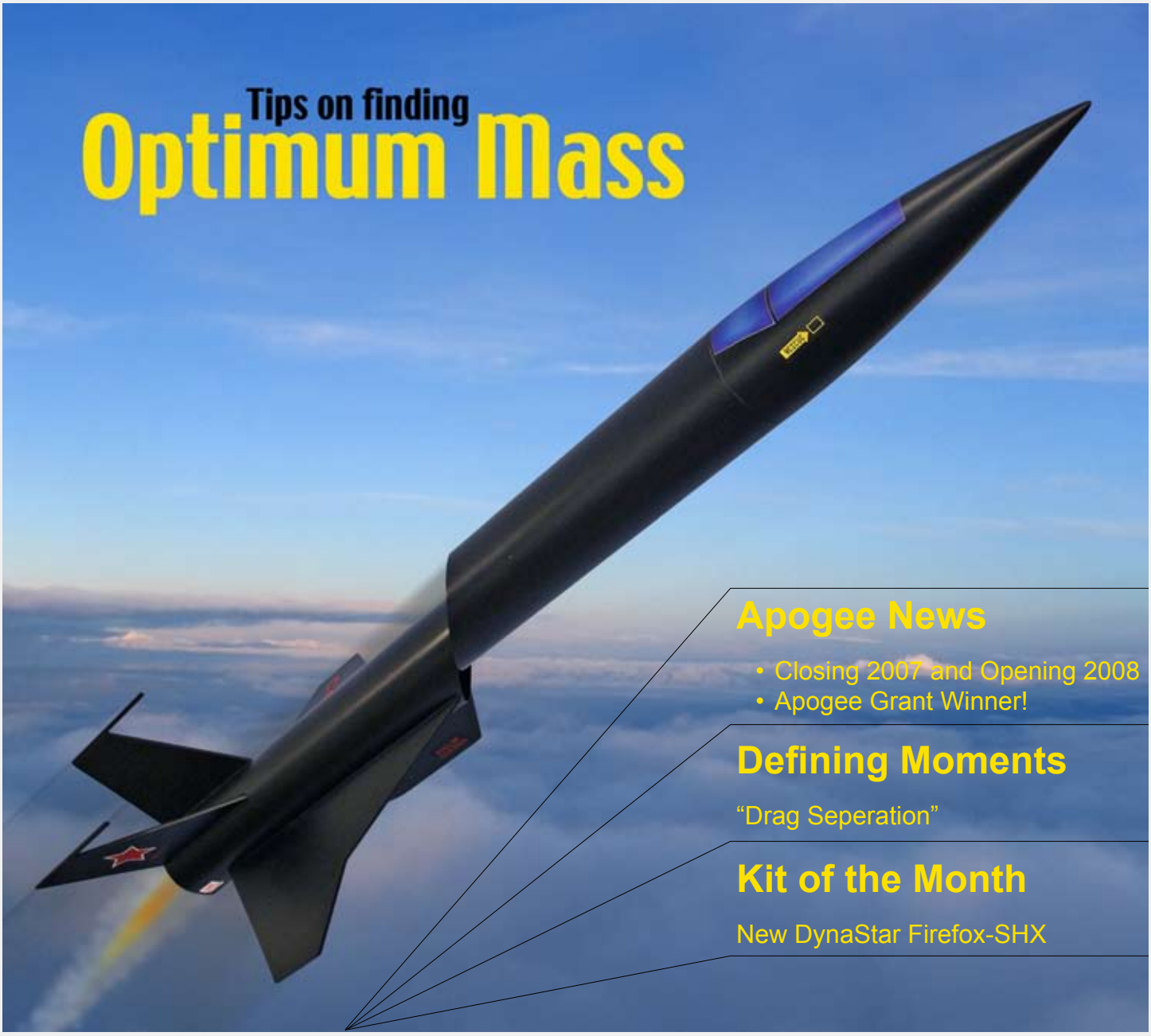
Apogee Components

PEAK OF FLIGHT

NEWSLETTER



Tips on finding Optimum Mass

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Defining Moments

"Drag Seperation"

Kit of the Month

New DynaStar Firefox-SHX

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PEAK OF FLIGHT

TIPS ON FINDING OPTIMUM MASS

By Tim Van Milligan

Most rocketeers are familiar with the topic of Optimum Mass. By definition, it is the mass for the rocket that gives the highest flight with a given rocket engine and a given set of launch conditions. That sounds pretty simple, doesn't it? You calculate the Optimum Mass of the rocket, then build the rocket so that it weighs that mass, and you sit back and watch it achieve a high flight.

Unfortunately, it isn't so simple.

For starters, I urge you to get background information on the subject of Optimum Mass by reading Apogee Technical Publication #15. It can be ordered from Apogee Components at: http://www.apogeerockets.com/technical_publications.asp, or it can be received free when you order three times from Apogee Components as part of our Frequent Flyer Program (for details, please visit: http://www.apogeerockets.com/Frequent_flyer.asp).

The report gives a detailed description of the theory behind the Optimum Mass calculations, and what some of the common misconceptions are. There are three chapters of information covering things like: Optimum Mass in the presence of wind and for angled launches, and the Optimum Mass for multi-stage rocket. I guarantee that you'll learn something new by reading it. I don't want to rehash that information, because it is very detailed and I don't want to spoil the surprises you'll find buried in that report.

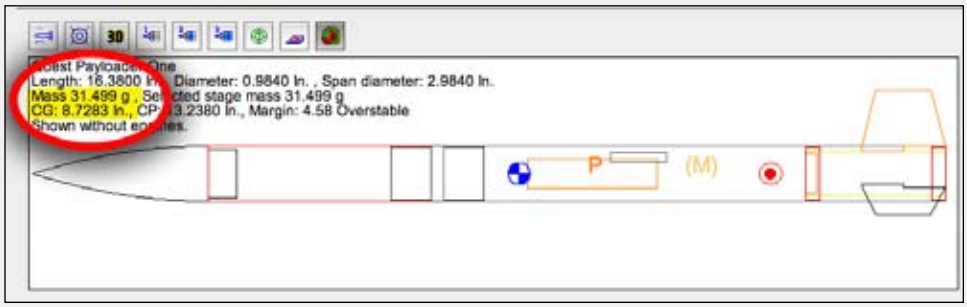
When RockSim runs the Optimum Mass computations, it automatically runs many launch simulations to find that particular simulation that gives the highest flight. The difference between one simulation and the next is the mass that RockSim uses. It usually zeros in on the Optimum Mass in less than 30 simulations. It is remarkable how fast RockSim is. I've found that it takes fewer than 10 seconds, even for high performing rockets.

But the more I research the subject, the more complex I find it to be. It isn't as simple as selecting "Predict Optimum Mass" from the simulation menu in RockSim. If you don't set up the scenario correctly, you'll get garbage data back from the software.

What I want to do in this article is guide you through the process of setting up the simulations so that when you do run Optimum Mass calculations, the results should be pretty good.

Note: Optimum Mass is available in the 30-day trial edition of RockSim. Even if you don't own RockSim yet, you can still play with it.

Step 1: The first thing you'll need to do after opening your rocket design is to note the empty mass and the CG position of the rocket without the engine installed. Write it down on a piece of paper so that you don't forget it.



Step 2: Click on the "Mass override" tab on the top of the screen, and enter the mass and the CG position of the rocket in the sustainer section. Be sure to check the little box that says "Use the values shown on the next page for all the simulations."

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About this Newsletter

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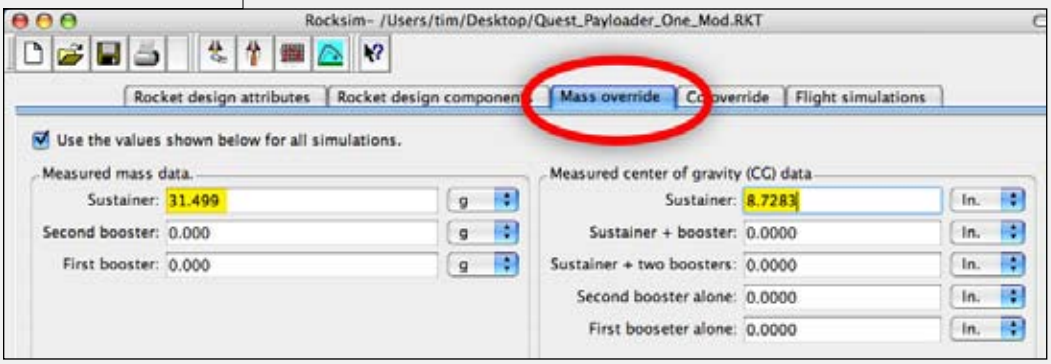
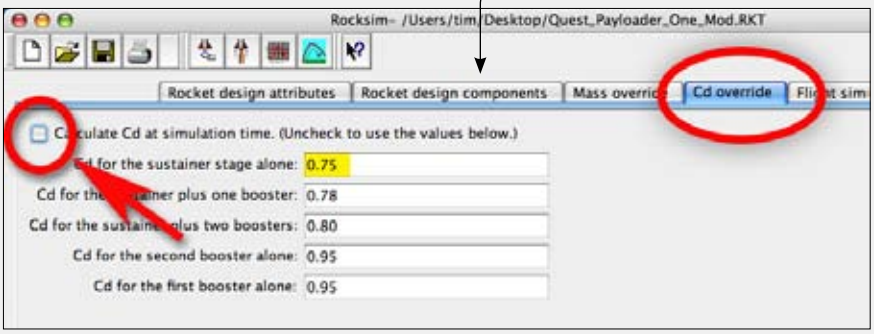


The reason we want to use a mass override is that we want to control the CG position of the rocket. If you recall from the series of articles on Dynamic Stability, the location of the CG will affect the trajectory of the rocket. We want to make sure that we control the location so that when we run the Optimum Mass calculations in RockSim, the software is always putting the mass at the same point. Otherwise, we won't be comparing apples-to-apples during the simulations.

Step 3: Now click on the "Cd override" tab. We want to use a fixed Cd for the simulations, so you'll enter in a value for the Cd of the rocket. If you don't know where to start, then use 0.75.

If you are really meticulous, you can do the back-tracking technique to find the average Cd of the rocket that will match the altitude that RockSim calculates dynamically. In other words, you can run a simple simulation with RockSim calculating the altitude, and then use the Cd override to get a number to will yield a similar altitude.



For example, say RockSim gives you an altitude value of 1000 feet. You would then guess at a Cd that would give you a similar altitude. It will probably take you about 10 flight simulations to get a close Cd value that would give you the same 1000 feet altitude for the rocket. If you don't want to manually do all that guessing, you can use the SMARTSim software (http://www.ApogeerRockets.com/smartsim.asp). It will get you the number much quicker.

Be sure to uncheck the box on the screen that says "Calculate Cd at simulation time. (Uncheck to use the values below)."

Why do we want to use a fixed Cd? Great question!

The reason is that in real life, the Cd is going to vary wildly throughout the flight. It changes in response to the rocket's velocity and angle-of-attack. So by using a fixed value, we eliminate the variability, which will result in the Optimum Mass simulations.

I know this is hard to understand, so let me try to explain it with an example. Which rocket is going to go faster, a lightweight one or a heavy one? Obviously the lightweight rocket is going to go faster if all the conditions are equal.

But since we know that the drag coefficient is higher with a faster rocket, we can say that we are not really having things equal. In other words, it is highly possible that the lighter weight rocket has a higher drag coefficient than a heavier one. So it will simulate too low, while a heavy one may simulate to a much higher altitude.

By using a fixed Cd, we've eliminated that variability.

Step 4: Pick your rocket engine. Remember that each rocket engine will give a different Optimum Mass in your rocket design. I'll refer you to Technical Publication #28 on selecting rocket engines.

Step 5: In the RockSim Simulation Properties screen, click on the "Launch Conditions" tab. On this screen, we need to set the wind speed to zero.

RockSim wants to mimic real-life conditions as much as possible, so it will introduce random variability to the wind. For example, at liftoff the rocket may be flying through wind blowing at 5 miles per hour. Then 200 feet up, the wind speed may be 7 miles per hour.

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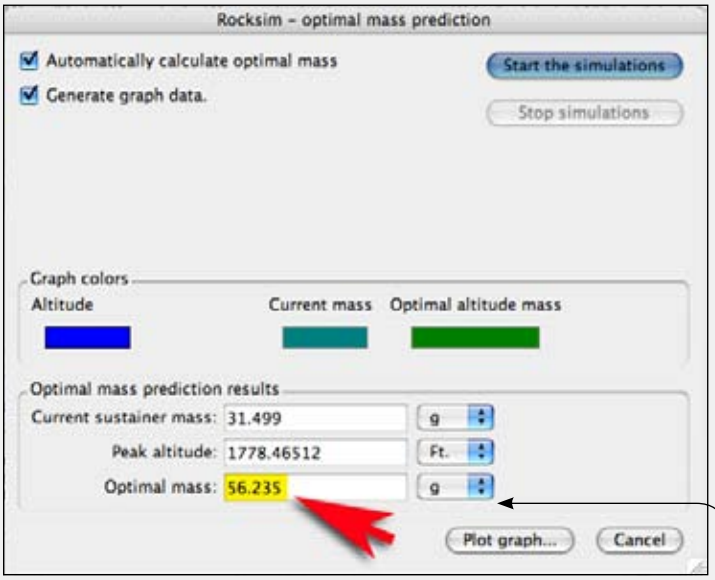
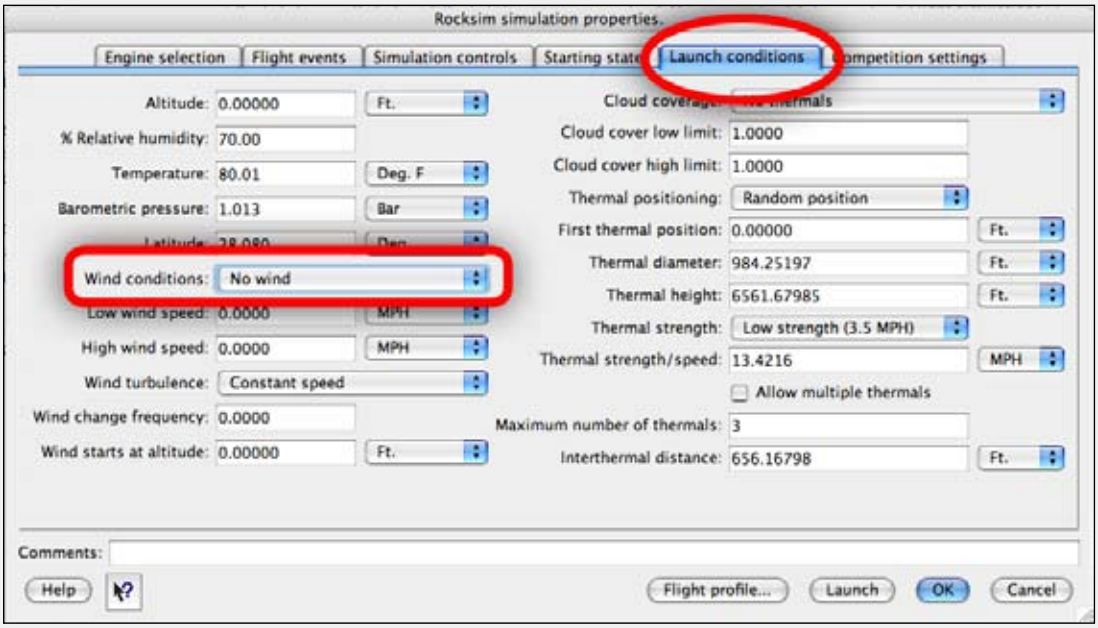
The variability is random. That is why you can run dozens of simulations back-to-back and get slightly different altitude results. The altitude is different because the rocket reacts differently to changes in wind speed. Again, see the articles on Dynamic Stability Analysis to see how the rocket will behave in different wind conditions.

By turning off the wind completely, we will force all the simulations in the Optimum Mass calculations to react identically.

Note: if you want to add wind, make it a "custom speed range" for the wind conditions. Then set the upper and lower wind speed values to the same identical number. This will make a constant wind with no variability.





At this point, write down the reported values for the "Optimal mass" and the "Peak altitude" on a piece of paper.

You can click on the "plot graph" button on the bottom of the screen, and you'll get a graph showing how the altitude changes with different masses.

Step 6: Now launch the rocket. With the simulation highlighted, select "Predict Optimal Mass" from the "SIMULATION" drop-down menu. You can check the two boxes at the top of the screen, and click "Start the simulations" button.

The software will then run through its computations. You'll see its progress as it counts off the number of simulations it has completed. When it is done, you'll get an Optimum Mass value.

The optimal mass that is reported back should be the best mass. Unfortunately, we've found that for some reason it isn't quite correct the first pass through.

We've talked about the usefulness of this graph in Peak-of-Flight Newsletter #198 (page 5), so I won't go into further detail here as it would only be redundant.

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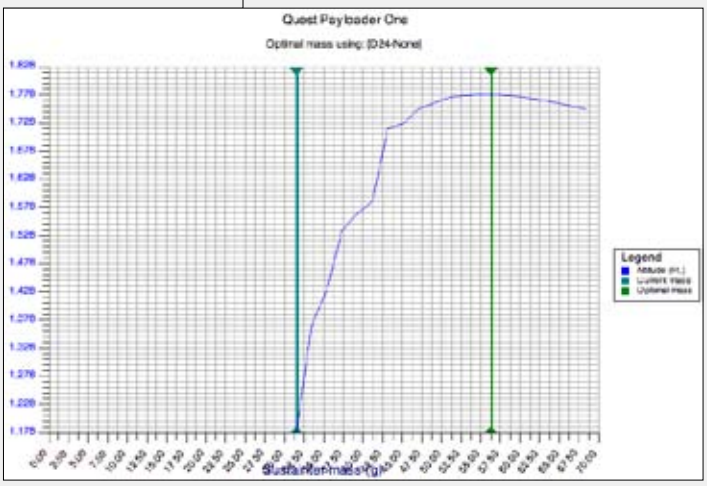
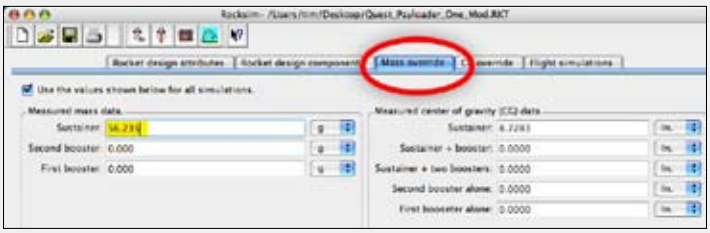
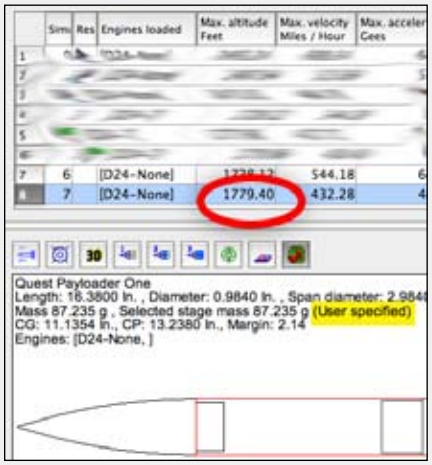


You can close out the graph and the Optimum Mass screens at this point.

Step 8: Now go back to the "Mass override" tab on the main screen of RockSim. I want you to confirm that the Optimum Mass reported is indeed the true value. Type the value reported on the Optimal mass screen into the Measured mass data section. You can leave the CG position alone.

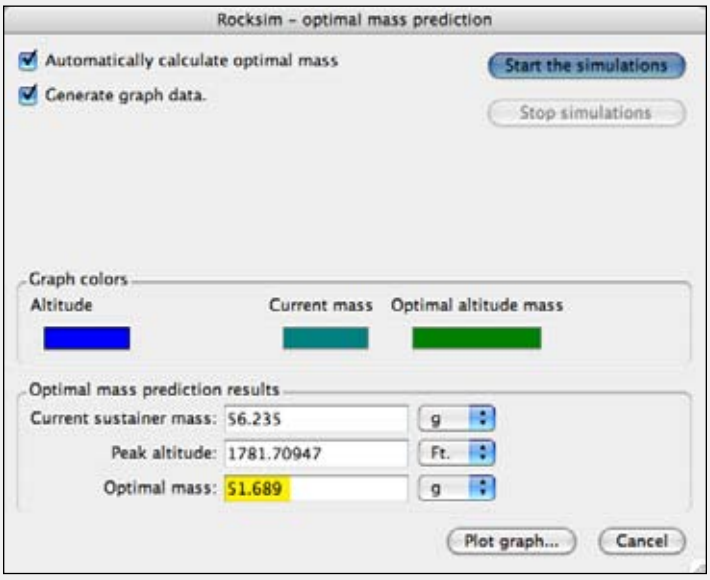


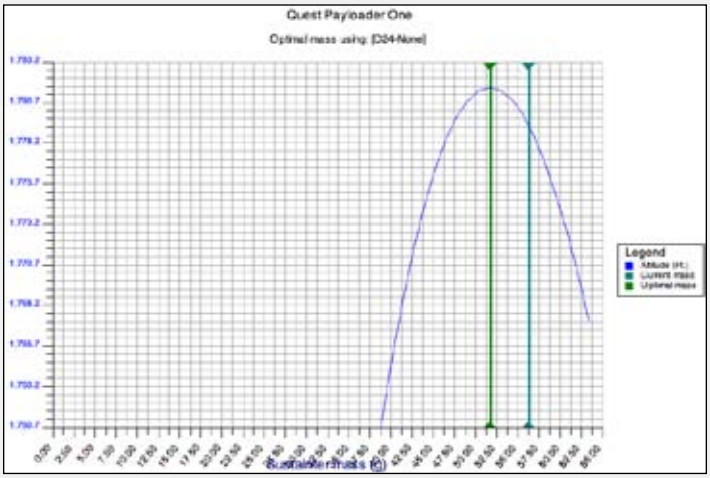
Then run a new simulation. All you need to do is hit the launch button, since all your initial conditions are the same as before.



If the altitude results are equal (or pretty close) to what was predicted when running the Optimum Mass calculations, then you're done. You've found the Optimum Mass of the rocket for the given engine, drag coefficient and launch conditions.

If the result is off significantly, then I've found that running an Optimum Mass calculation a 2nd time will zero in on the true value. Why a second run-through is necessary is not totally known yet. We think the first time through the underlying conditions are somehow polluted with bad initial values; and then they are overridden the second pass through the Optimum Mass algorithms. We're still trying to track down the exact cause, but it looks like running it a second time does the trick.





One thing to remember is that the Optimum Mass changes with the drag coefficient of the rocket. I just wanted to show you this, so that you can keep this fact in mind as your running your Optimum Mass simulations. This is shown in figure 12, which happens to be for the Apogee Aspire rocket flown using an F62 engine.

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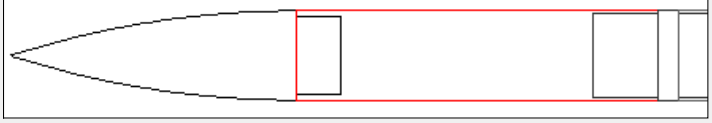
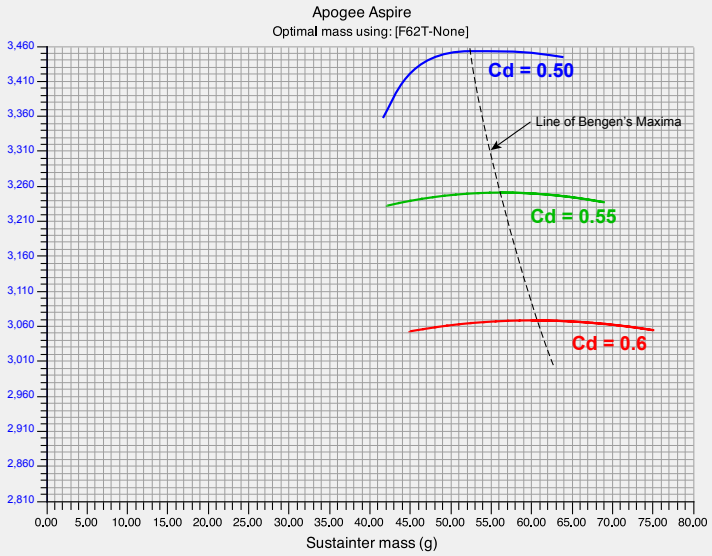
	Simu	Res	Engines loaded	Max. altitude Feet	Max. velocity Miles / Hour	Max. acceleration Gees
7	6		[D24-None]	1728.12	544.18	66.46
8	7		[D24-None]	1779.40	432.28	47.31
9	8		[D24-None]	1781.71	450.45	49.97

Quest Payloader One
Length: 16.3800 In. , Diameter: 0.9840 In. , Span diameter: 2.9840 In.
Mass 82.689 g , Selected stage mass 82.689 g (User specified)
CG: 11.2678 In., CP: 13.2380 In., Margin: 2.00
Engines: [D24-None,]





As you can see, the lower the Cd value, the lower the Optimum Mass of the rocket. Since the Cd is very difficult to predict accurately, that leads us to a dilemma. What Optimum Mass should we actually build the rocket at?

My suggestion is to build the rocket at the lower Optimum Mass. Why? Because it is much easier to make the rocket heavier to get it up to the optimum value than it is to make it lighter. To make it heavier, you can always add ballast to the rocket, such as tracking powder, or sand in the nose cone.

After building your rocket at a lower Optimum Mass, go ahead and actually launch it and measure the altitude. From that, compute the average Cd value and plug that into Rocksim to compute the Optimum Mass. From there, add the correct amount of ballast and go for your record-setting flight.

For some reason, many modelers don't like having to do a test flight prior to going for the record-setting flight. I've had many people tell me that the cost of the big motor is going to be too expensive for them to afford a test flight.

My suggestion for those modelers is to build a scaled-down version of their big rocket. The Cd for the small rocket is going to be very close to the big version. That is the beauty of the Cd number; it is independent of the size of the rocket!

References:

Technical Publication #15: Understanding Simulations From the RockSim Software.

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. Before he started writing articles and books about rocketry, he worked on the Delta II rocket that launched satellites into orbit. He has a B.S. in Aeronautical Engineering from Embry-Riddle Aeronautical University in Daytona Beach, Florida, and has worked toward a M.S. in Space Technology from the Florida Institute of Technology in Melbourne, Florida. Currently, he is the owner of Apogee Components (http://www.apogeerockets.com) and the curator of the rocketry education web site: http://www.apogeerockets.com/education/. He is also the author of the books: "Model Rocket Design and Construction," "69 Simple Science Fair Projects with Model Rockets: Aeronautics" and publisher of a FREE e-zine newsletter about model rockets. You can subscribe to the e-zine at the Apogee Components web site or by sending an e-mail to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject line of the message.

APOGEE NEWS

By Tim Van Milligan

We just finished up another great year. Our sales for 2007 were up over 13% compared to 2006. I attribute this to our great customers coming back for more of our outstanding service. My goal is to try to make purchasing from Apogee more than just a transaction; I'd like it to be a grand "event" in the lives of our customers. Look for more of that in the coming year.

The year 2007 was also a big one for Apogee Components because of the move last April into our present 6,000 square-foot building. It has more than double the floor space compared to our old facility. With the extra room we hope to stock more of the items that you'd like. If you have suggestions for us, please feel free to drop me a note with your recommendations.

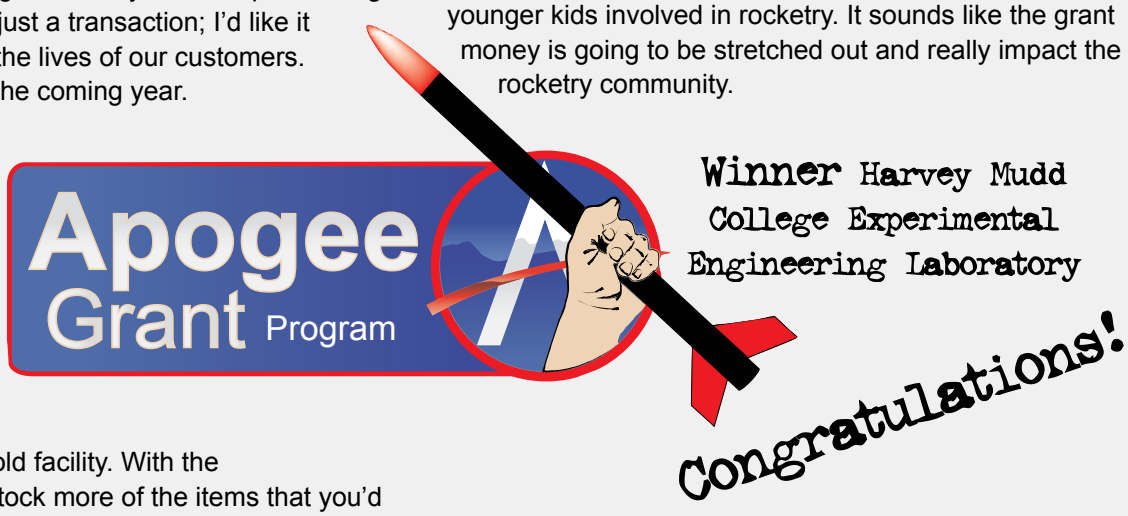
In the last two months, we have added a few new kits offerings, such as the ones by Mad Cow Rocketry, and a brand new DynaStar Mid-Power Model Rocket called the FireFox-SHX. The SHX part means that the kit was designed by Shrox, so you already know it is cool looking.

We've got a new Apogee kit that is going to be released soon. It is called the "Avion." The rocket is a 24mm diameter bird that is about 15 inches long. It is designed to be a skill-level 1 rocket, so it will be great for school groups and youth organizations like scouts and summer camps. We're probably about a month away from releasing it, as we're just waiting for the decals to come back from our printer.

Finally, I'd like to announce the winner of this year's Apogee Grant contest. The prize of $300 in Apogee merchandise goes to the educational organization that I feel best promotes the hobby of model rocketry.

The $300 is a lot of money to me, since it comes right out of my own pocket, so I am looking for unique approaches to getting the word out about rocketry. I'm not going to award the money based solely on how needy the organization is. Every organization seems to have big needs; I want to give the money to that group that is going to really focus on spreading the news on how great rocketry is.

This year's winner of the $300 Apogee Grant Program goes to Harvey Mudd College Experimental Engineering Laboratory in Claremont, California. They are sending their students out to middle schools in their area to help get younger kids involved in rocketry. It sounds like the grant money is going to be stretched out and really impact the rocketry community.



DEFINING MOMENTS

"Drag Separation"

Drag separation is used to describe the condition where a rocket's parts become disengaged because the aerodynamic drag force on bottom section of the rocket is greater than the drag on upper part. In some cases it can be good, while in other situations it can cause shredding of parts.

An example of a good use of drag separation is when you want the upper stage of a two-stage rocket to disengage from the booster stage. Usually the upper stage will be made a smaller diameter than the booster stage, so that the drag force acting on the booster is greater than the drag on the top stage. As long as the booster motor is burning and creating thrust, the stages will stay together. But as soon as the booster motor burns out, the higher drag force acting on the rear part of the rocket will slow it down and pull it away from the top part.

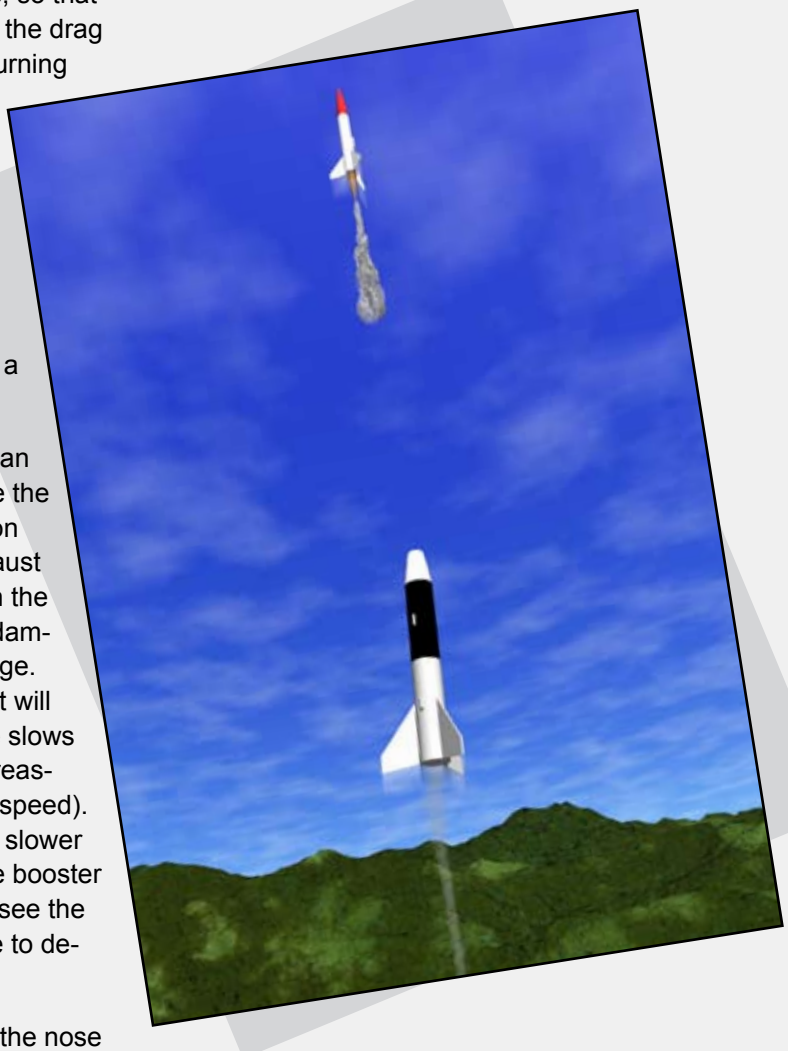
The top stage then can coast away from the booster. Because it has lower drag, it can travel a lot higher. If the top stage is unpowered, it is called a "boosted dart."

If it contains a rocket engine, the upper stage can be ignited mid-air. The effect is cool to see because the smoke starts high in the air. And this delayed ignition actually has some advantages. First of all, the exhaust gases of the upper stage do not directly impinge on the front part of the booster stage. This prevents heat damage and soot from accumulating on the booster stage. Second, allowing the upper stage to coast a little bit will actually give you a higher flight. As the upper stage slows down before the engine fires, the drag force is decreasing (remember drag increases at the square of the speed). This means that the average speed of the rocket is slower than if the upper stage ignited immediately after the booster stage burns out. Run your RockSim simulations to see the increase in altitude when you allow the upper stage to delay a little bit before it ignites.

On many large-diameter, single-stage rockets, the nose cone can drag separate from the back end of the rocket. If this occurs when the rocket is still traveling at a high rate of speed, it will pull the parachute out too early and shred it to bits. This is very bad, because now the big rocket is coming down fast without a chute to slow it down.

What high-power modelers will do to prevent this is to put two or three small plastic screws or rivets through the tube and into the shoulder of the nose cone. These plastic screws are then sheared apart by the force of the ejection charge when it ignites to push the nose cone off the rocket. The plastic screws are called "shear pins" and are meant to be replaced between flights.

For more information on the use of shear pins, see the book: "Modern High Power Rocketry 2."
http://www.ApogeeRockets.com/Modern_hpr.asp



KIT OF THE MONTH

DynaStar Firefox-SHX

This rocket kit has a shape reminiscent of a Soviet-era fighter jet. The inspiration actually came from the 1982 movie starring Clint Eastwood called “FIREFOX.” The model is meant to look like a mean and stealthy fighter jet.

The unique trait of this rocket is the offset body tube. Even though the nose is not on the same centerline as the engine tube, the rocket is robust enough that it flies straight and true on D, E and F size rocket engines.

The Dynastar FireFox-SHX kit was designed by Shrox, who creates some unique designs that can be built using traditional rocket materials. Shrox has always attempted to make kits that don’t need a lot of specialty parts. He likes things that can be easily scaled up or down, so modelers can make several different versions of the same kit.

This is a simple-to-build rocket that uses traditional model rocket construction techniqes that you may be familiar with from building smaller models.

The bigger parts actually makes it easier to build this model than a smaller rocket, because the parts are easier to grasp.

Another feature of this kit is that the rocket has a low mass compared to it’s internal volume. That is possible due to the lightweight nose cone, and balsawood fins. You’ll be able to fly this rocket to about 340 feet up using the inexpensive D12-3 rocket engine. With composite motors, this rocket can easily go over 1000 feet into the sky!

Big Performance on Mid-Power Motors

Like the other kits from “DynaStar Mid-Power Rockets”, the FireFox-SHX is designed to fly on the less expensive “D” size black-powder rocket motors. And it will give you the same performance as other mid-power kits that require “E” and “F” size composite propellant rocket motors. The lighter weight rocket allow the rocket to fly faster and higher.

Kit Features

- Offset Body Tubes Create A Air-Scoop Appearance
- Plastic Nose Cone
- Colorful pressure-sensitive decals
- Laser-cut balsa wood fins
- Large 1/4 inch Launch Lug
- Premium Quality Body Tubes
- Large 32” diameter plastic parachute
- Die-Cut Cardstock Centering Rings and Bulkheads
- Kevlar® Shock Cord
- Spring-steel engine retainer clips

For more detailed information go to:
http://www.ApogeeRockets.com/firefox.asp