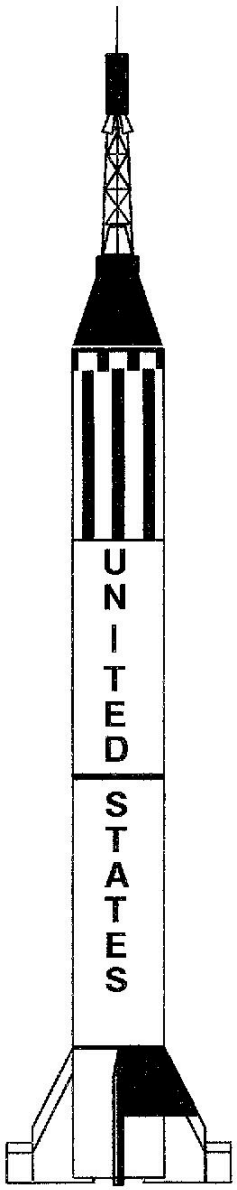
AeroVentures

MERCURY-REDSTONE



AeroVentures Industries

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CONSTRUCTION MANUAL

1. A good reference shot.
2. A view of the escape tower nozzles.
3. Escape tower and nozzles.
4. Aft segment and launch ring.
5. Launch ring. Note the cross support for the launch rod.
6. Capsule parachute attachment.
7. Drogue canister. Note shape of top (sanded to shape).
8. The busy end of the rocket. You can see the parachute attachments. (primary and mortar)
9. Underside of capsule with no electronics installed (except switch jacks).
10. Escape tower showing closet rod plug and groove for capsule parachute attachment.
11. Liftoff at LDRS XV. The first flight of the prototype.
12. Recovery of rocket after first flight.
13. Flight #2 climbing into a clear Florida sky.
14. Aft (booster) segment, completed fins, and a few bulkheads.
15. Completed capsule ready for structural covering. The 4" top is NOT glued on yet.
16. During assembly. Note the cross braces on the lower half of the upper segment. They are not required on the upper half because the 4" tube adds stiffness. Extending it to the lower bulkhead would probably be O.K.
17. A segment of a similar rocket (not Redstone) ready for covering. Note the lines marked on the poster board.
18. Some bulkheads.
19. An end view of some completed fins.

INTRODUCTION

We have developed this unique set of plans for several reasons. The most obvious is to keep the cost down. The modeler may add the miscellaneous parts as construction, time or the budget dictates. By not supplying the wood, the modeler can make use of existing stock or hand select each piece for its particular purpose. Poster board is difficult to ship without damage and there is always one of those discount city type stores around the corner. Due to the low weight and low altitude of the model, parachute size is not critical and most experienced rocketeers should have just about all the chutes they will need.

Everyone has their own favorite adhesive but some guidelines will be presented here. This is also a good time to mention that a lot of modelers like to add that extra glue or fiberglass wrap for added strength. Various rockets of this type of construction have hit the ground at terminal velocity for one reason or another with minimal damage. The light weight construction really works well. Remember that kinetic energy thing($1/2\ M*V^2$). Well keeping the mass low works wonders for all aspects of a flight vehicle. Four basic types of adhesives are used (spray adhesive, contact cement, medium and thin Cyanoacrylate(CA), and quick-set epoxy) throughout construction and the builder is advised when each is appropriate. Make sure all parts fit together well and use the glue sparingly. That weight adds up fast. Properly glued joints are always stronger than the base material.

We have tried to make the instructions as complete as possible and cover the wide variety of backgrounds of our builders. We ask that you follow the instruction carefully and understand each step BEFORE you carry it out. This certainly doesn't mean you shouldn't customize your model. After all it is YOUR model. You must also decide how scale your model will be before starting construction.

FINISHING

If you are a true scale buff, you should have several references on hand during construction. You can produce the envy of all space modelers. If painting is your preferred finish, it is recommended that you use one of the iron on coverings such as Coverite that accept paint. They add considerable strength to the model and provide a nice base for the paint. We highly recommend the pre-colored iron on coverings such as Monokote. They are very light weight and provide a quick, durable, and attractive finish. The iron on coverings tend to cover a lot of imperfections and surface flaws. If you haven't used an iron covering and have never seen them, we recommend that you find the local R/C club. Check the local hobby shop for the club nearest you. A look at some typical airplanes covered with the iron coverings will make it very clear what you can accomplish. You will be amazed how well those little cracks and voids cover up. The iron on coverings are durable and easily repaired. The prototype vehicle was covered entirely with Monokote. The only paint on the entire model was on the escape tower.

CONSTRUCTION MANUAL

The manual is written to address the level of all potential builders. The instructions are purposely printed on one side so the builder can make notes or comments on the facing page. The manual has a section on covering to give some basic guidelines. Of course read and understand the manufacture's directions that came with the covering also. The included tips will help in the actual covering sequence.

SYSTEM OPERATION

Every modeler has a favorite method of parachute deployment. We will briefly describe the method used on the prototype for completeness. The main rocket uses 2 parachutes that are 4' diameter each. One would probably have worked fine but we wanted the rocket to descend slowly. It wasn't expected to go very high so drift would not be a problem. The capsule and escape tower each have 30" diameter parachutes. There is also a 4' reserve parachute in the main rocket. The capsule has 1 liftoff timer. The main rocket has an altimeter and R/C backup system.

The liftoff timer in the capsule was set to go off at apogee according to a computer simulation. The timer ignited a standard flashbulb under the capsule and tower parachutes located in the top of the capsule. This blew the parachutes out and the tower completely off. The tower was not attached to the capsule to avoid damage on the way down. The capsule parachute would deploy and pull the capsule from the main rocket. The capsule was attached to a deployment bag that encased only one of the main parachutes (the one on the bottom). The capsule would pull the parachutes out and strip the deployment bag at line stretch. The main parachutes would inflate and every thing would be on it's way down. The capsule was NOT attached to the main rocket. In the event of a timer or charge malfunction in the capsule, the altimeter in the rocket was programmed to blow a flashbulb charge under the main parachutes at apogee. A piston was not used to save weight, and this was a back-up. In retrospect, a piston is probably the best method to use for the main parachutes, even as a backup. A blow-by failure on the second flight necessitated using the back-up parachute system. The single deployment bag philosophy went something like this. If everything worked as planned and the capsule separated but did not strip the bag, the main parachute that was not in a deployment bag would inflate. If the capsule timer failed and the backup (altimeter) activated, the un-bagged parachute would inflate. The deployment bag was on the bottom of the parachute stack to help pull both parachutes out if the capsule fired as planned. Then the capsule would strip the bag and return on it's own. This may sound a little complicated but it really wasn't that bad and allowed redundancy. You may of course choose to do something different.

If the capsule charge does not fire, the altimeter will blow the capsule off and deploy the main parachutes. The capsule will free fall to the ground. It was decided not to attach a parachute to the bottom of the capsule for scale reasons. In fact, on the maiden flight of the Mercury-Redstone the capsule timer did not fire. It was inadvertently not wired. The capsule and tower hit the ground and only broke a few glue joints on the escape tower. It was ready to fly again in 5 minutes with no visible signs of damage. A second timer could be used in the rocket instead of an altimeter. We simply used an altimeter to also record the altitude of the flight. An altimeter could be creatively wired to blow the escape tower and the capsule but we wanted some redundancy. It is tough to loose such a neat rocket over a bad $1.00 flashbulb, battery, wire, powder or whatever. A redundant timer seems like cheap insurance when you think of the time we put into some of our rocket projects. In fact on the second and subsequent flights, a backup timer was also added to the capsule.

There are some non-traditional rocket building techniques employed in the Mercury-Redstone. The goal was to keep the rocket inexpensive and light. The desire was to have a large scale rocket with scale-like liftoffs. The low altitude allows for a great view of parachute deplyment. You can also use larger than normal parachutes for soft landings and not worry about the rocket drifting away. If you deviate from the plans, the final weight of the rocket could be affected significantly. The rocket actually builds quick once you prepare all the parts. The best way to build this rocket is to make all the parts and then assemble it. You will find the entire rocket can be assembled very quickly.

ADHESIVES

There are several types of adhesives (glue) available to the modeler today. Too many times we hear people state that they only use one type of glue. This is not good. There are certain advantages for each type of glue and you should use the glue that is most appropriate for each situation. Throughout this manual the construction steps will give recommendations for the most appropriate type of glue. These are only recommendations but the logic should be apparent at each step. Everyone has their own opinion about glues but we will cover some basics for those not so familiar.

Cyanoacrylates (CA)

CA is probably the most widely used model glue today. It is of the 'instant' variety, also known as 'super glue'. There are several brand names (Jet, Zap, Hot Stuff, etc.) that are distributed by the hobby industry. Each manufacturer/distributer will make various claims about their brand but most modelers agree that the different brands are of similar quality and work equally well. All brands are offered in various viscosity's or thicknesses. There is basically three that most modelers are familiar with, thin, medium and thick.

Thin CA is used when a joint already fits tight and you want the glue to 'wick' or soak into a joint. A good example is gluing several pieces of sheeting together to make a large sheet. It sets very fast (1 sec). Medium is probably used the most and works more like traditional glue. You can apply it to one piece and then join a mating piece. It sets a little slower than the thin (about 5 sec) and allows a little more freedom in positioning the parts. Thick allows the builder to reposition parts a little more and tends to fill gaps better. Of course you should NOT have gaps and all parts should fit properly. There are special ones that are safe to use on foam and might be used when dealing with the fins. Use the CA sparingly here as it will eat the foam in large amounts even though is is not supposed to.

Epoxy

Epoxy is two parts mixed together. You only mix the amount you will immediately use. Epoxy comes in various brands and in various 'set times'. The set time can be anywhere from 5 minutes to 24 hours. The most popular ones are 5 min, 15 min, 1 hour and overnight. The 5 minute variety should be adequate for this type of model. If more working time is desired, a slower setting type may be used.

Spray Adhesive

Spray adhesive is a special use glue that has a place here. It was used to glue the sheeting to the fins. There are old wives tales of it pulling up from the foam but if the surfaces are properly prepared and the glue is used properly, you won't have any problems. The surfaces should be vacuumed and wiped with a damp cloth. There are various brands but modelers seem to have the best luck with Scotch brand 3M-77. Wal-mart, K-Mart, hardware store, home improvement stores, and some hobby shops will carry it.

Contact Cement

Contact cement comes in various types. Most generic ones will work fine for gluing the posterboard to the stringers and bulkheads. You should test the glue you use before attempting to glue a large skin on. It sets quick, is very strong, and is easy to work with. Be sure to work in a well ventilated area.

FIN CONSTRUCTION

The fins on the Mercury-Redstone are constructed of foam and balsa wood. You may be tempted to use poster board but don't. The wood is actually lighter which is good in the back of a rocket. The wood is also stronger than the poster board. There is not very much used in the fins so cost is not a real issue. Probably the best foam to use is the blue construction foam. It already comes in 3/4 " thick sheets and is stronger than the white stuff. If all you can find is the white stuff, it should work fine. It might be a little more susceptible to damage on landing but slightly larger parachutes should solve that problem.

1. Cut the four steering fins to shape as shown in the sketches. Sand the surfaces to a smooth finish. This is necessary to get a good glue bond. You can either hot wire the leading edges of the fins or sand them down. Hot wiring is a little easier but you should build a simple fixture to help. Sanding will work just fine for the few fins we are going to make here.

NOTE:
One of the steering fins will probably break off on every landing. The rocket is very light but that is still a lot of weight to support on a single point at impact. You could make the steering fins entirely from balsa if you like. It is probably a little easier. DON'T be tempted to make the main fins this way. You can't afford the weight back there.

2. Cut and shape the main fins as described above. It is a good idea to start with the small steering fins in case of any accidents. It is a little easier to get the techniques down on smaller parts.

3. Cut the balsa sheeting to shape and pre-glue the sheets together before applying the sheets to the fin. It works best to cover each side in two separate pieces joining at the peak of the diamond airfoil shape. Be sure to glue the sheets together with the grain running parallel to the fin leading edges. Use some wax paper and thin CA. The glue joint will be stronger than the original wood if done properly. Make sure the wood and foam fins are free of dust. A quick vacuum of the parts will ensure this.

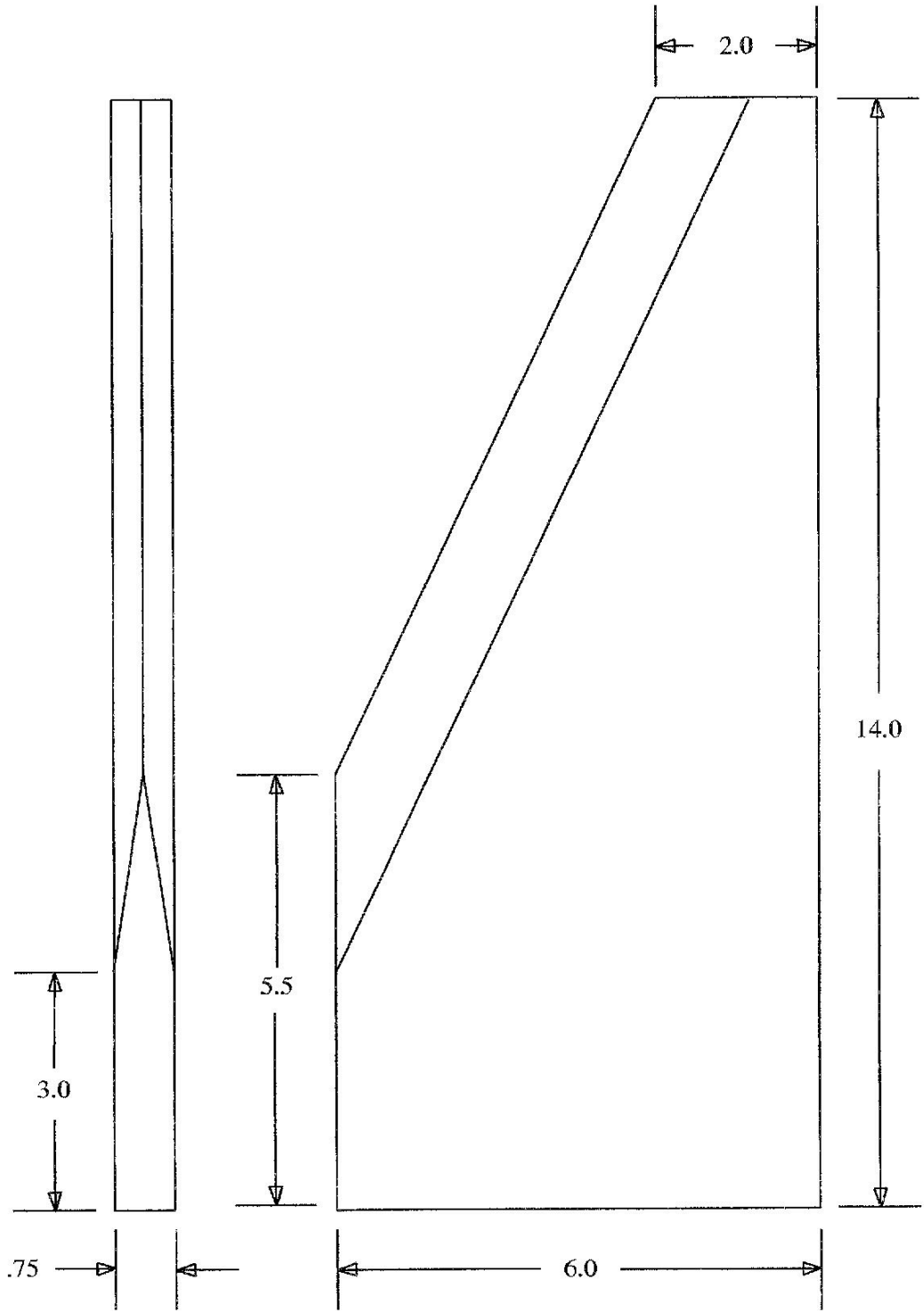
4. Using spray adhesive (or your glue of choice for foam) attach the balsa skins to the foam. Work carefully completing one side before going on to the next.

5. Sand the edges of the sheeting before sheeting the edges of the fins. Sheet all the edges at this point. You might cut some notches in the fins later to get a good fit in the rocket but that is easily accomplished through the balsa sheeting.

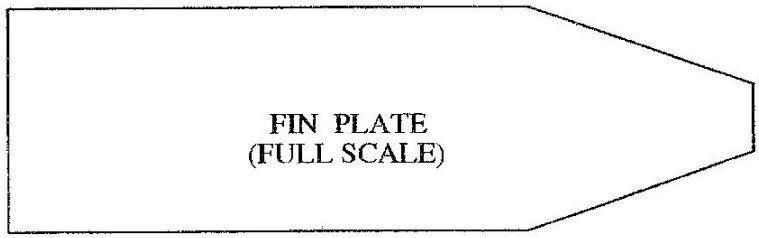
6. Cut the fin plates from 1/8 plywood. It is probably easiest to paint these before attaching. Mask off the areas where the steering and main fins will glue on and paint the plates.

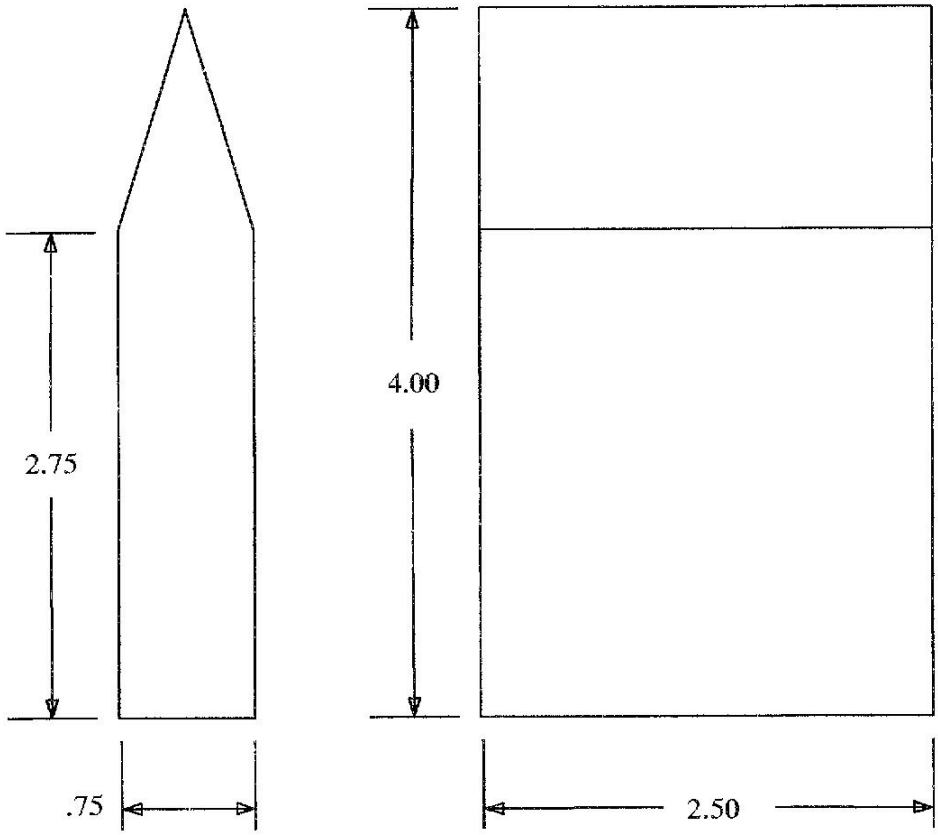
7. When the fins are finished, final sand with some fine sandpaper and sat aside until later. DO NOT glue the steering fins on now. They will be attached after covering the fins.

After the rocket is completely finished, glue the fin plates to the main fins securely. It is then probably best to tack glue the steering fins in place. One will most likely break loose on landing. If the glue joint is weaker than the surrounding parts, the fin will easily break off and can be re-attached in just a few minutes. The flight loads on the small fins are minimal and if one broke off in flight, it probably won't affect the flight assuming there is sufficient static margin.



MAIN FIN (1/2 SCALE)

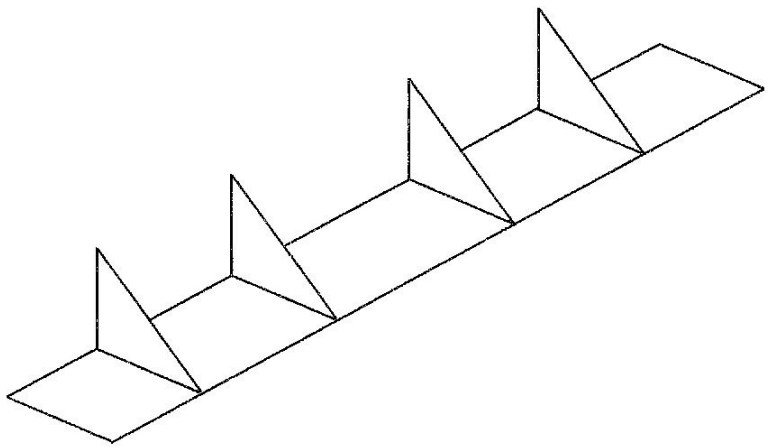




STEERING FIN (FULL SCALE)

BOOSTER SEGMENT

DESIGN NOTE:
The builder should study the plans carefully and understand each step before beginning construction. This model is recommended for the experienced modeler so some of the details of construction will be left to the builder. The main rocket is built in 4 seperate segments and attached together either by gluing or with screws. A simple fixture could be constructed to ease building the segments but some patience should produce straight ones without the fixture. Carefully understand the entire construction before beginning.



Optional Fixture Use
Arrange the triangular supports to match the plans locations. Use clothes pins to hold the bulkheads to each support and glue every other stringer in place.

DESIGN NOTE
You need to decide if you want to glue the segments together permanently or bolt them together. The prototype was bolted together with 6-32 socket head screws and blind nuts. However, special tools will need to be fabricated and lots of patience is required to reach through the cutouts in the bulkheads to the bottom of each segment for attachment. If you come up with a better way of attaching the segments (without adding a ton of weight) please let us know. We will assume you are going to bolt the segments together and some assembly tips will be covered later.

1. Cut the bulkhead blanks (squares) out. The easiest way to cut the bulkheads is to spray glue the paper templates to the wood. The spray adhesive works well and you can easily remove the template when finished. Trim off any excess paper. It will get in the way later and cause the template to tend to lift up during sawing.

2. Dill the 5/32 attachment holes first. Be sure to target the holes the best you can. A drill press works good for this. Using a wood bore, drill the corners of the cutout holes. The center of the radius is marked on the template.

3. The launch rod guide holes are slightly over drilled to allow for any misalignment and make it easier to put the rocket on the launch rod. You may adjust the size of these holes to fit your rod but a 1/2 rod is recommended. The prototype used 5/8 holes.

4. When all the holes are drilled, cut the bulkhead out. A power scroll saw works best. Sears and Dremel sell a nice hobby one for about $100 and is well worth it. Cut the large circle first. There are several ways to cut the stringer notches but the easiest is probably to make the radial cuts on each notch and then use a standard 1/4 wide wood chisel and knock the notches out. A small stick of wood with some sandpaper glued to it will allow you to get into the notches to sand the bottom.

NOTE: Test fit a few stringers before you cut all the notches. You want each stringer to be snug in the notch, NOT loose. This will make it much easier to assemble the segments if the stringers stay where you put them.

5. Cut the fin notches out. Test fit the fins in the notches and label the best fits. Now would also be a good time to label the fins (1-4 works fine) and the corresponding bulkheads.

6. When all the bulkheads are cut out, lightly sand then to remove any burs. Try not to put any radius on the outer edge or where a tube goes through the bulkhead. A nice radius on the inside cutouts (lightning holes) won't hurt. Also a nice radius on the launch rod holes will help load the rocket on the launch rod.

7. You may build a fixture as shown or assemble the segments free-standing. The freestanding method works fine but requires a little patience to get things lined up. Start by marking the locations of the bulkheads on the stringers. A felt tip marker works well for this. Install the 8 blind nuts on the upper bulkhead and 2 on the lower for the motor retainer. Use a bolt to pull the blind nuts in firmly and then epoxy them in place being careful not to get epoxy in the threads.

8. Rough up the motor tube where it will contact the bulkheads. This will allow the glue to stick better.

9. Using every other stringer, assemble the bulkheads and motor tube. With the bulkheads all level and in place, tack every other stringer in place continually checking the alignment of the bulkheads. This is probably easiest done standing the section up on the work bench. Make sure the bulkheads are all parallel to the bottom one and the sides are vertical. When satisfied, securely glue the remaining stringers in place.

10. Carefully slide the motor tube in and securely epoxy in place. Make sure there is a nice glue fillet all the way around the motor tube at the bulkhead joints.

11. Test fit the fins and adjust the notches so the fins are a snug fit. Don't allow them to be too tight as it will make them difficult to install after the booster covering is on.

NOTE: Unlike a traditional rocket, these fins DO NOT need to extend to the motor tube. The glue joints at the bulkheads is plenty strong enough. Extending the fins to the motor tube would only add weight in the wrong part of the rocket.