ISSUE 40

APOGEE PEAK OF FLIGHT NEWSLETTER

Selecting Rocket Motors for Your Models: Part 3

By Tim Van Milligan

The Newsletter 39 we discussed the importance of selecting the right profile that you want your launch to achieve. This must be done in advance of choosing the rocket motor for the model.

To make again the comparison that we discussed earlier: The first thing that NASA does when getting ready to launch a satellite is to determine which orbit to place the satellite into. Without having this goal, you can't tell if you've been successful or not.

I want to stress how important this first step is. Without selecting the profile, we can't really choose any motor for the rocket. I get so many people that ask me what motor to use (see Newsletter 1). I really can't answer that question without knowing the purpose of the launch, or actually seeing the rocket.

We will assume that you know the flight profile you want the rocket to achieve. Now we can start looking at the model.

The next criteria to consider when choosing the motor is the size of the rocket. The size plays two roles. The mass of the rocket is the first parameter to consider. A lightweight rocket doesn't need as big a motor as a heavier one. This gives you a wider latitude in selecting motors for different flying conditions.

For example, if you first decide that you want the rocket to reach 1000 feet, and you were going to choose a F motor for it. This is probably based on optimal flying conditions (no wind). But when you get to the flying field, you discover the wind is blowing 15 miles per hour. Because the model is likely to weathercock, it may not reach that 1000 foot altitude. So now you can swap out a G motor for it.

For a heavier rocket, your first choice may have started with the G motor. But now when you get to the field, you discover that there is no waiver in effect. So the higher power motor (H) may not be allowed, and/or you may not be certified to use it.

I always recommend building the airframe as light as possible. It gives you a wider selection of motors to choose from. And if the model is too light (which doesn't happen too often), you can add sand as a ballast to the rocket to make it heavier.

The size of the rocket also plays a role in how much drag the rocket has. Drag has a similar effect as weight; preventing the rocket from flying as high as possible. The cross sectional area is one factor in the drag equation. The bigger the diameter of the rocket, the higher the drag force.

As we all know, another big component of the drag force on the rocket is the drag-coefficient of the model. This is the mystical number that is very difficult to predict without wind tunnel tests. But there are certain things we can look at on the rocket that will give us an indication of whether or not the model has a low drag coefficient or a high one.

Examples of low C_d models: airfoiled (streamlined) fins, boatails on the rear, fin fillets, smooth painted surface, and without a lot of protuberances poking out from the core of the rocket. These models will fly higher, and will be less susceptible to disturbances trying to force the rocket on an unintended flight profile.

To review, here is what we need to know which motor to select for the rocket:

1. What is the intended flight profile?
2. What is the physical size of the rocket?
3. How much does it weigh?
4. What is the drag coefficient of the rocket? (high or low drag)
5. What are the launch conditions (calm or breezy)? Is the launch site big enough to allow the rocket to come down long distances away?
6. Are there any physical limitations of the model itself? Such as not built strong enough for a really high thrust motor? Or what is the largest diameter and longest motor case that can be inserted into the rocket?

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At this point, we can now start running simulations.

That's right... After three articles on the topic of selecting motors for your rocket, it all comes back to running computer simulations. If you're reading this article, it is likely that you have a computer; which means you can run a simulation. So you have no excuse not to run them. Plus, you can download the free demo version of RockSim from the Apogee web site at: http://www.apogeerockets.com/rocksim.asp

Here is the approach you should follow. Start by selecting a motor you think might work. It doesn't matter if it does or not; we're only trying to find the "size" (A,B,C,D,E...) that will work. So just run the simulation anyway. Then compare the results to the flight profile you want to see. When running the first simulation, always assume optimal launch conditions -- no wind, and a straight up launch.

The first parameter you're going to look at is the altitude of the flight profile.

If the rocket doesn't fly high enough, use a bigger motor. If it is too high, select a smaller motor for the next simulation. Keep running them, until you get into the ballpark.

Then, start looking at other key parameters of the flight profile; like the lift-off velocity. This is where you'll be choosing the average thrust of the motor. For example, in 18mm D motors, you have a choice of the D21, D10, or D3. A higher thrust motor will give you a faster lift-off velocity, and straighter and more stable flight. But the model won't fly as high as a lower thrust-level motor.

I personally like to use the lower thrust-level motors; because they are easier to follow as the rocket ascends into the air. So if a low thrust motor will get you results that are close to your intended flight profile; then start seeing how it flies when there is some wind.

However, a lower thrust motor is more susceptible to weathercocking. You may wish to revisit the article in Newsletter 34 for help in deciding if the rocket is weathercocking too much. If it is, then try the higher thrust-level motor; and see how much of a difference it will make.

The next step would be to select the right delay for the motor. The delay controls when the recovery device is deployed. Again, you compare the results of the simulation to the flight profile that you'd like to see. I personally start my simulations by using the longest delay motor possible, and then switching to shorter delays and see what happens.

One tip that I found works well for me. If there is a choice of two delays that would work for a particular flight profile, then use the shorter delay in the actual flight. This gives you a little better safety margin on the mission. For example, a longer delay deploys the recovery device after apogee, while the short delay deploy it a little before apogee.

The last thing you might try in your simulations is to see how the rocket reacts by angling the launch rod. You do this if there is any wind. As mentioned in the last article, sometimes you may wish to angle with the wind, while other times you might angle the rod into the wind. It depends on the mission of the launch.

I realize that the key thing in all this is to correctly interpret the results of the simulations. For additional guidance, you may wish to read our Technical Publication #15 - "Understanding Rocket Simulations for RockSim." You can find more information about this publication on the Apogee web site: http://www.apogeerockets.com/technical_publications.asp

You will find that selecting a motor is a looping process. You end up repeating the steps in the processes many times until you find a motor that best meets your intended flight profile. But as you do this over and over, you are actually gaining a lot of insight and experience.

At some point, you'll start choosing the initial motor in the simulation process based on past experiences. You'll have a gut feel for how the motor will affect the flight of the rocket. When you reach that point, I can assure you that you have accomplished the first step in being considered a rocketry expert. At this level, you'll be able to select motors in a quicker amount of time. But don't forget -- always run your simulations. You will undoubtably find something new. I still do. I never try to stop learning.

Simulations are a fast way to gain experience and make the motor selection process more accurate and quicker. But you also need that "real-world" experience that comes from actually going out and launching the rocket.

You have to be able to observe the flight and see if it met your flight profile expectations. I've found this harder for new modelers to determine because events happen so quickly during the launch. You have to train your eyes and brain to notice the important things that affect the flight. So a long time ago,

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I created a little flight form that allows modelers to view the flight, and record the events that occurred. This is called the *"Apogee Flight Record."* There is a companion Technical Publication (#9) that explains how to use this form. It is also described in my book *"Model Rocket Design and Construction"* in the chapter on flight testing.

For those people that would like a sneak peek at the Apogee Flight Record form, you can find it by clicking here.

In conclusion, I think choosing motors correctly is a difficult the first time. But it gets easier and easier as you run your simulations and perform actual launches. You get better as quickly as you learn from your results.

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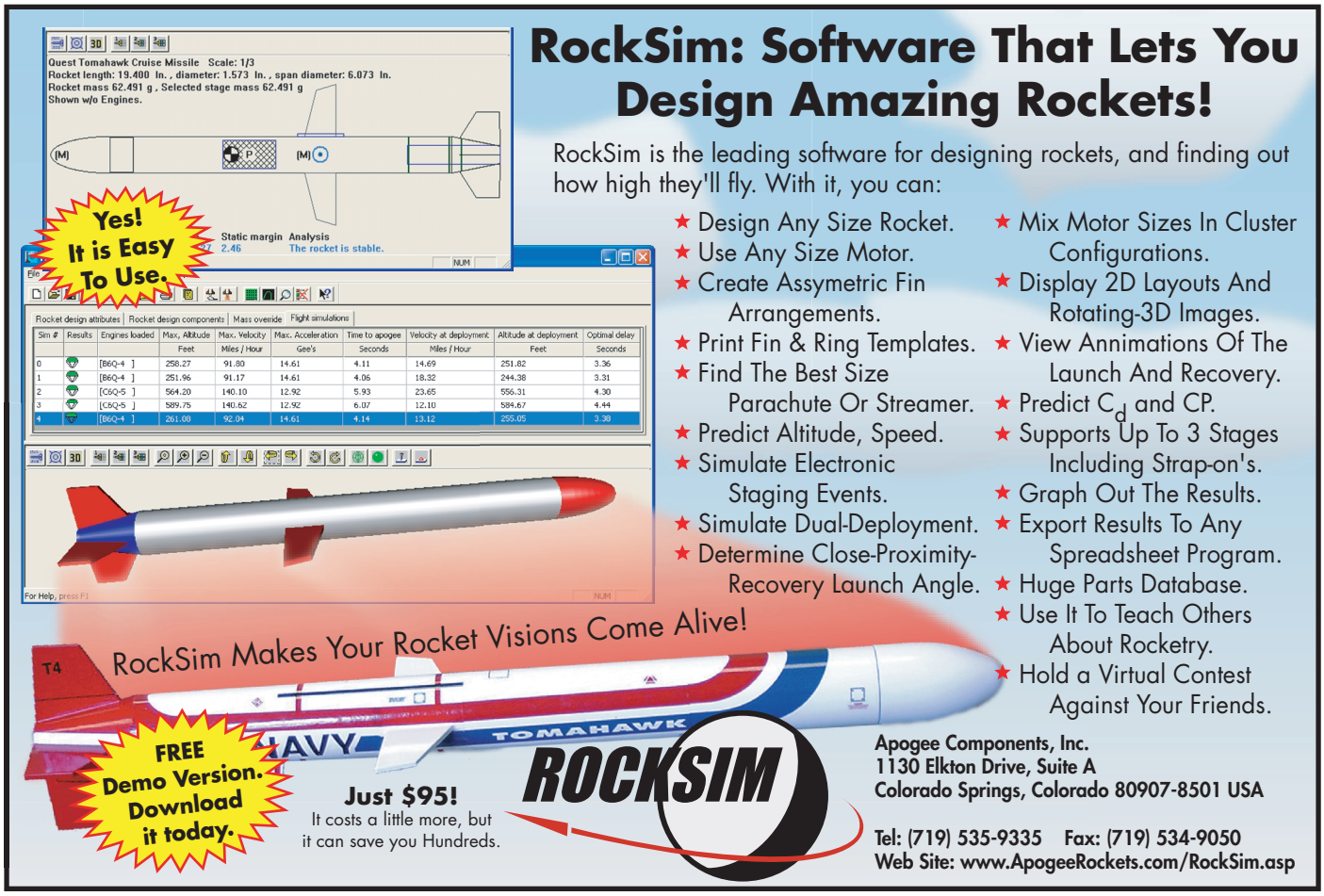
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