat.
- j) Secure all parts so they can't fall out or get knocked out in an accident.

After determining best location draw cut outs on wing.

Use soldering iron or razor blade to cut out foam.



Use hobby knife to punch hole for elevon horns.



Enlarge hole slightly with soldering iron for glue.



Glue horns in place working glue up through slit.



Apply glue on the top of the wing to secure horn.



Drill out TOP hole in horn for EZ connector with 1/16th bit.



Insert EZ connector in top hole and put snap ring on.



Cut out battery compartment. Keep it tight.



Pull the foam out in small sections.



Cut a slot for the ESC and receiver.



Cut slits and push the servo wires into the foam.



Glue servos in place. Put clear tape over wire slit.



Punch hole for staple to make pushrod wire guide.



Put glue in hole and press staple into place.



Wire guide should be tight enough to keep pushrod from flexing.



Cut pushrods to length.



Cut slits for velcro strap to hold battery in place.



Place battery in place and secure with the Velcro.



Fit ESC into slot. Enlarge hole for air flow to cool ESC.



Adjust elevon to be up 1/4".



Angle of bottom of elevon should be angle of bottom of wing.



### **PUSH RODS AND SERVO HORNS**

- a) Put your push rods on the outside of the servo arms to get the maximum width. This allows you to place your push rod slightly further out on the elevon, reducing the force required to move the entire elevon, and reducing any chance of twist in the elevon. You will want to use the hole closest to the servo.
- g) Use the push rod to measure directly back from the hole in the servo arm, and place a mark on the front edge of the elevon. Depending on your servo, you may need to use a small drill bit to widen the hole in the servo arm, so that the rod fits through.
- h) Use a sharp blade and cut a slit completely through the elevon where you want the horn. The mark you made in the previous step should be the *inside edge* of that slot, not the center to allow enough room for the EZ Connector on the servo horn.
- i) Remove the extra tab that comes attached on the back of the servo horns.
- j) Push the servo horns partway up through the bottom of the elevon.
- k) Use hot glue along the base of the servo horn, and down through the melted slot, around the horn, to keep horn in place. Push the horn in the rest of the way so that the base is flat against the bottom of the elevon. As the hot glue dries, make sure the horn is facing straight forward.
- l) Your horns should point towards the servos, and the front of the horn should be close to the hinge line for the best leverage.
- m) Attach the EZ Connectors to the control horns with a pair of pliers to the top hole in the control horn.
- n) Remove the servo arms, slide the push rod Z-bend through the hole in the servo arm. Place the end of the push rod through the EZ Connector, then set the servo arm back on the servo.
- o) Mark a spot on the wing about halfway between the servo and the elevon, directly underneath the push rod.
- p) Remove the push rod, and use your soldering iron to melt a hole at the mark you just made. This hole should be wide enough and deep enough that the push rod guide (the metal staple included in the kit) can sit in it, and extend just over the push rod.
- q) Fill the hole with hot glue, and set the push rod guide (staple) in place. Hold it there while the glue dries. The staple keeps the push rod from flexing to the sides/up and down to keep the rod more stable.

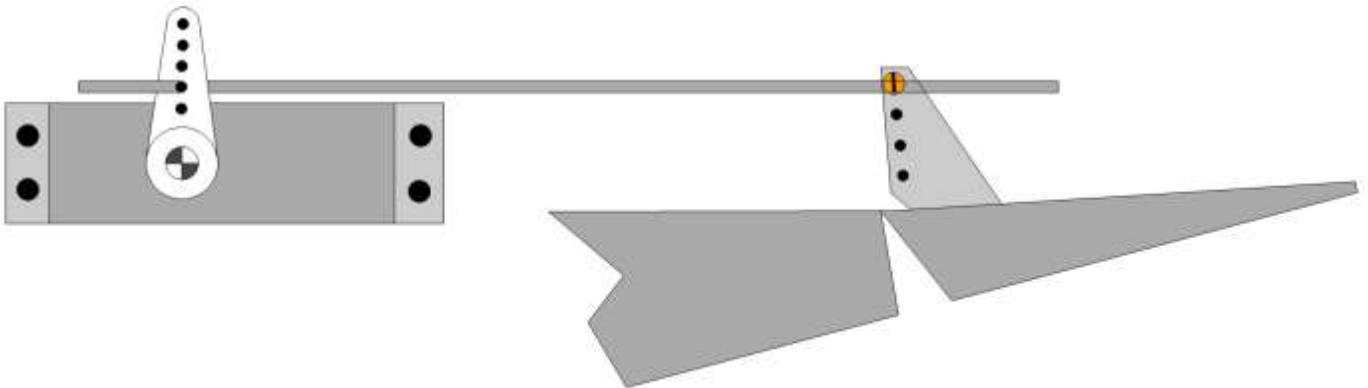
### BATTERY BAY – VELCRO RETENTION STRAPS

- a) To hold the battery in place during flight, you can install Velcro strap or use clear tape. A simple way to install Velcro is to cut a slit through the bottom front of the battery hole and one through the bottom in the middle of the slot that contains the radio and then feed the Velcro through and fasten it on the top of the wing. You can use either tape or velcro to secure the receiver, speed control, and wires in place. See photo above.

### PUSH RODS & ELECTRONICS TESTING

- a) You will need elevon, delta or programmable mixing to mix the aileron and elevator channels to fly a plane with elevons.
- b) Consult your radio manual for help if needed. On the Spektrum DX6i you may want to do manual mixing as described on our web site.
- c) Remove the servo arms from the servos. Connect all electronics, including a battery, but for safety purposes, make sure you do not have prop attached to your motor at this point. Turn on your transmitter(tx) and allow the servo gears to “center” themselves.
- d) Slide the push rod through the closest hole to the servo in the servo arm (still unattached to the servo), then slide the end of the push rod through the guide, and into the EZ Connector on the elevon. Then re-attach the servo arm to the servo so that the arm is perpendicular to the push rod.

# Maximize Leverage



- e) With the EZ Connectors still loose, center the Subtrim function on your transmitter then put the servo arms perpendicular to the push rod.
- f) Let the EZ Connector slide over the push rod as you lift your elevon so that the angle of the top of the elevon is parallel to the bottom of the wing. This is an approximate angle and may need to be adjusted during test flights depending on CG and weight. This is called **REFLEX** and is used on all flying wings and deltas.
- g) Once in place, tighten the set screw on the EZ connector, and use snips to trim off excess push rod.
- h) Repeat on other elevon and set it at the same angle.....
  
- i) Set the wing on a flat surface, and hold a ruler vertically next to the trailing edge of each elevon. Use your tx to set the throw (range of movement) on the elevons to 3/8" (1cm) up and 3/8" down. Make sure your stick movement translates to the proper up/down on your elevons:

STICK UP	Both elevons down	NOSE DOWN
STICK DOWN	Both elevons up	NOSE UP
STICK LEFT	Left elevon up / Right elevon down	ROLL LEFT
STICK RIGHT	Right elevon up / Left elevon down	ROLL RIGHT

### **ELECTRONICS COVERING, DECALS, & FINIS**

- a) After testing all electronics, cover your receiver, ESC, and the slots you buried wires in with clear tape and/or laminate to keep the radio from ejecting in an accident. The ESC gets hot and needs ventilation. The receiver and wires do not.
- b) Add any other decals as you wish, but be careful not to add so much that it changes the Center of Gravity. *The lighter, the better!*
- c) Install prop with numbers facing the plane (if prop is installed backwards, it will not give you the necessary power).
- d) Test the throttle and make sure the motor is turning in the correct direction (air blows to the back of the plane). If not, unplug two of the three connectors between the motor and the ESC and reverse them. Try again.
- e) Check your CG, the throw on the elevons, your linkages and reflex (slight up trim on the elevons) before launching.
- f) It's always a good idea to have someone else double check your work. Field test and range check your equipment, then launch, trim, and enjoy!

### **LAUNCHING**

**Launching from the wingtip is an art form and hard for many new flyers.** In the videos you see us launch our flying wings holding the plane by a wingtip while swinging it forward. We are setting the plane on the air without Frisbee spinning the plane. If you spin the plane at all the outside wing will have more lift because it is moving faster and the plane will roll the opposite direction and hit the ground. If you have any trouble, launch from the center of the plane with fingers on each side of the motor and toss the plane at the horizon. Don't throttle up till your hand is clear of the propeller.

### **The most common problems we see are:**

- a) **CG too far back.** Flying wings will not fly tail heavy. A good sign you are tail heavy is you can't control the plane or the plane won't stay trimmed. When you try to loop the plane will roll over. Add weight to the nose to see if the problems resolve. It is not uncommon to need an extra ounce or two of lead depending on how light you build.
- b) **Too much movement in the elevons** so the plane stalls on launch as you pull up on the elevator. Our planes have huge elevons to decrease drag so they don't need as much movement in the elevons as planes with small elevons. This is a very common problem!!!! May be combined or confused with tail heavy airplane symptoms.
- c) **Loose servos in the foam, linkages and push rods that flex, and poor leverage with push rods not installed per plans, elevons are too soft and twisting.**

**We design our planes to use the same inexpensive motors, ESCs, batteries and servos to save you money and keep you flying.**

Try all of our planes. They each have their own personality. If you are a new flyer and having trouble learning, spend some time on a simulator or get some hours on one of our slow fly planes like the Storm Chaser or Albatross to help you learn to fly.