Merlin Missile Solutions

Unique Solutions for High Performance Rocketry

The Sword

Lance Knoechel, Designer

THE SWORD Assembly Guide

Congratulations on your purchase of Merlin Missile Solutions' first rocket kit, *THE SWORD*! You will find its materials and this detailed assembly guide to be of superb quality. Coupled with your patient craftsmanship, the result will be a truly unique rocket that you will be proud to have in your fleet.

We strongly recommend that you carefully read, understand, and follow each step in this assembly guide in the order given. It is also a good idea to test fit all parts before gluing. If you have any questions, please contact us for clarification ***before*** you begin.

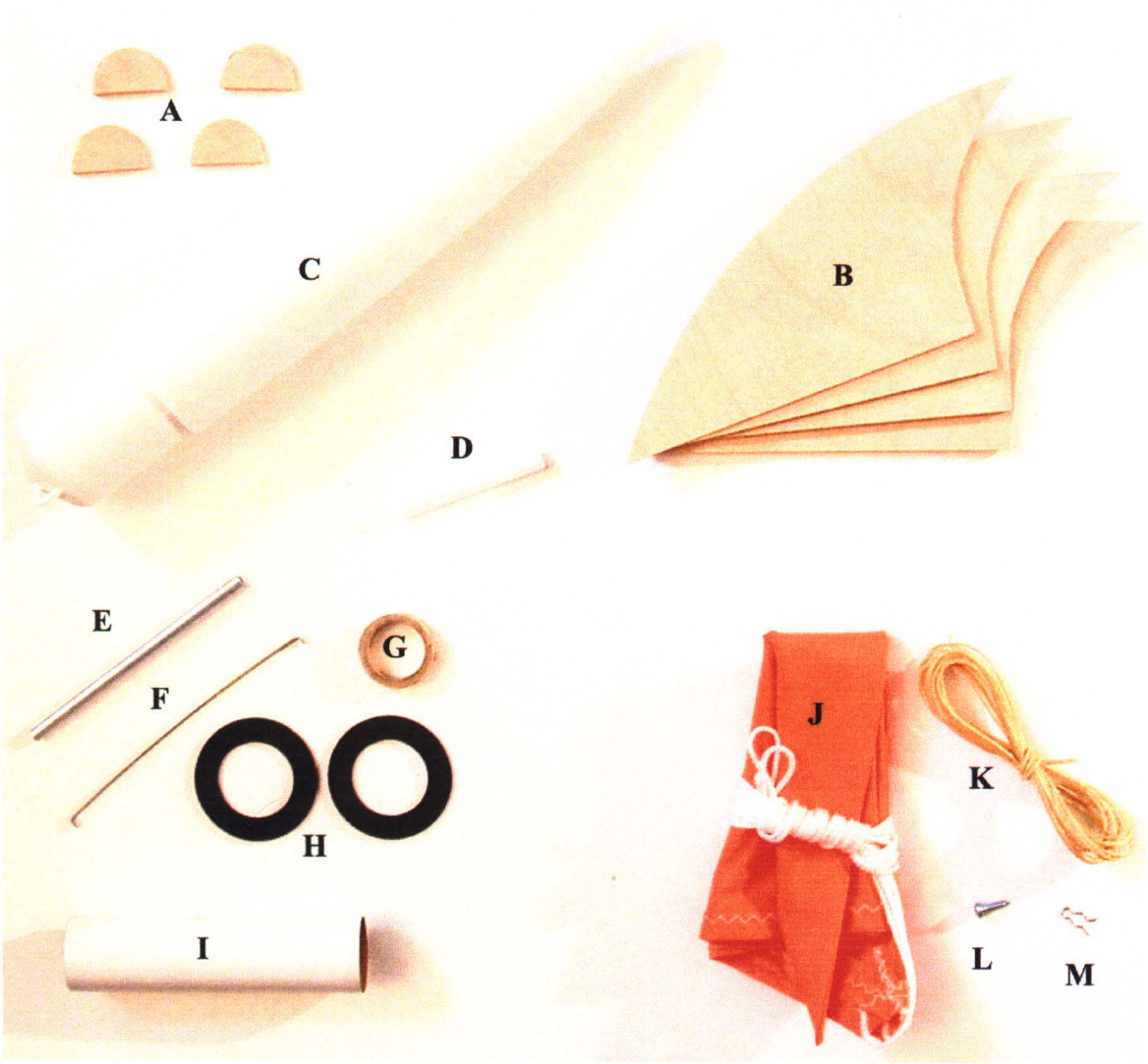

Figure A - Parts

Parts List – The following items should be contained in your kit. Though we make every effort to ensure that all parts are included, please verify that there are no discrepancies ***before*** you begin. Contact us immediately for any shortage.

- ❑ 1 – This Assembly Guide
- ❑ 2 – Large, upper fin attachment templates (at the end of this assembly guide)
- ❑ 2 – Small, lower fin attachment templates (at the end of this assembly guide)
- ❑ 1 – 34" BT60 body tube (not shown in Figure A)
- ❑ 1 – 2" BT60 coupler (not shown in Figure A)
- ❑ 4 – lower, smaller fins (A)
- ❑ 4 – upper, larger fins (B)
- ❑ 1 – 8" LOC/Precision 1.52 nose cone (C)
- ❑ 1 – 3/16" launch lug (D)
- ❑ 1 – Motor mount assembly (bag marked with a red dot) includes:
  - ❑ 1 – 2 7/8 x 3/16" aluminum tube (E)
  - ❑ 1 – E-size engine hook (F)
  - ❑ 1 – thrust ring (G)
  - ❑ 2 – motor tube centering rings (H)
  - ❑ 1 – 3 ¾" 24mm E motor tube (I)
- ❑ 1 – Recovery package (bag marked with a blue dot) includes:
  - ❑ 1 – Top Flight Recovery 18", 6-line parachute (J)
  - ❑ 1 – 12' #346 Kevlar bonded thread (K)
  - ❑ 1 – #4 x 3/8" screw (L)
  - ❑ 1 – 1/8" hitch pin (M)
- ❑ Additional items needed, but not included:
  - ❑ 1 ½" Masking tape
  - ❑ Cardboard or sturdy paper board
  - ❑ Sandpaper (various grits are helpful)
  - ❑ Thick CA adhesive (with accelerator if preferred)
  - ❑ Epoxy (30 minute cure time is strongest)
  - ❑ Hobby knife
  - ❑ Pencil
  - ❑ Drill, 5/32" & 3/16" drill bits
  - ❑ Tape measure or ruler
  - ❑ Finishing and painting supplies
  - ❑ Motors
  - ❑ Launch equipment

- **Motor Mount** – Since most any shock cord will deteriorate over time and use, *THE SWORD's* motor mount is designed to allow for easy access to the aft attachment of the Kevlar shock cord for maintenance and/or replacement. Ensure that you completely understand the construction of the motor mount before proceeding. See Figure B.

Figure B – Completed Motor Mount

- Roughen the surface of the motor tube with medium-grit sandpaper. This will help to ensure that the epoxy will adhere properly.
- Place a mark 3/8 of an inch from each end of the motor tube and another mark 5/8 of an inch from the end of the motor tube. This will be the *forward* end of the motor tube.
- With a hobby knife, cut a 1/8" wide slit along the circumference of the forward 3/8" mark. Attach the engine hook to the motor tube by placing one of its hooks into the 1/8" slit in the motor tube. The engine hook should be flat against the long section of the tube.
- Using a 5/32" bit, drill a hole in the middle between the inside and outside diameter of *one* of the centering rings. This will be the *forward* ring. Note: it may be easier to drill this hole and the next at the same time (warning--there are two different sized holes, so drill the smaller dimension first, then open up one of the rings to the larger diameter).
- Using a 13/64" bit, drill a hole in the middle between the inside and outside diameter of *second* centering ring. This will be the *aft* centering ring.
- Slide the centering rings onto the motor tube, over the engine hook, with the drilled holes on the opposite side of the engine hook. Do not glue, yet.
- Using medium-grit sandpaper, abrade the aluminum tube along its entire length and ends to make certain the epoxy will fuse to it.
- Using a drill bit, sandpaper and/or a small rounded file, lightly chamfer one of the inside ends of the aluminum tube. This will be the forward end of the aluminum tube. This will assist the threading of the Kevlar through the tube and reduce friction that may cut into the cord over time.
- Insert the aluminum tube through the hole in the aft centering ring until it fits snugly against the hole in the forward centering ring. A wax paper-covered toothpick slid into the forward

end of the aluminum tube will help hold it in place and ensure that the inner diameter of the aluminum tube matches up with the hole in the forward centering ring.

- After confirming that all parts of the motor mount fit properly, dab *small* amounts of epoxy onto the various connections of the assembly. Make sure not to get any epoxy inside the aluminum tube.
- Once the epoxy tacks have cured, remove the toothpick from the aluminum tube.
- This is an important step to ensure a strong motor mount and will help to avoid a "punch through". Using epoxy, make fillets around both sides of each of the centering rings where they meet the motor tube, around the aluminum tube where it attaches to the centering rings, and along the aluminum tube where it almost touches the body tube. Take your time with this step. It requires a little patience for the epoxy to cure. Let gravity do the work for you, not against you. Allow the motor mount to thoroughly cure before proceeding to the next step.
- Inside the first ¼ inch of the forward end of the motor tube, add epoxy around the entire circumference.
- Insert the thrust ring into the forward end of the motor tube until it seats against the engine hook protruding into the motor tube. Allow epoxy to cure.
- Using medium-grit sandpaper, roughen the first four inches of the interior of the body tube.
- Using a tongue depressor or similar stick, liberally add epoxy to the entire inner circumference from 3 to 4 inches inside of the body tube.
- Insert the completed motor mount ONLY half way into the body tube.
- Working around the partially inserted motor mount, liberally add epoxy to the entire circumference of the first inch inside the body tube.
- Completely insert motor mount so that the aft of the motor tube is flush with the aft of the body tube.
- Brace the body tube, with the forward end pointing up and allow to fully cure before proceeding to the next step. This will create strong internal fillets where the motor mount meets the body tube.

- **Fins** – The fins are made of 1/8" birch plywood. Not being a competition rocket, it is not necessary to put a sharp bevel on the fins and, in fact, will weaken them. Instead, a slight rounding of the forward edges of the large upper fins and the same rounding around the outside edges of the lower fins will ensure their strength and provide a beautiful appearance for *The Sword*. If rounding of the edges is preferred, it is best to perform this task before attaching the fins to the airframe. In addition, if a smooth finish is desired on the fins, quality grain filler may be used and/or sanding may be done before attaching the fins. Attempting to finish the fins after attachment is more awkward and may cause undue stress on the fin joints. If using grain filler on the fins, do not use on the first ¼ inch of the root edge of the fins. This will allow the epoxy to adhere better.

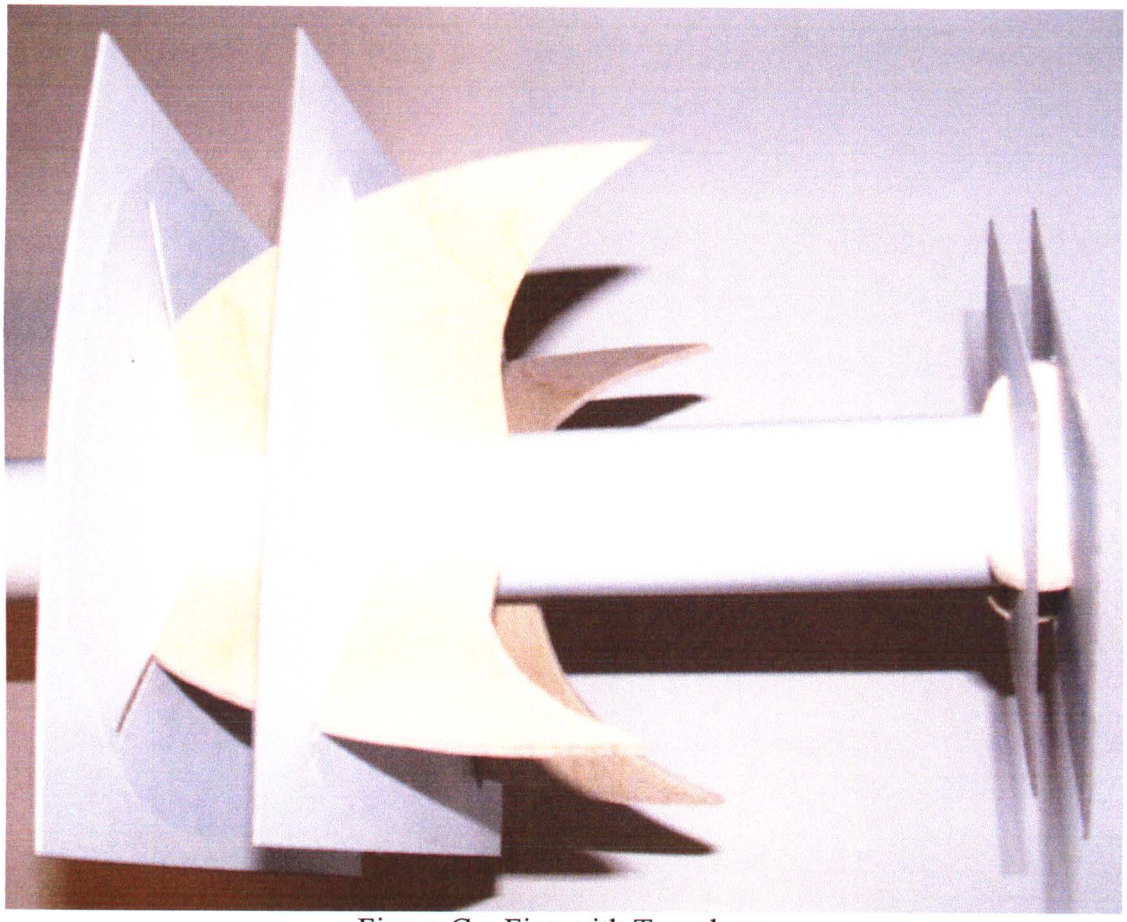

Figure C – Fins with Templates

- Using light to medium sandpaper, roughen the first 1 ¼" of the surface of the aft end of the body tube and from 5 ¼" to 10 ¼" of the aft end of the body tube. This will provide better bonding for the fins.
- Glue each of the fin templates (located at the end of this Assembly Guide) to sturdy paperboard or cardboard. Allow to thoroughly dry.
- With a hobby knife, carefully cut out the outline of the body tube & fins from each of the four, now stiff, fin templates.
- Using an aluminum angle or straight doorframe, draw a straight line from the aft end to about 11" up the airframe. This will be your fin template centering line and launch lug line.
- Place a mark 10" from the aft end of the body tube.
- Using a straight piece of paper, wrap around the body tube at the 10" mark you just made so that the straight edges of the paper meet. Draw a line around the circumference of the body tube along the straight edge of the paper. This will be the forward mark for the upper fins.
- Making sure all fin templates are facing the same direction, first slide onto the airframe from the aft end both large fin templates, then the smaller fin templates.
- Insert the four large upper fins into the templates, aligning the forward tips to the 10" mark made around the body tube. Align the centering marks on the templates to the centerline you marked on the airframe. Make sure the fins are tight against the airframe.
- Insert and align the small lower fins into the templates. The aft end of the lower fins should be flush with the aft end of the airframe.

- ❑ Review the alignment of all fins to ensure they are straight and tight against the airframe. Adjust if needed.
- ❑ Tack each fin with just a small dab of thick CA or a little epoxy at each end and on each side of the fins. Allow to thoroughly cure.
- ❑ Carefully remove the fin templates, cutting if needed, and confirm the proper alignment of the fins. Redo if necessary.
- ❑ Apply an epoxy fillet to both sides of each fin. Carefully smooth the epoxy with a tongue depressor or plastic spoon before it sets up. Allow the epoxy to partially cure before rotating the airframe to do the next set of fins.

❑ **Launch Lugs** – During this step, be careful not to get any epoxy inside of the launch lugs. Even a small amount of epoxy can cause the rocket to lock up on the launch rod.

- ❑ Cut the launch lug in half, at a 45-degree angle.
- ❑ With the angled end of one of the two launch lugs pointing forward and the long end against the body tube, epoxy the launch lug along the centering line, with the aft end of the lug flush with the aft end of the airframe.
- ❑ With the angled end of the remaining launch lug pointing forward and the long end against the body tube, epoxy the launch lug along the centering line, with the forward end of the lug aligned with the 10" mark on the airframe.
- ❑ After the epoxy has cured, create epoxy fillets on each side of both launch lugs. Allow one side to fully cure before doing the other side.

❑ Shock Cord

Glue the BT-60 Coupler inside the forward end of the airframe so that it is flush with the end of the body tube. You may need to chamfer the inside of the body tube and outside of the coupler with your fingernail for it to slide into the airframe. This will strengthen the end of the body tube to help avoid zippers and provide a more snug fit for the nose cone.

- ❑ Attach one end of the Kevlar cord to the hitch pin, using the bowline knot show in Figure D.

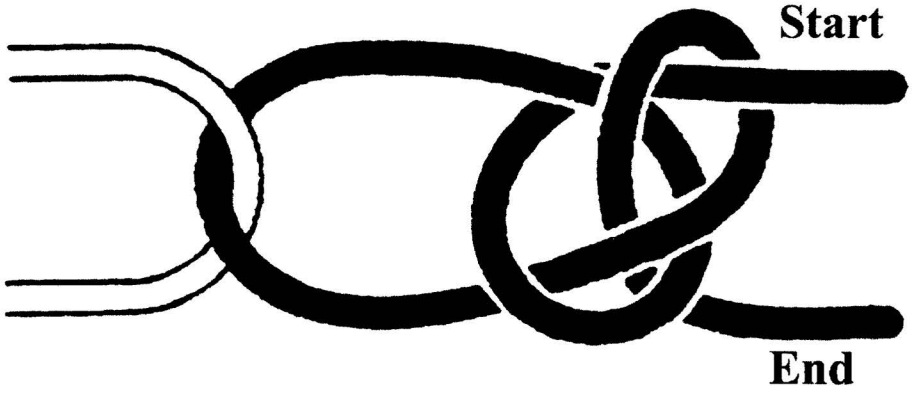

Figure D – Bowline Knot

- Dab a small amount of epoxy or CA onto the knot to help ensure it doesn't come loose.
- Feed the free end of the Kevlar cord through the 3/16" aluminum tube located in the motor mount, out through the forward end of the body tube.
- Secure the hitch pin by screwing the #4 x 3/8" screw into the end of the aluminum tube. The two ends of the hitch pin may need to be bent slightly flat to keep the hitch pin from sliding into the aluminum tube.
- Tie an overhand ½" loop knot 2/3 of the way up the Kevlar thread.
- Using the same knot as used to tie the Kevlar to the hitch pin, connect the shock cord to the nose cone.
- Dab a small amount of epoxy or CA onto the knot to help ensure it doesn't come loose.
- The nose cone may be slightly loose in the body tube. Wrap some 1 ½" masking tape around the neck of the nose cone until it fits snugly into the airframe.
- Attach the parachute to the loop knot. Using a clip style swivel will help with maintenance and reduce tangling upon rocket decent.

Finishing

- Fillets should be sanded smooth. More shapely fillets can be made on top of the epoxy with Testors' Contour Putty, Elmer's Fill N Finish or Poly Fiber's Super Fil.
- The nose cone will need some sanding to remove the mold seams. In addition, the tip of the nose cone may be sanded slightly to make it a finer point.
- Use only white or light gray primer. Metallic paints do not provide sufficient coverage for dark primers.
- See Figure E for the Paint Scheme

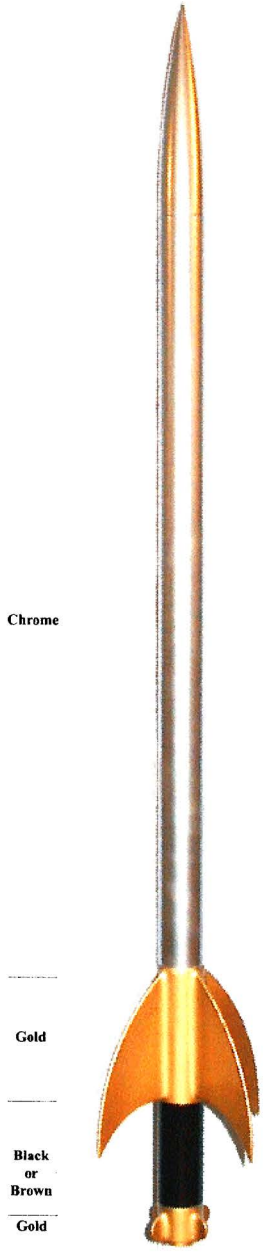

Figure E - Paint Scheme

- **Flight Preparation & Launching**
  - Make sure you load a sufficient amount of fire-retardant wadding into the airframe prior to packing the chute.
  - The Sword will fly on most any 24mm E or F motor (See the tested motor list, below). Make sure to follow all motor manufacturers instructions carefully.

- **Additional Information**
  - Center of Pressure (Barrowman): 32.904 inches
  - Center of Pressure (RockSim): 33.860 inches
  - Tested Motors: Estes E9-4, Aerotech E28-4, Aerotech F24-4

Happy Flying!!!

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THE SWORD Addendum

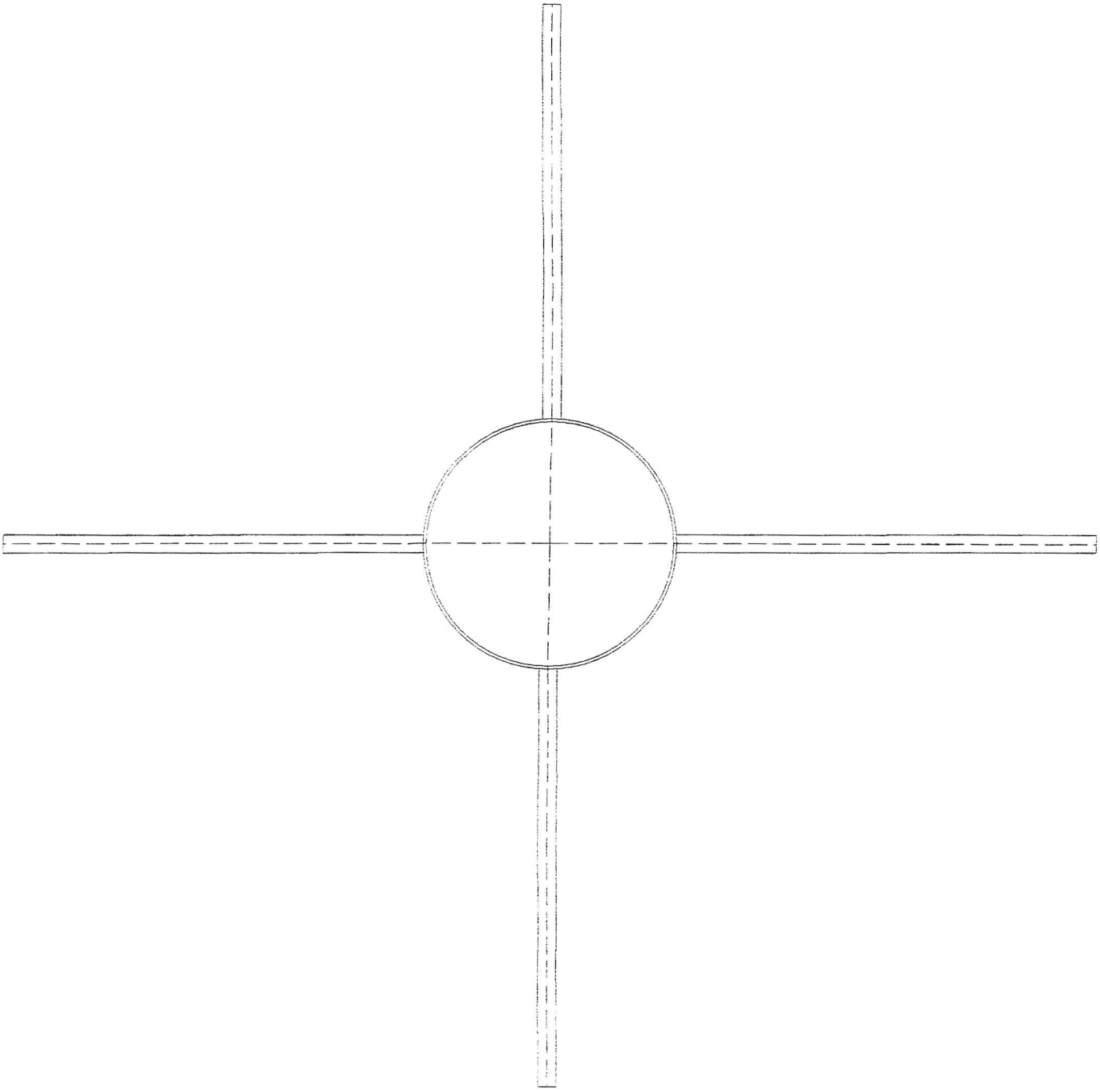
In February of 2004, Chan Stevens purchased one of the first SWORD kits (#6 to be exact). Chan was kind enough to share his experience with the building of this kit and has published a review of THE SWORD in EMRR (www.rocketreviews.com/reviews/kits/merlin_sword.html). Chan's input has been invaluable in the development of this Addendum and the improvement of future rocket kits from Merlin Missile Solutions.

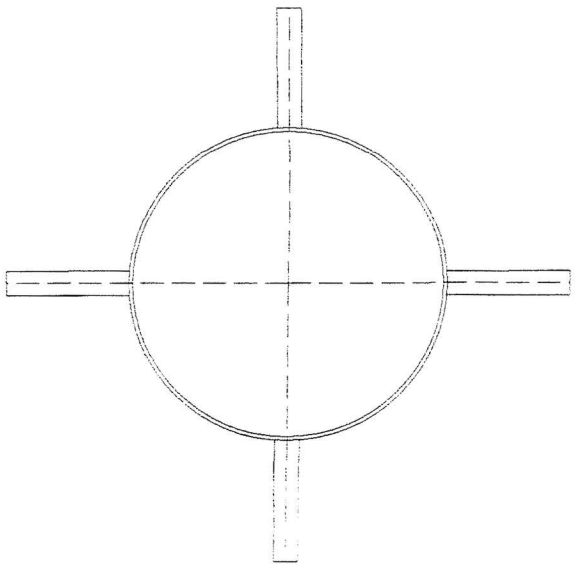
A 2" BT-60 coupler has been added to the kit. Prior to installing the shock cord, glue the BT-60 coupler inside the forward end of the airframe so that it is flush with the end of the body tube. You may need to chamfer the inside of the body tube and outside of the coupler with your fingernail for it to slide into the airframe. This will strengthen the end of the body tube to help avoid zippers and provide a more snug fit for the nose cone.

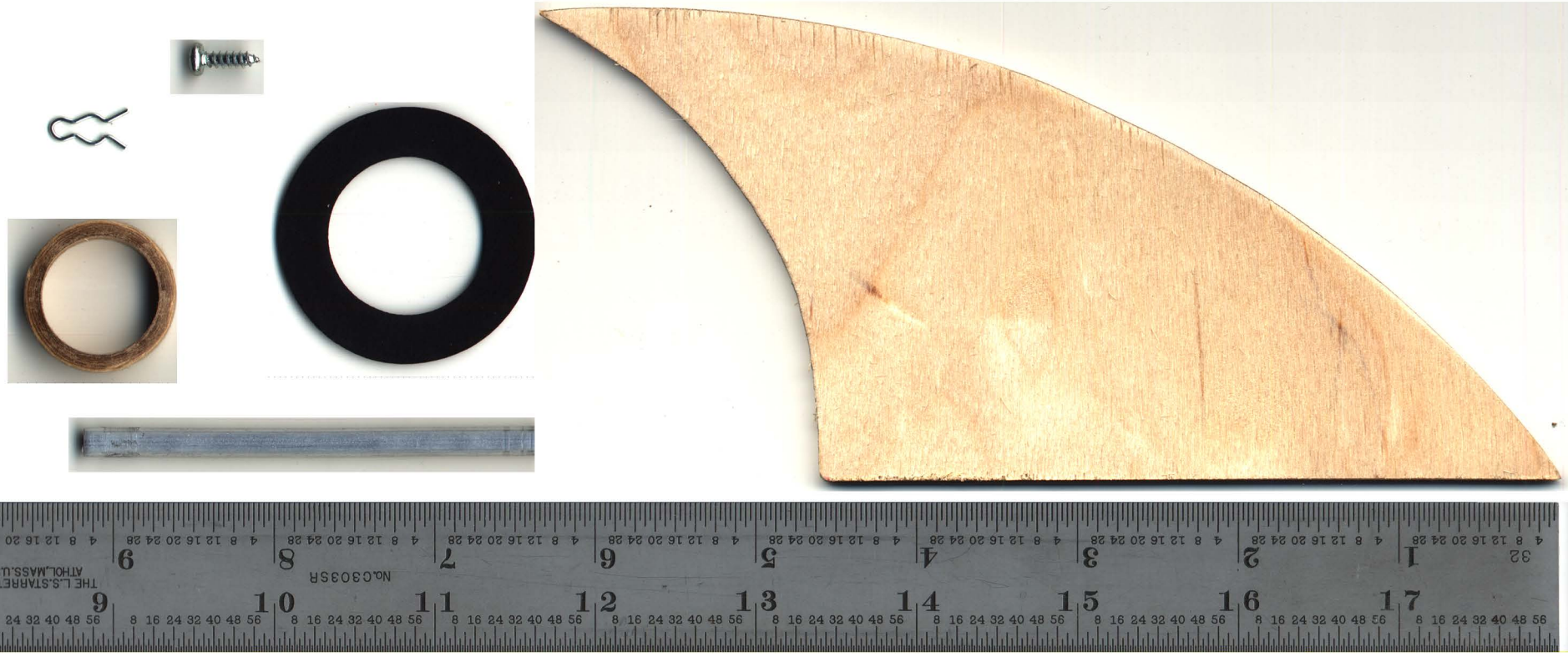
When drilling the holes in the centering rings, it may be easier to drill both at the same time (warning--there are two different sized holes, so drill the smaller dimension first, then open up one of the rings to the larger diameter). You'll need some uncommon drill bits for this--5/32" and 13/64", though 7/32 could work for the larger.

When chamfering the aluminum tube, lightly chamfer only one of the inside ends of the aluminum tube. This will be the forward end of the aluminum tube. This will assist the threading of the Kevlar through the tube and reduce friction that may cut into the cord over time.

The original Sword used a much lighter nose cone that soon became unavailable. Its replacement, the much heavier LOC/Precision resin cast nose cone increases the weight of The Sword considerably. The increased weight may not allow for the use of "D" motors and the E9-4's should be used in place of the E9-6's.





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