12. Cover the booster segment as described in the Structural Covering section. Carefully mark the booster as shown in the sketch for the fin cutouts. Using a straight edge and a hobby knife, carefully cut the skin away where the fins attach. Adjust the width of the cut to match your fins.

13. When satisfied with the fit of each fin, securely epoxy the fins in place. It takes a little patience but you can get the fins in and out of the slots by angling them.

14. Sand any high spots on the forward bulkhead and you are ready to build the next segment.

UPPER SEGMENTS

The upper segments are built similar to the booster with one major exception. Each segment should be built on the previous one. This will insure proper alignment between the segments. It may get difficult to build the upper segment this way due to the height of the assembled rocket. Good fixturing or careful alignment could probably substitute for building the upper segment on the rocket. However the lower ones should be assembled this way to avoid any misalignment. If the lower segments are not aligned, the entire rocket will be crooked.

1. Place a piece of wax paper on the upper bulkhead of the booster. Punch holes where the screws attach the segments together and bolt the lower bulkhead of the next segment to the booster. Be sure the launch rod holes are aligned. We will now assemble the next segment on the previous on with a piece of wax paper between them to keep from gluing the segments together.

2. Add the blind nuts to the inside of the bulkheads as necessary according to the drawings. A little epoxy on each blind nut will ensure they don't come loose. If you are going to glue the segments together, it is still a good idea to use 3 or 4 blind nuts here to keep the segments aligned while you build them.

3. Add the stringers and remaining bulkheads. Be sure to align the bulkheads so the launch rod holes are aligned.

4. When you are confident of the bulkhead alignment and that the walls are vertical, securely glue all the stringers to the bulkheads. A long straight-edge or plumb bob will help ensure the walls are aligned and vertical around the rocket.

5. Carefully remove the new segment from the previous one. Sand any irregularities and the segment is ready for covering.

6. When you get to the upper segment. Prepare the tubes and install similar to the motor tube. Decide on any electronics arrangements and install any hard points before sheeting the segment. There isn't much room to reach in there after it gets sheeted. It is a good idea to review the recovery section before finishing the upper segment.

7. If you are going to fly a lot of electronics, it might be a good idea to add some diagonal cross braces between the stringers on the upper segment (photo 16). Be careful not to warp the segment when gluing the braces in. The cross braces will also help the segment hold its shape while gluing the covering on.

STRUCTURAL COVERING

The prototype was covered with standard poster board. This bulkhead construction method was perfected on the 1/40 scale Space Shuttle which had an 8.25 in. diameter external tank. The ET was covered with balsa which is probably a little stronger than the poster board but much more expensive. The poster board method has been used successfully on other rockets and presents an inexpensive simple solution for low speed subsonic rockets.

1. Layout the poster board and figure out which orientation you want to use. For the two short segments, a single piece can be used that is wrapped lengthwise around the segment. For the longer segments, two pieces of poster board will need to be fastened together.

2. Place two pieces of poster board next together and securely hold them together and aligned. A friend could really help here. While holding the two pieces together, lay a piece of the wide (2 in) clear packing tape along the joint. Be careful not to incur any wrinkles. Use a piece of cloth (T-shirt works good) and FIRMLY rub the tape down. Turn the boards over and tape the other side.

3. Lay the poster board on a flat clean work surface. Place the segment on the poster board carefully lining the joint up with the center of a stringer. Mark the poster board so 1/2 inch extends past the upper and lower bulkhead. Slowly roll the segment along the edge and mark the center of each stringer on the board. Mark off 6 stringers in each direction. Also locate where the bulkheads will contact the poster board. Photo 17 shows a segment on a piece of poster board. Notice the posterboard has been marked but not cut yet.

4. When you are sure the marks are accurate, use a straight edge and knife and cut the board along the outer marks. There should be 6 marks on either side of the tape joint. This will put the seams at diametrically opposed locations and centered on a stringer.

5. Test the contact cement on a scrap of the poster board and a scrap of stringer material. Make sure it does not attack the paper. It shouldn't but there are various brands for various purposes. Apply contact cement to the stringers, bulkhead edges and poster board. When the glue is ready according to the directions, carefully place the rocket segment on the poster board with one of the stringers centered on the taped joint.

7. Roll the segment toward one end carefully applying pressure to the bulkheads to ensure good contact. Make sure the piece of poster board that is lifting off the table doesn't inadvertently touch the rocket segment. It will instantly stick and probably in the wrong position. Laying a few scraps of poster board on the glued section of the poster board will help prevent this. The poster board will NOT stick to the dried contact cement if it does not have glue on it.

8. Roll the segment to the end and make sure the edges are stuck well. Remove the work strips from above and roll the other direction. Be careful and keep firm pressure on the bulkheads as you roll.

9. The preceding may sound difficult but is actually very easy. Using a small pair of scissors or a sharp knife, trim the excess poster board from the rocket segment. The segment is ready for final covering.

CAPSULE CONSTRUCTION

DESIGN NOTE:
The capsule is designed to be as light as possible. It is typically understood that the nose of a rocket can be a little heavier because it adds to stability. However, you should always strive to build structures as light as possible. If ballast is needed, it can be added later. Hopefully you won't just add ballast but add a payload that will bring the stability within acceptable limits. Timers, altimeters, beepers, computers, cameras, etc. can all add to stability and provide a side benefit. The prototype capsule and escape tower hit the ground on the maiden flight with practically NO damage. An engine bell on the escape tower broke loose at the glue joint and was ready to fly again in about ten minutes.

1. Cut out all the bulkheads and tubes for the capsule. Familiarize yourself with the parts and how they go together.

2. Epoxy C1 INTO the bottom of the 4" coupler tube. It is a good idea to insert the coupler into the body tube in the upper segment while the glue sets. This will ensure the coupler remains round.

3. Glue C4 to the coupler as shown. Notice that C4 goes inside of the coupler about 1/4 inch below the edge of the coupler tube.

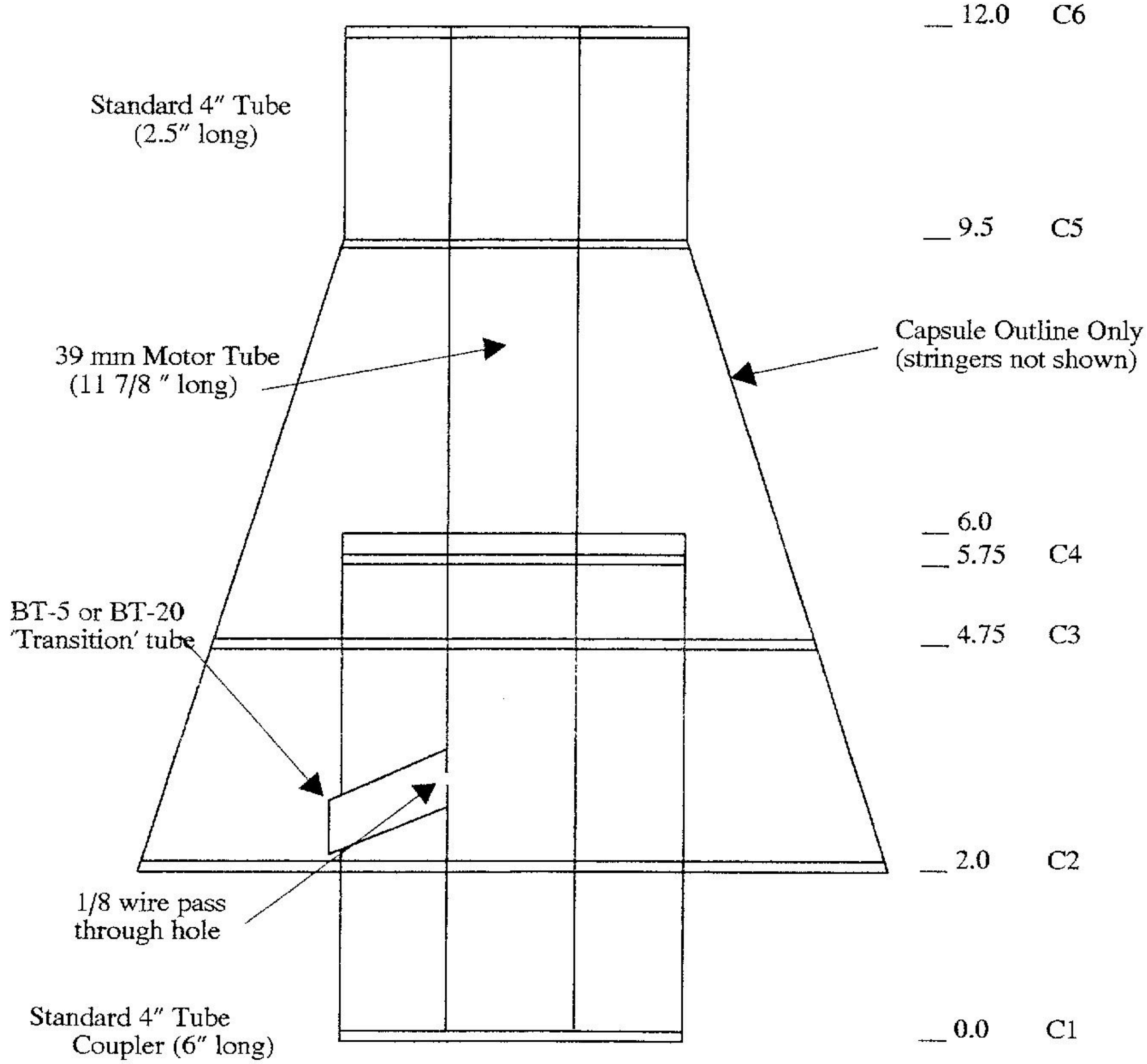
4. Locate C2, C3 and the 38 mm tube. Add every other stringer at this time. If you let the stringers overhang at the bottom and top (C2 and C5), you can get a better glue joint and sand them flush later.

5. When satisfied that the bulkheads are perpendicular to the tube centerlines, glue the stringers and bulkheads. DO NOT glue the 38 mm tube. Just use it to locate the bulkheads. The location of C3 is not critical. It may drift up and down a little. It is not necessary for the stringers to bottom out on this bulkhead only.

6. A small transition tube should now be fabricated from a 18 mm or similar tube. This will allow the charge lead for the escape tower to be easily routed to the payload area at the base of the capsule. The tube is angled slightly to be able to see the lead from the equipment bay. When satisfied with the transition tube, drill an 1/8 - 3/16 hole in the 38 mm tube. Clean the hole out well as you will need to pass ejection charge wires through it from inside the 38 mm tube in the future. Glue the transition tube and the 38 mm tube in place. Orient them so you can see up the transition tube from one of the cutouts in C2. Try to get a good seal of epoxy at the bottom of the 38 mm tube.

7. Add the remainder of the stringers. Sand the upper and lower ends flush.

DESIGN NOTE:
At this point, you need to decide what electronics (if any) will be in the capsule. A single liftoff timer located here can initiate the entire deployment sequence. When you are confident with the payload installation, proceed to cover the capsule. All the calculations and measuring in the world will not make up for a capsule that is even the slightest bit out of alignment. The easiest way to cover the capsule is to make a wrap that is too large on the top and bottom and trim it later. Before proceeding, place the framed capsule on the upper segment of the rocket and perform any final sanding. Rotate the capsule to find a "Best Fit" orientation. Mark the capsule and upper segment. From now on, use these marks when fitting the capsule to the rocket for other work of finishing.



SHOWN 1/2 SCALE

8. Glue a parachute lanyard to the upper end of the 38 mm tube. The prototype was glued to the outside of the tube to avoid interference with the parachutes. You may do which ever you are more comfortable with.

9. Lay out the capsule on a piece of poster board and mark a center stringer location on the center of the poster board. Mark the stringer that will be considered the center. Carefully roll the capsule one direction and carefully mark the center of each stringer on the poster board. Mark off 6 stringers locations. Roll the capsule the other way starting at the center and mark the other 6 locations.

10. Trim the poster board about 1/2 long on the top and bottom. Temporarily tape the poster board in place and make sure the ends come together well. When satisfied, apply the contact cement to the stringers and the poster board.

11. Carefully place the capsule on the poster board making sure the center stringer is centered on the line previously marked. Being careful not to allow the free end of the poster board to touch the capsule, carefully roll the capsule along the poster board. Some scrap poster board will keep the free end from sticking. When complete, roll the capsule the other way.

12. Carefully trim the upper and lower pieces of poster board flush with the bulkheads.

13. Cut a 4" piece of body tube to fit the top of the capsule.

14. Add the upper segment of 4" tube and C6. Note C6 should fit inside the body tube.

15. This completes the basic construction of the capsule. You are ready to add the electronics (if used) and finish the capsule. See the covering section for tips on covering your capsule.

ESCAPE TOWER

The escape tower might appear complicated but it is actually quite easy to assemble. Be sure to take your time to ensure it is straight.

1. Cut the tower bulkheads out. Drill through T2 and partially through T4.

2. The top of the drogue canister is most easily made from a piece of balsa. You can laminate it up from smaller pieces. Cut it out round and then draw a 3/8 circle on the top. A little patience and a power sander will produce a nice piece.

3. Glue the drogue canister top and bottom together with a piece of body tube. The diameter is not critical. Glue a piece of balsa between the top and bottom to support the poster board. Cut and glue a piece of poster board around the canister. Trim the edges and sat aside.

4. Glue T1 and T2 together and bevel the edge all the way around. Test fit the tower plug. A piece of 1.5" closet rod will fit nicely in the 38mm tube. You could use a tube coupler with a plate in it but the solid plug seems to work good.

5. The nozzles were made from a block of balsa wood. You can turn them on a lathe, order them from a turning vendor, or make them yourself on a sander. Gluing a piece of 1/4 dowel into the upper (narrow) end of the nozzle will make a nice handle to hold the part while manually turning against a sander disc. A 1/5 rest to set the dowel on while turning works good.

6. The solid rocket motor should be 2" diameter. We fudged a little and used a tube coupler for a 2.16 tube. The coupler was covered with poster board (to avoid filling tube spirals) and the circumfrential bands were also made from poster board. The entire motor canister can be made in just a few minutes with contact cement. Glue a wood cap on the upper end. You might want to add an extra block on the inside of the cap to help support the lightning rod (for display purposes).

7. You should have all the parts for the tower made except the actual struts. The template on the foldout drawing is a guidelines only and you may need to sand the individual ones to get a good fit during assembly. The best results are probably to tack glue the tower together with CA and fillet glue later with quick set epoxy. Cut the struts out according to the plan view on the drawing.

8. Building from the base up, tack glue the three uprights and then add T3. Make sure the tower is straight. Add the cross supports. It is best to continue checking the escape tower on the capsule on the upper segment to ensure it is straight. A 'clocking' or orientation mark will help get the tower in the same place every time. If the angle needs to be adjusted, pull the T1 &T2 assembly from the bottom of the uprights and lightly sand the long leg.

9. When satisfied, add the solid motor and nozzles. Notching the nozzles slightly will allow them to fit a little closer to the tower.

10. Carefully break the tower loose from the base. Paint the tower red and monokote or paint the drogue canister. There are some tips in the covering section. This completes the basic escape tower construction.

ELECTRONICS

There obviously many different ways to deploy the parachutes. Some sort of redundancy should be employed. An altimeter or simple timers will do a fine job. The prototype had a timer in the capsule, an altimeter in the main rocket and an R/C backup. The R/C backup really provides a sense of security. No matter what happens, you can deploy those parachutes anytime you like. Whatever you choose, make sure you use a checklist and operate safely.

COVERING AND FINISHING

SCALE NOTES:

This model is not exact scale. Is any model? It is close as possible in scale size for the building materials provided. The most noticeable difference is that the lower segment (with the word STATES) should be about 2 inches longer. This would have made it near impossible to cover with the poster board so the segment was simply shortened. The fins are slightly oversize but you can't really tell. They are also a little thicker to use 3/4 foam without any additional work. The bottom part of the escape tower is not right. Each vertical leg should split at the top of the drogue canister. You may make the changes if you like but we didn't think it was worth it. Were trying to make a good looking scale-like model as easy as possible to build.

The most practical way to finish such a large and lightweight model is with an iron-on film. The model airplane community has been using them for years with great success. They come in every color of the rainbow and provide a quick and durable finish. For this type of structure, the covering also adds considerable strength.

There are three (3) very important things to remember when covering; patience, patience, and patience. If you follow these three important rules, you will produce an excellent finish. If you have never been exposed to these coverings, you should get in contact with a local R/C crowd. A brief walk through a typical pit area will instantly show you what kind of finish you can expect. You will mostly see the iron coverings. These coverings come in every color imaginable and are offered by various manufactures. The prototype model was covered with Top Flite's Monokote. There are several different brands of iron coverings. Some have a fabric like texture and accept paint very well. If you are a painter, you should use one of these types of coverings. The covering will add strength and give a good surface for the paint to stick to. A typical household iron will work for the iron on coverings but there are special irons made for the application. They are small, lightweight, and have a better temperature control than most household irons. They only cost around $25.00 and are well worth it. We will assume you have decided to cover the entire model with a pre-colored film such as Monokote and are familiar with the manufacturers directions. It is probably best to cover the easiest parts first and work up to the more difficult ones. The steering vanes are probably the easiest to cover. They have a simple contour and cover fairly quickly. Cover them in several pieces, usually one side at a time. The smaller pieces are easier to work with. When using light colors such as white, be careful about making the seams straight. Cover the fins next. Do all the white parts before the black. You will get the best results this way.

When covering the main body, it is probably easiest to use small strips that run the length of each segment. About 4-6 inches wide seems to work good. Be sure to keep the seems straight and only overlap about 1/4 inch. Slowly work your way around the segments leaving about 1/2 inch overlap on both ends. When the segment is covered, cut small slits in the covering on the ends. The slits should be about 1/2-3/4 inch apart. This will allow you to fold each small piece over the bulkhead on the end. You should be able to make a nice close out using this method. Temperature control is very important. If you keep the temperature so it will just stick the covering down, it will easily pull up if you make a mistake. When the job is finished, you can increase the heat and permanently seal/shrink the covering.

For the upper segment, pre-mark the segment as shown. Add the white pieces first and then the black. A little patience will provide a nice job. For small parts like the drogue canister, use several small strips. It might seem a little tedious but it actually goes smoothly and produces an excellent finish. Wait until the drogue canister is covered and the tower is painted to glue the tower base on.

The capsule should be covered in several small pieces. The black covering hides the seams well. It is a good idea to first wrap a 1/4 " wide strip of covering circumfrentially around the joint centered on the joint. This will make it easier to finish the segments at the joint. Cover the upper part first (the 4" tube section). You can probably use one strip about 2 3/4 inches wide. For the main part of the capsule, it works out well to cut strips of covering that are just a little wider that the sections between stringers. About 1/4 overlap on each segment works good. This will require 12 strips to cover the main part of the capsule. Leave about 1/4" overhang at the bottom. When finished, slit the overhang about every 1/4 inch and iron it to the first capsule bulkhead (C2).

The letters down the side were cut from Monokote. Temporarily tape the paper templates to the monokote and simply cut them out with scissors or a hobby knife. You could also find some stick on letters or use the sticky monokote trim.

RECOVERY

The parachutes used on the prototype are described in the introduction. The methods of attachments might seem a little odd but we have successfully used them on several models. This type of model never really sees high speeds so 'stripping' is not really a problem. The most notable difference is the parachute for the capsule is attached to the outside of the ejection charge tube. This prevents interference with the parachutes. A small grove was made in the tower plug to rout the attachment cord to the parachute. It works very well. The 'shock cord' mount is simply a piece of heavy duty braided nylon line that is laid in a "U" shape (aboput 4 inches) and epoxyed to the tube. Be sure to scuff the tube before gluing. The length of line glued is dependent on the load expected. The glue will be in shear which is very strong. The paper tube will rip before the glue gives. If the gluing area is sufficiently large, the tube won't give either. Remember the model flies fairly slow and it is very light. There was a small problem with ejection blow-by on the second flight. A piston setup really seems like the way to go to deploy those main parachutes. Use what you are most comfortable with. Just be sure to have an independent back-up system.

Some computer simulations are provided in the performance section to aid in parachute selection and timer setting. The numbers have been verified with altimeters and ground timing and should provide good starting guidelines assuming your rocket weights and motor selections are similar. It could be possible to securely attach the tower to the capsule. The capsule-tower could then be lowered on one parachute. A lot of rocketeers insist on keeping all the parts of a rocket together which could be done here. One large parachute could be deployed. If you attempt this, be sure to use lots of shock cord to keep the capsule from coming back and hitting the main rocket. Regardless of what you decide, make the decisions before finishing the upper segment. It could also be possible to use motor ejection as a primary or backup means of ejection. This was not attempted on the prototype due to the added weight and complexity of the stuffer tubes required.

ASSEMBLY

You may choose to glue the segments of the rocket together. We bolted the segments together with 6-32 screws and blind nuts. One of the sketches shows the blind nuts on the underside of the forward bulkhead on each segment. If you choose this route, a few tips might help. We choose to bolt the segments together because we thought we would be able to assemble the rocket at the field and it would obviously be easier to transport. It turns out that it was more difficult than anticipated. We ended up getting a car it would fit in.

The 6-32 screws need to be socket head cap screws. We took a standard 6-32 ball driver (check your local hobby store) and inserted the handle into a piece of 1/2 PVC pipe about 4 ft. long. We then drilled a 1/8 hole through the PVC and the handle and inserted a screw. This allowed the reach into the rocket segments and the ability to put sufficient torque on the bolts. Of course you would assemble from the aft segment up. The next problem was holding the screws to the ball driver to insert into the 28 inches of rocket. We tried everything we could think of and had the best luck super-gluing (CA) the screw to the ball driver. Just a small drop worked fine and when the screw was snug, you can easily break the glue. It doesn't stick well to the ball on the end of the driver. A magnet didn't work because every time you bumped the wall, it fell off. Be sure to start all of the screws on the segment you are working on before you tighten them down. You might have a little difficulty reaching all of them in the upper segment but patience should pay off. I think we ended up leaving one or two out because we just could not get to them. Try not to leave two out that are next to each other.

On the aft segment, insert a piece of cellophane or plastic between the segments to prevent any false readings on an altimeter if you fly one. If you have any questions, feel free to give us a call. We will try to help the best we can.

PERFORMANCE

It seems that not enough importance is placed on model rocket performance. Ejection times are guessed at and we see parachutes striping off at nearly every launch we attend. It is an absolute must that we have some idea of a rockets performance BEFORE its first flight. Sometimes this is based on experience but more often than not, the experience used to make a particular decision is just not enough. The Mercury-Redstone we are constructing here is certainly not your typical model rocket. It is hard to find someone with experience with this type of rocket. In this case, rockets of similar size and construction were flown with R/C recovery systems and a basic database was formed. This section is not really important to the successful flight of your Mercury-Redstone (as long as you follow the recommendations) but it is informative and might provide a basic understanding.

The most unknown variable in model rocket flight is the rockets drag coefficient (C_d). This is a non-dimensional number that is based on a reference area and predicts the total drag of the rocket throughout flight. For rockets that travel very fast, this number can change significantly. However, for a rocket of this type, we can assume it will remain constant. This assumption is based on several things but the most obvious is that the rocket doesn't travel very fast. The original C_d of this Mercury-Redstone was guessed at 1.0 with a reference area based on the rocket diameter. If we had taken into the account the frontal area of the fins, and the surface friction (there is a lot of surface area on this model), we might have come up with a more accurate (and certainly different) C_d. However, we wanted to keep it simple. After all, we are only guessing at ejection times for a slow, low flying rocket.

A simple computer program was run to predict the model's altitude for the engine selected for the first flight. For the first flight, an onboard computer recorded altitude and the C_d was modified. The modified C_d was then used to predict the performance of the rockets second flight. Again an on-board altimeter was flown and the results closely matched the predicted altitude. Based on this limited data, a somewhat more educated guess can be made for various motors and expected rocket performance. The computer program started as a basic projectile motion solution for a College Physics experiment. It was easily modified to simulate vertical rocket flight. Actually all the program does is solve the classic equation (F= M*A) for very small time steps and them sums up the results to estimate altitude. The program was first written in BASIC and later modified to run on a spreadsheet. This made it easier to see results graphically. The results have been checked against all the commercially available rocket prediction routines and provide similar answers.

DATA RESULTS

The data from the computer program is presented for flights #1 and #2. The onboard computer provided maximum altitude for flight #1 (207 ft) but the profile was lost due to operator error. Flight data from flight #2 is presented on the same graph as the computer prediction. Computer data for both flights is presented in spreadsheet format through engine burnout.

Lets look at some of the numbers associated with flight #2. The flight used an Aerotech I181W with no ejection charge. Maximum predicted velocity was 173 ft/s (118 mph). It is also interesting to notice the predicted velocity as the rocket leaves the launch rod. There are various rules of thumb people follow here and we will not go into a discussion of static stability vs. velocity (note use of words 'static' and 'velocity' as if they could be compared...) By linear interpolation, the velocity at 8 ft. (the length of the launch rod) is predicted to be 45 ft/s (31 mph). At burnout, the rocket is slowing down and is expected to coast for 3 more seconds. The computer run shows apogee at 5.1 seconds. So based on estimated C_d from previous flights, we would expect to initiate recover just before 5 seconds. The data shows that if we start recovery at 4.5 seconds, the rocket will be traveling at 15 ft/s and be approximately 5 ft below apogee. With this information, it would appear we should start recovery on the early side (4.5 seconds sounds like a good number). This will allow the majority of the events to occur right at that 'hang time' as the rocket starts descending. Of course this is all theoretical and based on several assumptions, but it is a place to start.

Lets look at the actual data recorded from the onboard altimeter and compare it to the predicted results. We have superimposed the predicted data on the actual data for a comparison. The powered phase of the flight closely resembles the computer model with a slight shift to the left. The computer compartment was not vented well and was not sealed off from the engine compartment 7 ft. away. The spike and shift of the curve at burnout probably have something to do with this. The coast phase seems to fade off quicker than the computer predicted. A higher C_d could account for this. The escape tower and fins are contributing a lot of drag that is usually not accounted for on a typical model rocket. This is why the C_d is as high as it is when compared to average model rockets (for the reference diameter). It is apparently not quite high enough but close enough for this model. If you listen to the video carefully, you can hear the maximum altitude being reported by the onboard altimeter. Apogee appears to occur nearly a full second later than predicted. Video analysis shows actual apogee at approximately 5 seconds which correlates with the computer data, especially if we shift it over. The tower/capsule timer was set at 4.5 seconds and the main ejection timer (altimeter in timer mode) was set at 5 seconds. The graph shows that actual average velocity near 175 ft/s which matches the computer predictions.

RECOVERY

Now would be a good time to discuss recovery. The altimeter recorded data all the way to the ground so lets take a look. The spikes around 7 seconds are apparently where the primary ejection charge went off. There was not sufficient wadding and blow-by burned the lines on the parachute in the deployment bag. The deployment bag stripped before the parachute was extracted. Tighter bag next time...When the main charge went off, the parachute with burnt lines came out and hung on the fins. This is evident in the video. The rocket descended for 3 more seconds before the backup charge was fired by R/C. This occurred at 260 ft. (10 sec) As seen in the video, the remaining two mains inflated and the mortar deployed reserve came out. The mortar deployed reserve was fired simultaneously with the backup main charge so the mortar wouldn't collapse an already deployed parachute and I wasn't sure what condition the mains were in after seeing something tangled on the fins. At approximately 20 seconds, the mortar deployed parachute inflated. Had the mains not inflated, the mortar deployed one would have inflated much faster due to the air velocity. The rocket remained on the 3 good parachutes until landing.

Lets do some quick math. Lets assume a Cd = 1 for the parachutes (most references say flat parachutes are good for .9-1.2). Knowing that :

$$\text{Drag} = 1/2 * (\text{Air density}) * V^2 * (\text{Area}) * 2 \text{ Parachutes}$$

Drag=weight, Air density=.00237, Area=3.1415*2^2 (radius=2)

Rearranging, Velocity = (6 lbs*2/.00237/12.56/2)^.5 = **14.5 ft/s**

Calculating the slope from the graph gives 15.7 ft/s. This is reasonable because we didn't count the spill holes in the parachutes which would make the model come down a little faster. If we add the third parachute, we calculate 11.6 ft/s The graph shows 12.2 ft/s These are very small differences. Maybe you could try the numbers accounting for the spill holes and compare the results. The change in descent rate occurs around 19 seconds according to the computer data and correlates to the video when the third parachute (purple reserve) inflated.

From physics, neglecting drag, particle motion states:

$$V^2 = 2*a*y$$

for free falling bodies where V is the velocity the object hits the ground, a is acceleration due to gravity, and y is the height dropped from. Back solving, (and skipping the math) we find that our 6 lb Mercury Redstone (the capsule and tower are on separate chutes) hit the ground the same as if we dropped it from a height of a little more than 2 ft. For comparison, 2 parachutes is about 4 ft and one four foot parachute is the same as dropping the rocket 6 feet. Interesting??? Notice weight doesn't come into play here (we neglected drag for this case). The moral of the story here is don't drop your rocket unless you have enough parachutes.

STABILITY

We have also included a spreadsheet that calculates the model Center of Gravity (CG) vs. it's Center of Pressure (CP). The upper part of the chart shows the CG calculations. The individual parts were weighed while carefully balancing at their CGs. A moment arm was calculated from the bottom of the rocket. The overall C.G. with a loaded motor is 52 inches from the bottom of the rocket. This was verified hanging the rocket from a loop of string at the field just before flight. The reason for the weight (CG) calculation on the spreadsheet is we can quickly see what effect changing payloads and motors will have. The lower chart shows a CP calculation by summing area moments for the individual pieces of the rocket. The CP comes out around 43 inches. So this rocket in this configuration has about 1 Diameter Static Margin (stable). Try not to let your rocket get much below this, .5 D would be an absolute minimum without 'experimenting'.

Hopefully this section has not been too technical. Try to get the important points. An 'H' or 'I' will give neat flights on a budget. Any bigger motors should be of the long burn type. One 4 ft. parachute will work but expect a broken fin. The first flight used 2 parachutes on a sod farm and one of the steering fins broke loose as designed. With 3 parachutes, a steering vane still broke loose. Put an altimeter, timer, R/C backup, or whatever other payload you can think of in the top. You need the ballast any ways for those darn small fins.

Redstone #1

	A	B	C	D	E	F	G	H	I	J	K
1								time	Ft	Velocity	Altitude
2	Model	RED1		Motor	H180W			0.1	45	17.48	1.748
3	weight	7		Manuf	Aerotech			0.2	45	34.85945	5.233945
4	altitide	0						0.3	43	51.01959	10.3359
5	velocity	0						0.4	45	67.6432	17.10022
6	CD	1.5						0.5	47	84.53812	25.55404
7								0.6	40	97.3679	35.29083
8	temp	80						0.7	38	108.5111	46.14193
9	diameter	8.75						0.8	36	117.9813	57.94006
10	motors	1						0.9	34	125.8282	70.52288
11								1	33	132.5884	83.78172
12	MALT	264.88						1.1	32	138.3172	97.61344
13	Time	4.1		t burn	1.4	H180W		1.2	17.49999	136.869	111.3003
14	MVEL	138.32		tp	10	29/240.230		1.3	2.999998	128.8842	124.1888
15	MAX G's	5.4455		t0	0	70		1.4	0	120.2174	136.2105
16	MAX F	47		t1	0.1	45		1.5	0	112.2603	147.4365
17	ALT BO	124.19		t2	0.2	45		1.6	0	104.9108	157.9276
18	VEL BO	128.88		t3	0.3	43		1.7	0	98.08548	167.7362
19				t4	0.5	47		1.8	0	91.71492	176.9077
20				t5	0.6	40		1.9	0	85.74107	185.4818
21				t6	0.9	34		2	0	80.11488	193.4932
22				t7	1.1	32		2.1	0	74.79462	200.9727
23				t8	1.3	3		2.2	0	69.74444	207.9472
24				t9	1.4	0		2.3	0	64.9334	214.4405
25								2.4	0	60.33456	220.4739
26								2.5	0	55.92432	226.0664
27								2.6	0	51.6819	231.2346
28								2.7	0	47.58884	235.9935
29								2.8	0	43.62871	240.3563
30								2.9	0	39.78671	244.335
31								3	0	36.04949	247.9399
32								3.1	0	32.40492	251.1804
33								3.2	0	28.8419	254.0646
34								3.3	0	25.35018	256.5996
35								3.4	0	21.92029	258.7917
36								3.5	0	18.54336	260.646
37								3.6	0	15.21106	262.1671
38								3.7	0	11.9155	263.3587
39								3.8	0	8.649139	264.2236
40								3.9	0	5.404711	264.7641
41								4	0	2.175173	264.9816
42								4.1	0	-1.04637	264.8769
43											
44											
45											
46											
47											
48											
49											
50											

Redstone #2

	A	B	C	D	E	F	G	H	I	J	K
1								time	Ft	Velocity	Altitude
2	Model	RED1		Motor	I161W			0.1	50	19.78	1.978
3	weight	7		Manuf	Aerotech			0.2	47	38.05125	5.783125
4	altitide	0						0.3	47	55.97482	11.38061
5	velocity	0						0.4	47	73.34403	18.71501
6	CD	1.5						0.5	47	89.97465	27.71248
7								0.6	42	103.4126	38.05374
8	temp	80						0.7	41.42857	115.7342	49.62716
9	diameter	8.75						0.8	40.85714	126.9068	62.31784
10	motors	1						0.9	40.28571	136.9277	76.01061
11								1	39.71429	145.8197	90.59258
12	MALT	442.06						1.1	39.14286	153.6263	105.9552
13	Time	5.1		t burn	2.2	I161W		1.2	38.57143	160.4063	121.9958
14	MVEL	173.02		tp	8	38/360.350		1.3	38	166.2289	138.6187
15	MAX G's	6.162		t0	0	0		1.4	35.2	170.1443	155.6331
16	MAX F	50		t1	0.1	50		1.5	32.4	172.3448	172.8676
17	ALT BO	272.03		t2	0.2	47		1.6	29.6	173.0153	190.1692
18	VEL BO	150.55		t3	0.5	47		1.7	26.8	172.3271	207.4019
19				t4	0.6	42		1.8	24	170.4336	224.4452
20				t5	1.3	38		1.9	17.99999	165.9971	241.0449
21				t6	1.8	24		2	12	159.2931	256.9742
22				t7	2.2	0		2.1	6.000006	150.5455	272.0288
23								2.2	0	139.9265	286.0214
24								2.3	0	130.3171	299.0531
25								2.4	0	121.5573	311.2089
26								2.5	0	113.519	322.5608
27								2.6	0	106.0982	333.1706
28								2.7	0	99.20988	343.0916
29								2.8	0	92.78335	352.3699
30								2.9	0	86.75955	361.0459
31								3	0	81.08863	369.1547
32								3.1	0	75.72815	376.7276
33								3.2	0	70.64174	383.7917
34								3.3	0	65.79797	390.3715
35								3.4	0	61.16951	396.4885
36								3.5	0	56.73246	402.1617
37								3.6	0	52.46574	407.4083
38								3.7	0	48.35069	412.2434
39								3.8	0	44.37064	416.6804
40								3.9	0	40.51065	420.7315
41								4	0	36.75724	424.4072
42								4.1	0	33.09814	427.717
43								4.2	0	29.52214	430.6692
44								4.3	0	26.01894	433.2711
45								4.4	0	22.57898	435.529
46								4.5	0	19.19335	437.4484
47								4.6	0.00E+00	15.85367	439.0337
48								4.7	0	12.55202	440.2889
49								4.8	0	9.280839	441.217
50								4.9	0	6.032859	441.8203