

AT-33 Strap-On Booster Parts List

| Item # | Item Name | Qty |
|--------|---|-----|
| 10068 | Engine Mount (AT-18/2.75) Tube | 2 |
| 10127 | AT-33/12.5" Slotted (Laser Cut) Tube | 2 |
| 13029 | CR 13/18 | 2 |
| 13031 | CR 18/24 | 2 |
| 13304 | CR-18/33 Cardstock (Rectangle 2/sheet) LC | 2 |
| 14352 | Plywood Support (Laser Cut) | 2 |
| 17050 | Forward Hook | 2 |
| 17051 | Aft Hook | 2 |
| 19467 | SLOTTED PNC-33mm | 2 |
| 24043 | Regular "D" Engine Hook | 2 |
| 29004 | Mylar Streamer 2" X 18" | 2 |
| 29515 | 100# Kevlar Shock Cord 8 feet long | 1 |
| 31145 | Instruction Sheet A | 1 |
| 31146 | Instruction Sheet B | 1 |
| 39103 | Face Card | 1 |

Optional Tools / Finishing Supplies

- ☐ Pencil
- ☐ Ruler
- ☐ Hobby Knife
- ☐ Wood Glue
- ☐ Thick CyA Adhesive (Super Glue)
- ☐ Plastic Packaging Tape

The AT-33 Strap-on Boosters kit is another fine product from:

APOGEE
COMPONENTS

Colorado Springs, Colorado USA
www.ApogeeRockets.com

What is Parallel Staging?

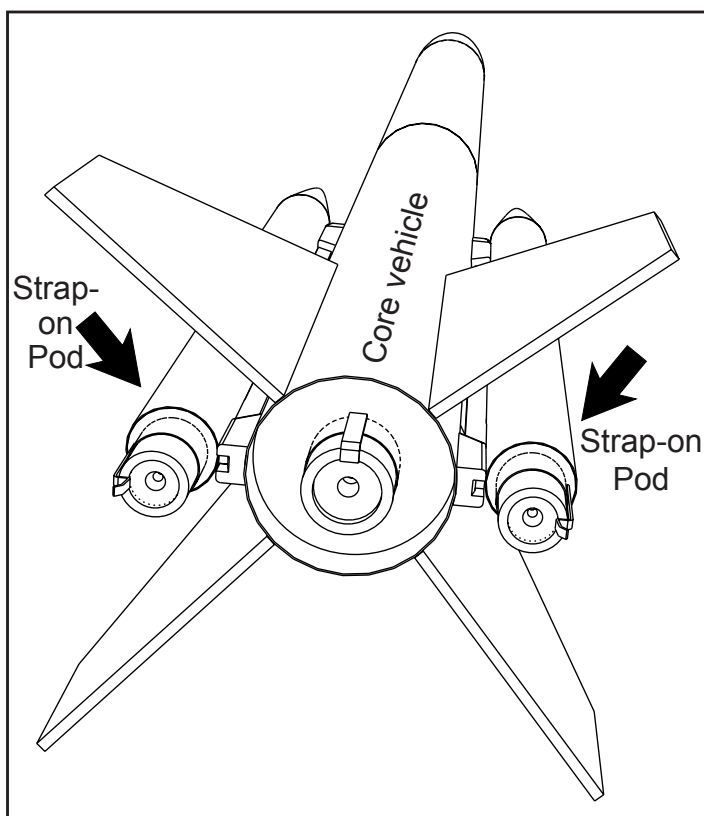
Most modelers are familiar with "Series Staging" where multiple rocket motors are fired in succession. "Parallel Staging" is where you add extra rocket motors to the side of the rocket and they are all fired at the same time instead of one-after-another. One advantage is higher lift-off thrust so you can get those heavier rockets safely into the sky. But parallel staging differs from a traditional "cluster" rockets in that the boosters are detachable from the core tube of the rocket, and fall off during flight. This lowers the drag and the weight of the core of the rocket, allowing it to fly higher into the sky.

Parallel staging is used extensively in the space industry because it saves money. Many satellite launch vehicles used it because of the higher costs associated with developing bigger and higher thrust rocket engines. It is cheaper to cluster a bunch of smaller motors together than trying to make a single engine with a lot higher thrust. The Space Shuttle used parallel staging to take Astronauts into orbit too.

For model rocketry, parallel staging isn't typically necessary because larger and higher thrust motors are readily available. Mostly it is done for one reason: "it just looks awesome!" There is something visually spectacular in seeing the side pods peel away from the core vehicle after the rocket takes off. Having things fall off while the rocket continues on a safe trajectory into the sky is always a crowd pleaser.

This strap-on booster pod set allows you to easily apply "parallel staging" to a wide variety of rockets. You only need to glue the four attachment hooks to the core vehicle in order to convert it to a parallel staged rocket.

What is nice about this particular design is that the pods are kept securely attached to the rocket during launch until the ejection charge of the motor in the side pod fires. This is the safest way to connect a parallel stage on the rocket, because if there is a motor malfunction, the entire rocket stays together. For example, if one side-pod motor does not ignite, it is carried along with the rocket and stays attached throughout the entire flight. It will come down with the core vehicle and its parachute.



This basic design was created by Ray Dunakin in the 1990's. It was featured in the 2008 book *Model Rocket Design and Construction* by Tim Van Milligan. What we changed in the design is the shape and size of the attachment hooks to make the rocket more aerodynamic, so that it can fly even higher in the sky. We also laser cut the wood parts to make assembly more precise so that everything fits nicer and goes together easier.

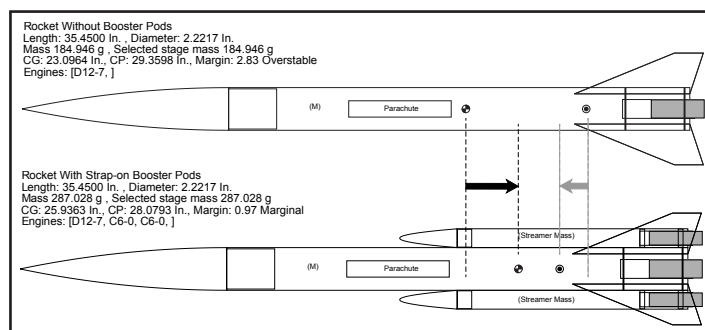
Choosing Which Rocket To Attach The Strap-On Booster Pods To

These strap-on booster pods can be added to almost any "stable" model rocket. It doesn't matter the diameter of the rocket you use, as they will fit on most tubes 24 mm diameter and larger.

The most important criterion for selecting which rocket to attach these side pods to is the core vehicle's stability. The rocket must have sufficient stability with the side pods attached so that it can fly straight.

The strap-on boosters add a significant amount of weight to the rear of the rocket, and therefore can move the Center-of-Gravity (CG) of the completed rocket rearward. This in general is "destabilizing." The Center-of-Pressure (CP) must always be behind (toward the rear of the rocket) of the CG for the rocket to fly stable. If the CP is forward of the CG, the rocket will go unstable when launched.

In general, the CP will shift slightly forward because of the strap-on pods. The only component that adds to overall CP position is the nose cones on the pods. The tubes don't change the CP position according to the Barrowman Stability Equations that are used to compute the final location of the CP. Since the nose cones are small, they will only shift the CP a little bit forward (it really depends on the overall shape of the rocket).



The strap-on pods will move the CG rearward, and the CP forward on the rocket. Make sure the CG remains ahead of the CP position.

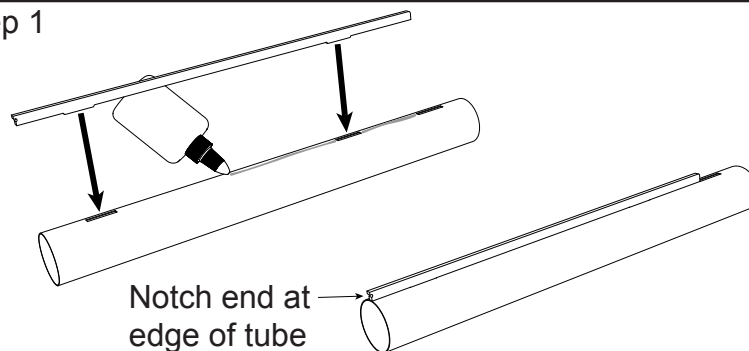
But the CG may move significantly rearward because of the extra weight of the additional rocket engines. This could move the CG behind the CP, which makes for an unstable rocket. Therefore, you should always test your design in a rocket stability program (like Apogee's RockSim software) before you begin assembly. You can download a RockSim design file to study from the Apogee web site at: https://www.ApogeeRockets.com/downloads/rocksim_files/strap-on_booster.rkt.zip

If your rocket does not have a sufficient stability margin (where the CG is at least one body tube diameter in front of the CP), you should make the fins on the core rocket larger, or add nose weight to move the CG further forward. If you still cannot get the CG in front of the CP, you should select a different rocket for attaching these Strap-on Booster Pods. In general, a long rocket is a better choice for parallel staging.

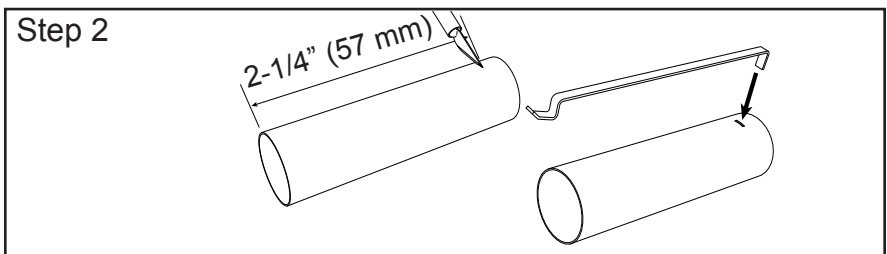
Assembling the Strap-on Booster Pods

☐ Step 1: Using wood glue, attach the laser cut plywood support to the side of the body tube. The tabs on the side of the wood will be inserted into two of the slots of the body tube. Allow the glue time to dry completely. Then add a small glue fillet along both sides of the joint where the wood meets the tube.

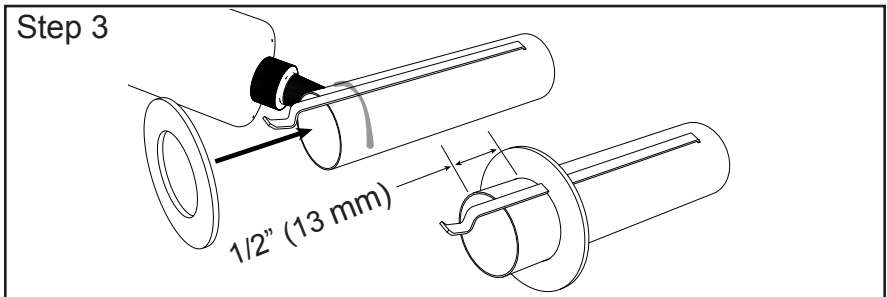
Step 1



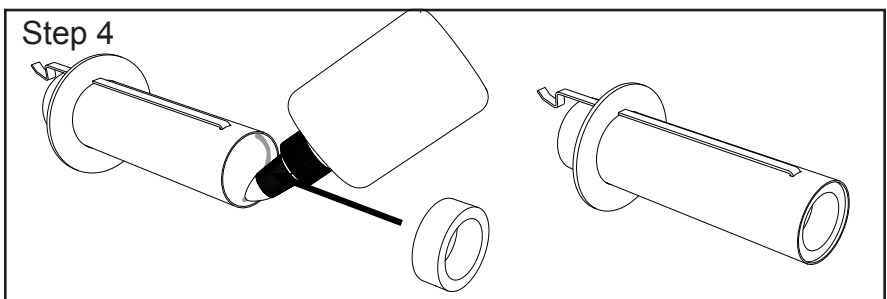
□ Step 2: With a pencil, mark the engine mount tube 2-1/4 inch (57 mm) from one end. Using a hobby knife, make a small slit at the mark for the engine hook. Insert the end of the engine hook into the slit as shown.



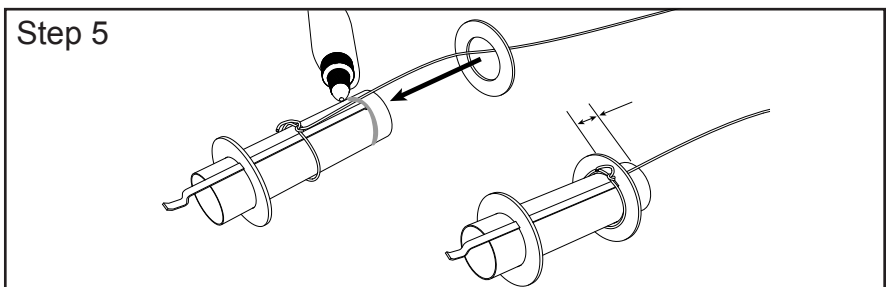
□ Step 3: Apply wood glue to the tube 1/2 inch (13 mm) from the end of the motor mount tube and slide one of the cardstock centering rings into place sliding the notch over the engine hook and placing the ring at a distance of 1/2 inch (13 mm) from the end.



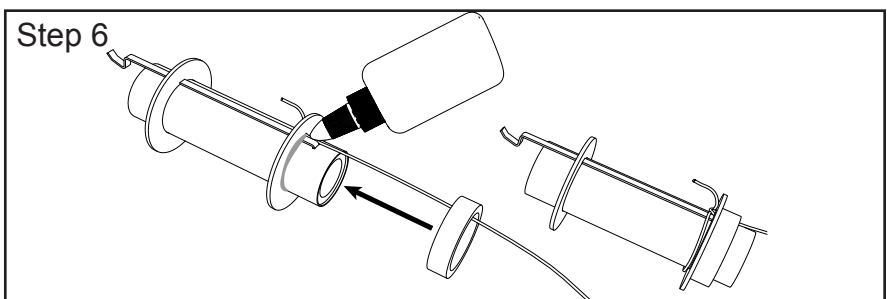
□ Step 4: Take the blue ring and glue it inside the front end of the tube. It should butt up against the part of the engine hook that protrudes inside the tube. Wipe away any excess glue.



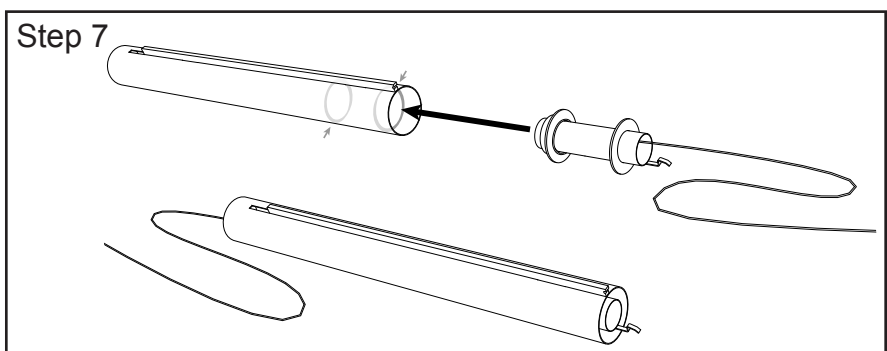
□ Step 5: Cut the shock cord in half. You only need one piece per pod. Pass one end of the shock cord through the second cardstock centering ring and tie the cord around the motor mount tube. Cinch the cord tight to the tube. Run a bead of wood glue around the forward end of the motor mount tube 1/2 inch (13mm) from the end. Install the cardstock ring so that it is 1/2 inch (13 mm) from the end.



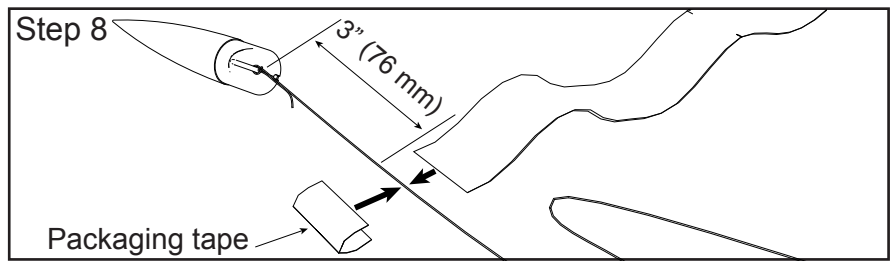
□ Step 6: Pass the shock cord through a green centering ring. Apply a bead of wood glue around the front end of the motor mount tube and install the ring tight against the forward cardstock centering ring. Apply fillets to the joints on both sides of the centering rings.



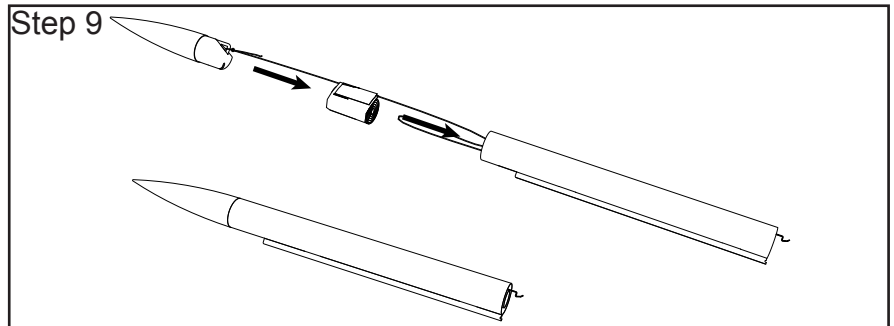
□ Step 7: Temporarily pass the shock cord through the motor mount and out the rear. Using a dowel, apply wood glue 2" (51 mm) and 1/2" (13 mm) inside the aft end of the body tube. Quickly and smoothly insert the motor mount tube into the aft end of the body tube. The engine hook should be positioned opposite of the wood support that is glued on the side of the body tube, and the edge of the motor mount tube should be even with the rear of the body tube. When the glue is dry, pass the shock cord back through the motor mount as shown, so that it comes out the front end of the booster pod.



☐ Step 8: Tie the shock cord onto the nose cone loop and tape the streamer about 3 inches (76 mm) away from the aft end of the nose cone using plastic packaging tape.

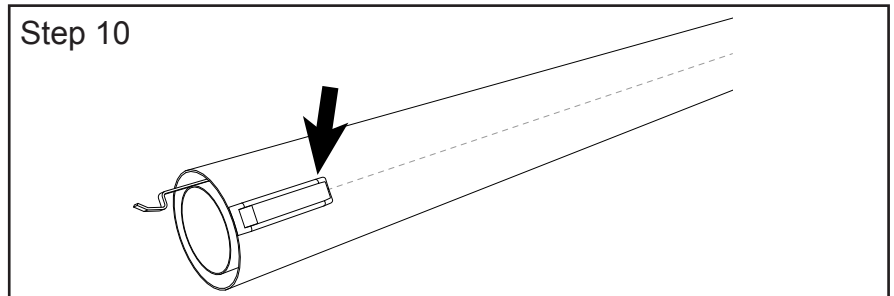


☐ Step 9: Roll up the streamer and put the nose on the pod tube. Then build the second booster pod in the same manner following steps 1-9.

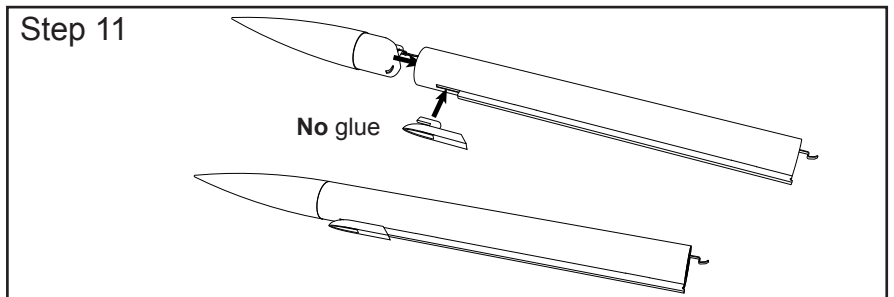


Mounting the Strap-on Booster Pods

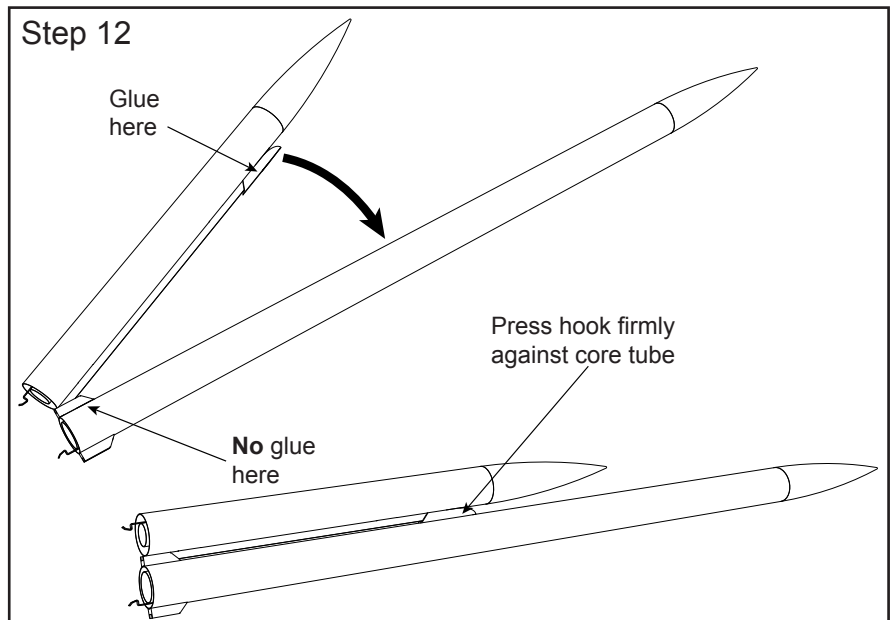
☐ Step 10: Draw two lines on opposite sides of the core tube where you want the pods to be positioned. Using super glue, attach the aft hook centered on the line. The back (flat) edge should be aligned with the back edge of the tube of the core rocket as shown.



☐ Step 11: Pull the nose cone out of the pod tube. Slide the hook of the forward attachment into the slot on the tube. Then push the nose cone back in to temporarily hold it in place. The slot on the base of the nose cone slides over the hook. This is what holds the hook to the pod.

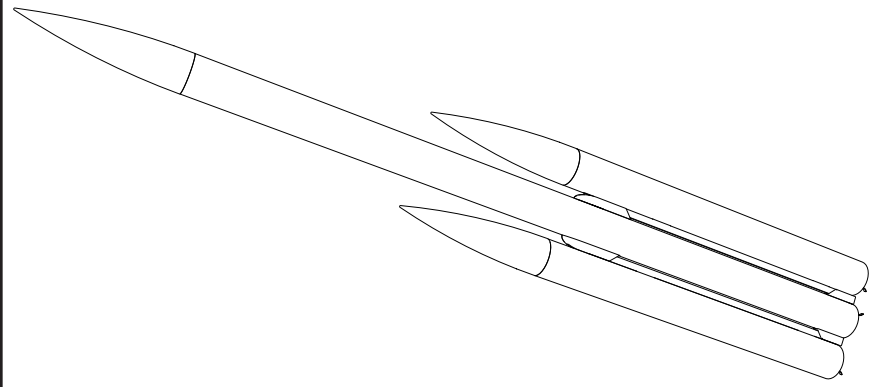


☐ Step 12: Apply super glue to the bottom surface of the front attachment hook. Place the notch (at the rear of the plywood support) into the slot of the rear attachment hook that was glued onto the core tube in step 10. Rotate the strap-on pod toward the tube so that the forward hook touches the core tube. Make sure the pod is straight along the tube before you press it into place. Allow the glue time to harden before removing the nose cone and taking off the pod.



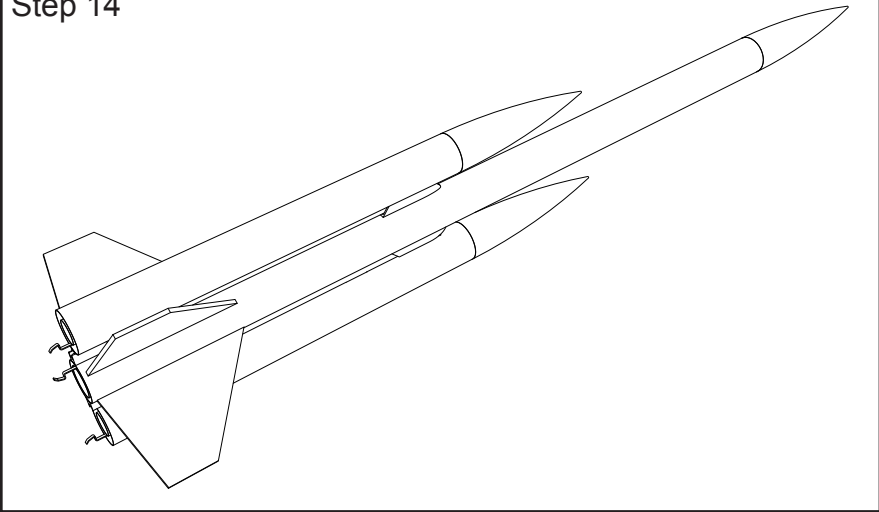
☐ Step 13: Repeat the mounting steps (11 & 12) with the other side pod.

Step 13



☐ Step 14: Make sure to add fins to your rocket. It will be unstable without them. The pods have an engraved line on the back that can be used for fin alignment if you want fins on the boosters as well as the core.

Step 14



Selecting Rocket Engines

The most important criterion for selecting rocket motors for the booster pods is always *safety*. When planning which motors to use, assume that things might not happen the way you anticipate. For example, when igniting cluster motors, maybe assume that one or more of the motors in the cluster may not ignite. Ask yourself questions like: What would happen if only the central motor in the cluster ignited? Does that one motor have enough power to lift the dead weight of the other motors that did not ignite?

When selecting motors, always make sure that the thrust provided by the core motor (in the central tube) has enough thrust on its own to safely launch the entire rocket. You have to take extra precautions when launching to make sure this motor ignites, so double check your igniter clips and your wiring harnesses prior to launch. If the core motor does not ignite, there will be no ejection charge to push the parachute out of the rocket to bring it down slowly and safely.

For the “most realistic” visual effect, you may want to use “booster” type rocket motors in the side pods. These motors have zero-second ejection delays (the motor name ends with -0). With a booster motor, as soon as the propellant has burned out, the ejection charge fires and pushes the nose cone off the strap-on booster tubes. This allows them to detach from the core vehicle and descend by streamer to the ground. And while the strap-on boosters have zero or very short ejection delays, the main motor in the core of the rocket might have a longer burn duration. What this looks like from the ground is that when the strap-on booster pods fall away, the middle motor continues to burn and drive the rocket skyward. It looks very similar to real satellite launch vehicles.

For example, with the core motor having a 24mm diameter motor tube, some good (visually appealing) choices for motors in the strap-on boosters might be:

Possible Motor Combinations

| Strap-on Booster Motor | Burn Time (sec) | Core Vehicle Motor | Burn Time (sec) |
|------------------------------|-----------------------|-----------------------|-----------------------|
| A8-0 | 0.5 | C11-** | 0.8 |
| B6-0 | 0.9 | D12-** | 1.7 |
| C6-0 | 1.9 | E12-** | 2.4 |

** The delay time for the core vehicle's motor will depend on the size and mass of the rocket. Run your computer simulations to determine the best delay time for your rocket. See https://www.apogeerockets.com/Advanced_Construction_Videos/Rocketry_Video_32.

Hooking up the Igniters:

The igniters of all the motors in the cluster should be wired in parallel. You can use a clip whip, long igniters, or add wire extensions to your igniters in order to twist the right pairs together.

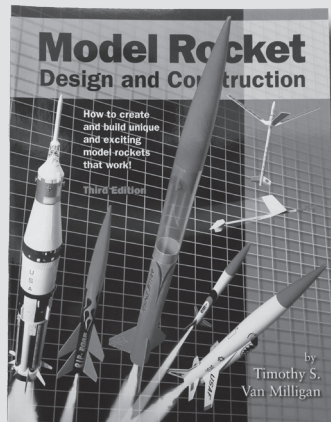
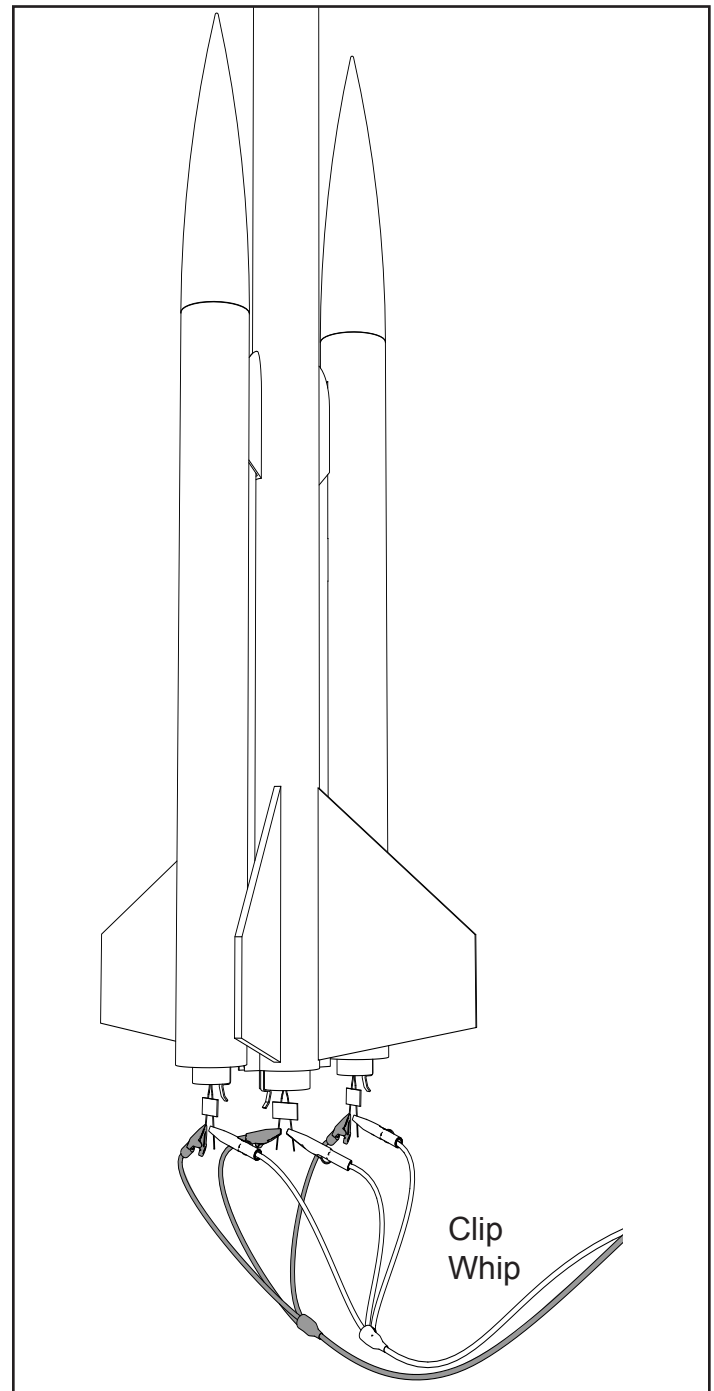
Frequently Asked Questions:

Q. Can the mounting hooks be used with other size rocket motors other than 18mm diameter?

A. They are robust and durable and can be used with other size motors. We recommend you stay in the mid-power range to minimize safety risks though. You as a user assume all risks for flying rockets, including this kit.

Q. Can composite propellant motors be used too?

A. We do not recommend mixing black powder motors in the same cluster as composite propellant motors. The reason is that black powder motors ignite quickly while composite propellant motors can take a second or two to come up to full thrust while sitting on the pad. If this occurs, the rocket could move with just the thrust of the black powder motors. If it moves, it is likely that it will yank the igniter out of the composite motor, thereby inhibiting it from catching fire. This would leave the rocket underpowered, and more importantly it wouldn't have a deployment of the parachute to bring the rocket down safely.



Model Rocket Design and Construction

This 328-page guidebook for serious rocket designers contains the most up-to-date information on creating unique and exciting models that really work. With 566 illustrations and 175 photos, it is the ultimate resource if you want to make rockets that will push the edge of the performance envelope. Because of the number of pictures, it is also a great gift to give to beginners to start them on their rocketry future.

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