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PEAK OF FLIGHT

NEWSLETTER

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Cover Photo: The US Rockets F with Multiple D Pods at lift-off. Get your own at: www.ApogeeRockets.com/Rocket_Kits/Skill_Level_4_Kits/F_With_Multiple_D_Pods

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Staging Composite Motors

By Connor McGrath

Many of us have launched a few black powder 2-stage rockets where the ejection charge of the first stage (booster) will light the second stage motor (sustainer) and then push out a parachute in the sustainer for a safe recovery, while the booster stage uses tumble recovery or a streamer and falls safely to the ground.

The NewWay Vigilangle rocket (www.ApogeeRockets.com/Rocket_Kits/Skill_Level_3_Kits/Vigilangle) shown in Figure 1 is a perfect example of a 2-stage black powder rocket that uses tumble recovery for the booster and a parachute for the main.

Figure 1: The Vigilangle kit is a conventional 2-stage rocket.

When you get into Mid and High power rocketry, there are some differences between the Black Powder motors and the Composite motors. The first and most important being that the black powder motors are end-burning. An end burning motor is a motor that is ignited at the bottom of the engine and burns up to the top. Composite motors are core-burning motors. A core-burning motor is any motor in which the igniter is pushed to the top of the propellant and the propellant will burn from inside out. The key is that the composite motors must be lit from the top. This is where staging composite motors becomes different from staging black powder motors, because a timer or an on board flight computer must be used to light the second stage of your rocket. This is compared to black powder motors where the ejection charge of the booster will light the sustainer motor. Composite motors are also not made with a -0 second ejection delay like the black powder motors.

It is highly recommended that dual deployment be used for the sustainer because if the sustainer's motor does not light (which is not uncommon) then you can be sure that the electronics will deploy your chutes. In comparison, if you relied on the ejection charge of the rocket engine and it did not light then the rocket would come in ballistic which is unsafe.

First things first: you will need a place to put your electronic in. The most commonly used apparatus is called an *inter-stage coupler*. It is very similar to an electronics bay used for dual deployment. Instead of having two bulkheads at each end of a coupler tightened together with threaded rods, an inter-stage coupler has one coupler bulkhead epoxied in the middle and another bulkhead at the end of the coupler. Inside will be a sled to attach the electronics. This is the simpler of the two ways to mount electronics.

A more advanced rocket would house the electronics in the sustainer of the rocket by building a sled on the outside of the motor tube as shown in Figure 2. You would then need to cut an appropriate sized rectangle in the body tube depending on the size of your sled, so that when you glue the motor mount in to the body tube the electronics sled can be accessed through the hole that you cut. Another piece of tubing could be cut to the same size of the opening that could be placed over the electronics sled and held down using plastic rivets or screws.

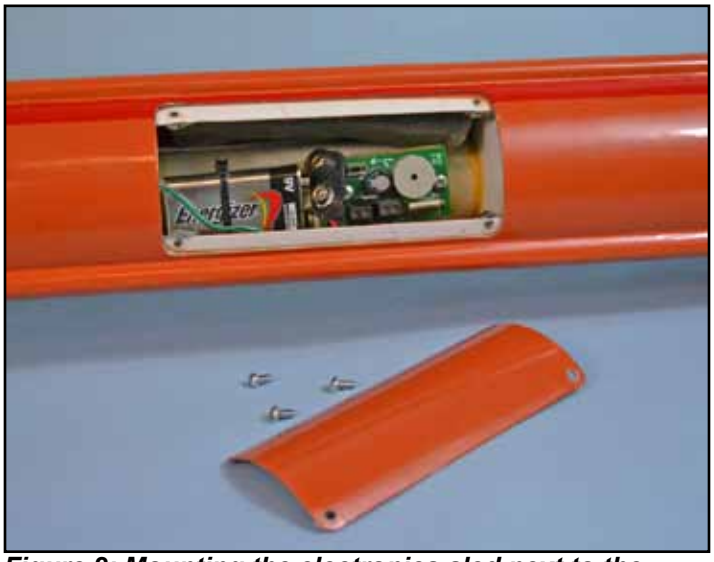

Figure 2: Mounting the electronics sled next to the engine mount tube in the sustainer.

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Another advanced setup for a 2-stage rocket that uses dual-deployment is that you can run the wires from your electronics bay in the sustainer (which is usually located between the payload/ main parachute bay and the bottom half of the rocket) down to a screw terminal to which you can then hook up your igniter.

For your first mid-power 2-stage rocket I would recommend that you use an inter-stage coupler because it is very simple and easy to incorporate into any rocket. If you are designing a 2-stage high power rocket then you should only be considering using the electronics bay inside of the sustainer.

When it comes time to attach the booster to the sustainer you will need to use a coupler to keep the two halves together. If you are using an inter-stage coupler then you can use the coupler with a switch band in the center to attach them together. One thing to keep in mind is that the coupler should be able to slide into the end of the sustainer and the top of the booster at least 1-1.5 calibers for a safe flight. You should use shear pins (www.ApogeeRockets.com/Building_Supplies/Misc._Hardware/Nylon_Shear_Pins_20_pack) to hold the coupler to the booster, so that the separation charge or whatever separation method you are using forces the coupler out the back of the sustainer instead of having the coupler separate from the top of the booster. If you're converting a kit into a 2-stage rocket then you may have to cut off some of the fin tabs in order to achieve this minimum distance.

Figure 3: A switch band prevents the coupler tube from sliding into the rocket.

If you do decide to mount your electronics in the sustainer you can easily permanently attach a coupler to the booster of the rocket, still following the minimum distance of 1-1.5 calibers inside of the sustainer. In both cases it may be a good idea to apply a thin layer of high temperature epoxy or a layer of fiberglass to protect the inside of the coupler from charring or catching on fire.

When the booster engine finishes burning you will need to know how your rocket is going to separate in order for the sustainer to continue on in its flight. There are many ways to do this, like drag separation or separation charge and pressurization from the ignition of the sustainer motor.

Drag separation will not work for all rockets. It works best with a booster with a greater drag coefficient than the sustainer. The idea is that when the booster motor burns, the rocket will begin to slow down due to drag and gravity. If the booster part of the rocket has more drag than the sustainer, the booster will slow down faster than the sustainer causing the 2 stages to separate. For using this technique you will need to have the electronics mounted in the sustainer because there will be no way to light the sustainer motor from an inter-stage coupler after the booster has separated. One problem with drag separation is that it is hard to know if it is going to separate or not. You can use this equation to figure out if the rocket will separate:

Step force, N = (Mass Booster / Mass Total x Drag Sustainer) - (Mass Sustainer / Mass Total x Drag Booster)

If N comes out positive, then your rocket will not separate and you will either have to re-work your design or use a different method to separate the stages. If N is negative then the rocket will separate and you will be fine. The second way to separate the two stages would be to use a separation charge. A separation charge is exactly the same thing as an ejection charge that you would use during

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dual deployment but instead of ejecting a parachute from the rocket it would push the booster stage away from the sustainer.

The location of the electronics will determine how you hook up your separation charge. If you have the electronics in the sustainer then this will be a little simpler. You should hook up your igniter and separation charge separately. You want to fire the separation charge a little bit after the burnout of the booster engine. The sustainer can coast for a short or long period of time depending on the velocity, and the igniter should be fired after the sustainer starts to lose velocity . This helps you gain altitude and allows you to control the flight profile of your rocket.

The easiest way to separate is to allow the pressure from the gases of the sustainer motor to blow the stages apart. The gases will act like a separation charge and push out the booster. This method should only be used for Mid-power rockets because. With larger engines you face having the motor over pressurize the coupler and have the body tube burst like a balloon. Like I stated before, if you are going to use this method you should line the inside of the coupler with a layer of fiberglass which has a high heat resistance or apply a thin layer of high temp epoxy such as J.B Weld or Pro-line epoxy thinned with denatured alcohol. It is okay to thin the epoxy for this purpose because you are not using it for its strength but its high heat resistance.

Safety Considerations

There are some things to take into consideration when aiming for a safe flight. For lighting the sustainer and better assuring that it will light, you can use a high power E-match and slivers of blue thunder propellant or pyrodex pellets for an extra oomph to get the engine lit. The reason we use blue thunder propellant is because it lights relatively fast compared to other propellants. You may have to sacrifice a small 24mm reload pack to get the small slug of propellant.

Figure 4: QuickDip allows you to add more pyrogen to the motor starter.

You can also use a dipped E-match. It is a regular E-match that is then dipped into more pyrogen. The pyrogen can be made or bought from many rocket vendors, such as the QuickDip from Quickburst (www.ApogeeRockets.com/Rocket_Motors/Motor_Starters/QuickDip). These steps do not

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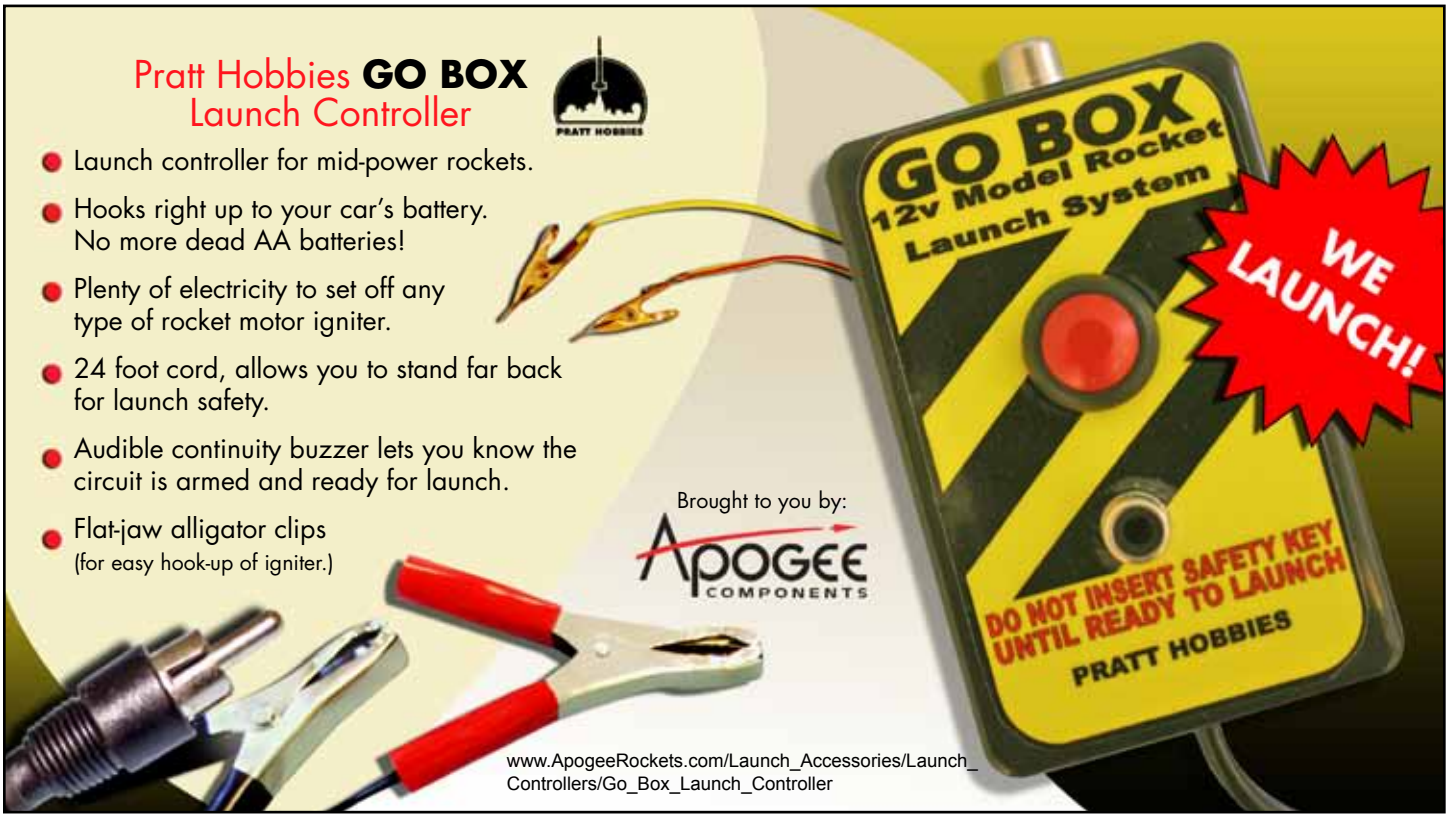

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have to be used when using most CTI motors because the motors have black powder pellets built into the top of them.

Preventing the sustainer engine from lighting when it is no longer safe is a necessary safety feature in all 2-stage rockets. Some altimeters have safety features that prevent the engine from lighting if the rocket is not going a certain velocity or with altimeters that have tilt-meters when the rocket is not facing up. An example is the MegaMetrum altimeter (www.ApogeeRockets.com/Electronics_Payloads/Dual-Deployment/TeleMega). You can also set an altitude minimum on some altimeters which won't allow the sustainer igniter to fire unless it has reached a certain altitude.

You should always take time to ensure you have a safe flight setup and some clubs are now even requiring that you have these safety features to be able to fly your 2-stage rocket.

If you follow these steps you will be on your way to mid and high power 2-stage rockets in no time. After you get used to setting up a 2- stage rocket you will realize that it is not nearly as hard as you originally thought it was going to be. Always make sure that rocket will be safe not only to prevent any injuries from occurring but also to protect your hard work from being destroyed from a simple mishap. Be careful once you start there is no going back!