

I S S U E 8 4 - J U N E 2 8 , 2 0 0 2

APOGEE

PEAK OF FLIGHT

N E W S L E T T E R

How To Save Time and Money By Using the RockSim Software

Optimum Mass vs. Peak Coast Time

Squeezing Out Every Inch of Altitude

Spin Doctor Plan: Part II

A Detailed Look at the Helicopter's Hinge Construction

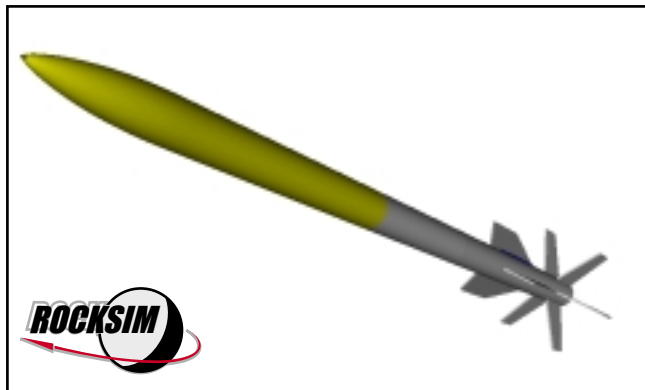
APOGEE
COMPONENTS

1130 Elkton Drive, Suite A
Colorado Springs, CO 80907 USA
www.ApogeeRockets.com
orders @ApogeeRockets.com
phone 719-535-9335 fax 719-534-9050

TEST FLY YOUR ROCKET DESIGNS BEFORE BUILDING THEM!**Save Time, Money, and Embarrassment By Knowing with Absolute Certainty that Your Rockets Are Safe to Fly.**

Did you know you can test launch your rocket designs before you even start to build them? As you can imagine, if you can perform a rigorous shakedown to your rockets before the glue is dry, you can still modify it to make it safer, or to make it fly higher! This has a lot of advantages in time and money:

1. You'll save money by making sure they fly straight. An unstable rocket that crashes is a waste of money because you can't fly it again and again.
2. Prevent a rocket that drifts out-of-sight and loses an expensive motor casing. This waste of money can be avoided by some pre-flight simulations and selecting the right rocket engine to use.
3. If you know all the parts you need to build your rocket, you won't order unnecessary items -- saving you money!
4. Save time by preventing building errors - You'll know exactly where each part is positioned when it is time to put the rocket together. You won't have any more rockets where parts have to be chiseled out and replaced after the glue has dried. Think of all the frustration you'll be saving yourself from.
4. By testing your design before hand, you know what rocket motor to buy. You won't end up spending money on rocket motors that have the wrong ejection delays.
5. You can actually design high performance rockets to fly from small launch sites. You'll know how high the rocket will fly, and how far away from the pad it will land.
6. You'll know the rockets projected weight, which is important if you are trying to build big rockets that don't require a waiver to launch them. This will also help you to select the right size parachute you'll need; so you won't buy the wrong size.
7. If you are going to attempt a Level 2 or Level 3 high-power certification, you'll need proof of CP location. You'll get this from RockSim.
8. You'll know what the rocket looks like in 3-D, so you can find what color choice looks best before you buy any paint.



And if you fly a lot of rockets, you'll find that by designing your own rockets, you will save hundreds, if not thousands of dollars compared to buying kits. And at the same time, you'll learn more about rocket science than expert modelers that have been flying rockets for years and years.

As you can see, using an advanced software like RockSim can save you a lot of money and a lot of time. But why RockSim? Can't you get the same features from a cheaper program?

First, before I answer that question, let me tell you a little bit about RockSim.

RockSim is the most popular rocket design and simulation software -- because it works! Over 2,500 high power fliers, universities, government agencies, and defense contractors use it. They trust it, and so should you.

What Is RockSim?

RockSim is a rocket design and simulation program for the Windows operating systems. It can be used to design models from tiny sizes to ultra-huge monster rockets!

When you create a rocket design, RockSim calculates the mass of the model plus it finds the CP and CG locations so the static stability can be determined. Then when you perform a simulation, it will tell you how high and fast it will go, plus where the rocket will land.

But deep down, RockSim is actually a collection of many unique computer programs -- that are seamlessly integrated into "one" package. The important part to you is that it is all "seamless" -- you can't tell where one part stops, and the next

cont. on pg. 3

TEST FLY YOUR ROCKET DESIGNS BEFORE BUILDING THEM!

cont. from pg. 5

starts. This is what makes it so powerful and so easy to use!

It has this list of mini-programs already built in:

1. A "CAD-like Drafting Program" to aid in laying out the arrangement of the component parts; and to draw 3D images of the rocket. While it is CAD-like, it is much simpler to use - even 10 year old kids use RockSim without any troubles.
2. A "Coefficient-of-Drag Prediction Program" to find out the efficiency of the rocket's shape. You can't even begin to tweak the performance of the rocket until you know its Coefficient-of-Drag. RockSim calculates this as you are still designing the rocket, so you can tweak the shape for optimum performance.
3. A "Optimum Mass Prediction Program" - to find the best weight of the rocket that gives the highest altitude. Did you know that sometimes you have to "add" weight to the rocket to make it go higher. RockSim will tell you what the best weight should be for the highest flights.
4. A "Center-of-Pressure Prediction Program" - to find the static stability of the rocket.
5. A "Center-of-Gravity Prediction Program" - to find out the overall weight of the rocket and its stability during flight.
6. A "Dynamic Stability Program" - to find out the trajectory of the rocket; including what happens when wind acts on the model. No other software has this capability- all assume there is no wind. "No wind?" -How ridiculous is that?
7. A "Flight Simulation Program" - to find out how high and fast the rocket flies; and as an aid in helping you in selecting rocket engines in achieving this performance.
8. A "Component Selection Program" - print out a list of materials to make it easier to gather parts when constructing the rocket.
9. A "Pattern Sheet Program" - used to print fin and centering ring patterns, to aid you in building your rocket design.
10. A "Component Design Program" - which helps you create new and unique nose cones, curved transition sections and odd shaped fins. RockSim is still the only program that will allow you to make any fin shape you want!
11. A "Special Events Editor" - used to select when, where, and how to use electronic initiation devices during the flight. If you're a high-power flier, and you use electronics on your

rocket, you need this feature to help you set the recovery sequences correctly.

12. A "Graphing Package" - to create order & meaning from complex information generated by each launch scenario.
13. A "Recovery Device Selection Program" - to determine what size parachute or streamer is needed to safely bring the rocket to the ground.
14. A "Landing Zone Prediction program" - to find out where the rocket will touch down, and to see if the field is large enough. Or you can use this to find out the angle the rocket needs to be tilted into the wind for a close proximity recovery.
15. A "Mass Prediction Program" - to find out what the rocket will weigh before you start building it. This will be needed to help you select the initial motor size required to launch the rocket.
16. A "Teaching Aid" - to help explain concepts to others using a visual tool of the 2D flight profile; and to generate raw data that can be analyzed in a classroom environment.
17. A "Cluster Engine Design Program" - To help you lay out the arrangement of motors that will fit into your rocket's body tube.

As you can see from the above list, RockSim is simply an awesome collection of programs designed to make rocketry safer and more fun for you!

You can order RockSim right now and use it immediately when you order it from our web site. Go to our web site at: <http://www.apogeerockets.com/rocksim.asp> to place your order, or to get further information about the software.



OPTIMUM MASS - SQUEEZING OUT EVERY INCH OF ALTITUDE

A reader asks:

“Tim, what is the difference between optimum mass for max altitude vs optimum mass for coast time? Would not maximizing coast time also maximize altitude? Why are these so different? I graph them and I get some that are quite divergent and some that practically, if not actually, coincide. Others tend to intersect somewhere in between.”

What should I be looking for here to determine my optimum weight? I keep getting confused - it also states that the optimum mass is without motor(s). Do I have to add or subtract this motor weight to get my optimum weight ???

Thank you for all these clarifications - I'll try not to bug you too much. I just find this all so fascinating....”

In this article, I'll start by answering the question about the maximum coast time mass, and the optimum altitude mass. Then I'll answer the other questions, and conclude by showing some examples on how to really get every bit of altitude from a model.

I'll be using examples from the RockSim program, since it is really the only way you can demonstrate this concept. If you don't own RockSim, download the FREE demo version from the Apogee Components web site. www.ApogeeRockets.com/rocksim.asp

Before I begin answering all these questions, let me point out that I've written much more extensively about this subject in Apogee Technical Publication #15. I urge modelers that are interested in this subject to read that publication. In a nutshell, it explains what optimum mass is in a way that even kids can understand. It then goes on to show how to tweak the performance of your model to get the highest possible altitude from your rockets. (www.ApogeeRocket.com/technical_publications.asp)

Onward to the first question... What is the "optimal coast time mass?"

If you look at the RockSim optimum mass prediction screen and run a simulation, you see the little box that says "Optimal

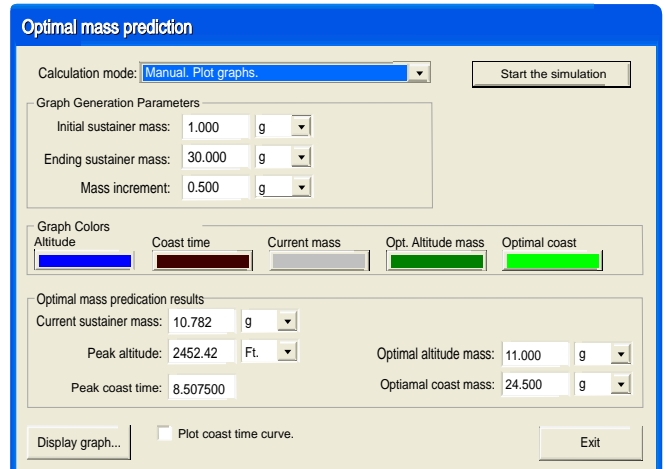


figure 1- optimum mass prediction in ROCKSIM

Coast Mass.” Next to it, you'll see the “Peak Coast time.” This Peak Coast Time is what we'll get if we make the rocket right at the optimal coast mass. See figure 1 as an example. If we make this rocket 24.500 grams, the rocket will coast a maximum of 8.05 seconds -- at which point it will be at its uppermost position in the trajectory.

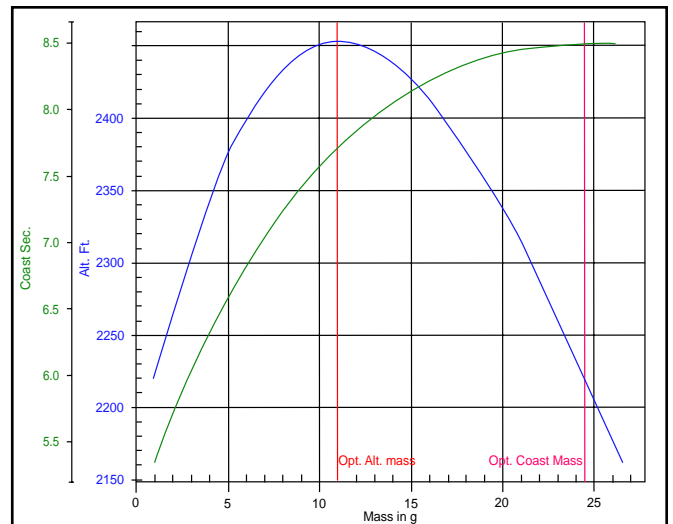


figure 2- optimum mass chart- it shows the mass for highest altitude is different from the longest coast time mass.

cont. on pg. 5

OPTIMUM MASS - SQUEEZING OUT EVERY INCH OF ALTITUDE

cont. from pg. 4

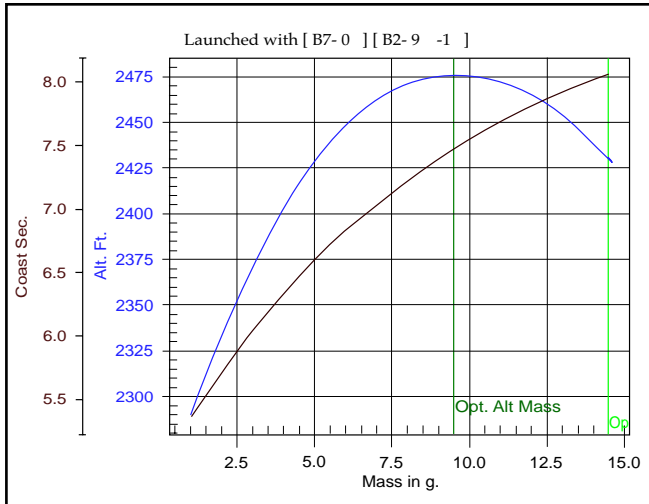


figure 3- delayed staging to make the rocket fly higher.

To be honest, I can't think of much use for the Peak Coast Time. It really doesn't have anything to do with the MAXIMUM altitude of the rocket. Most often, the if the optimum mass for peak altitude will be less than the mass to get the longest coast time. So if you add weight to the model to get the longest coast time, it will not travel as high as one that weighs at the "optimum altitude mass."

Figure 2 is the data of the simulations that are summarized in Figure 1. If you look at the graph, and you build the model at the mass of 24.50 grams (the optimal coast mass weight), the rocket will fly to an altitude of 2,220 feet. This is well below the maximum altitude that the rocket is capable of attaining.

The best altitude we can expect comes in at 2452.42 feet, which is over 232 feet higher. But to achieve that altitude, we must build the rocket so that it has a mass of 11.00 grams. That's much lower than 24.5 grams.

What is peak coast time mass good for?

Imagine this as a hypothetical situation. Maybe you're putting on a aerial display for a bunch of spectators. You decide that you want to put out as much smoke as possible -- and still deploy the parachute at the top most point in the flight.

This is where peak coast time might be useful. Your rocket

would have a really long delay and spew tracking smoke for the longest possible time. And yet it would still eject at an apogee point. To the spectators, it might give the *impression* of a really "really" high flight, even though you know the rocket had the potential to travel significantly higher.

OK. So that answers all the questions about peak coast time mass. Now we'll answer the questions about the more important number: "Optimum Altitude Mass."

As mentioned, if you build your rocket to the "Optimum Altitude Mass," it has the best chance of flying the highest.

The other question that was asked was about the motor weight. How does that figure into the simulations?

Speaking specifically about the RockSim program, the optimum mass listed in the chart is the weight of the rocket WITHOUT THE MOTOR. RockSim automatically loads the motor's weight in to figure out the altitude. If you're using any other program besides RockSim, I don't know if the simulations take into account the motor's mass.

How To Improve Your Altitude Even More

The reader that asked the questions was flying a two stage rocket. So in this sequence of examples, I'll be discussing I'm going to talk specifically about multi-stage rockets.

The answer to first question on your mind is: the optimum mass displayed by RockSim is for the top-most stage (sustainer) of the multi-stage rocket. If you look at picture of the two stage rocket in figure 4, we're going to discuss the skinny part of the model; since it is the upper-most stage.

Your next question is probably: "Since there is a optimum mass for the sustainer stage; what is the optimum mass of the

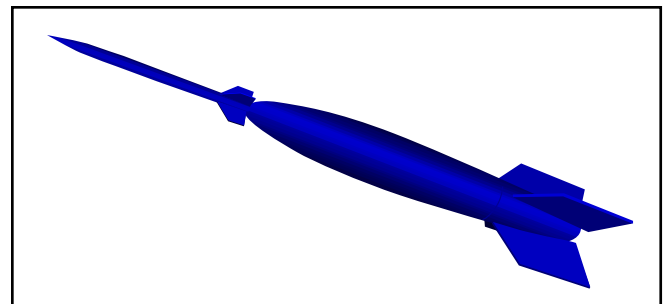


figure 4- A two stage rocket used in the examples in this article.

cont. on pg. 6

OPTIMUM MASS - SQUEEZING OUT EVERY INCH OF ALTITUDE

cont. from pg. 4

booster stage?”

I could answer that for you now, but it might take the fun away when you run your own simulations to figure out the answer. But if you just gotta know, you can find the answer in Apogee Technical Publication #15.

But getting back to our quest to make the rocket fly higher, let's take a look at the rocket shown in Figure 4.

This particular model is a pretty lightweight rocket, designed to fly on “B” motors. I've chosen a Apogee B2 motor for the top stage, and a Apogee 13mm B7 motor for the booster stage. In reality, there is some difficulty in staging this combination, but I'm looking at it from a hypothetical point of view. In this example, I want a high-thrust motor in the bottom stage, and a low-thrust motor in the top stage.

In figure 2, we see the optimum mass curve of the rocket using the B2/B7 motor configuration. The curve tells us that the optimum mass for the maximum altitude would be 11 grams (remember, we're talking about the sustainer, not the booster stage). The maximum altitude we can expect to get is 2452.42 feet.

Give me a Number!

Before we talk about improving this altitude, is there anything else this curve tells us? Answer: Yes.

Most modelers that use rocket software have a urgent impatience and seem to crave “a number.” They don't care what the number is, or what it means. “Just give me a number to use,” they say. This can become a crutch, and you may be missing out on some important information that may make your life easier.

What is useful about the plot, and why RockSim creates them, is because they tell you how much altitude you can lose if you don't build your rockets at optimum mass. It really isn't important how much altitude you lose, but what you can gain.

You see, when building some models, you can spend an enormous amount of time and effort trying to get the model at exactly the right optimum mass — particularly for small rock-

ets. But if you look at the chart, even if you are off a little bit in the mass of the rocket, you still can get close to the peak altitude.

You may not have to drive yourself nuts to get the optimum mass. You can trade off a little bit of altitude for a little less work during the building of the model. So in essence, the graph gives you some perspective on the flight of the rocket — which you don't get with “a number.”

By the way, the curve is called a “Malewicky Plot”, because they were first compiled by Douglas J. Malewicky.

Let's do an example. Look again at figure 2. Say you built the model, and it weighs 15 grams, instead of the optimum mass of 11 grams. You drop in altitude from 2452.42 to 2425 feet — just around 27 feet! What is more amazing? Go ahead and compute the percent change in the graph.

This is amazing. You lose a wee 1.1% in altitude even though there was a massive 36% increase in the weight of the rocket!

You have to ask yourself: is it worth the headache of building at the optimum mass if you know you won't be sacrificing that much in performance? This is a good question that every modeler should ask themselves. That is why the Malewicky plot from RockSim is worth its weight in gold; you can't get this information from just “a number.”

How can we get more performance from this particular two-stage rocket?

Lets go ahead and compare figures 2 and 3. Do you notice that in Figure 3, the peak altitude is higher? This is the same rocket, and we only changed one small thing, and got the altitude up to 2476 feet; and increase of 24 feet.

What was the small change we made? We put a small delay in the ignition of the upper stage motor. Instead of igniting the upper stage immediately at the end of the booster motor burn-out, we had it ignite just one second later. We used a technique that is called “delayed staging.”

cont. on pg. 7

Archives of this newsletter

All the articles that have appeared in this newsletter are archived at http://www.apogeerockets.com/education/newsletter_archive.asp



1130 Elkton Drive, Suite A
Colorado Springs, CO 80907 USA
www.ApogeeRockets.com
orders@ApogeeRockets.com
phone 719-535-9335 fax 719-534-9050

OPTIMUM MASS - SQUEEZING OUT EVERY INCH OF ALTITUDE

cont. from pg. 4

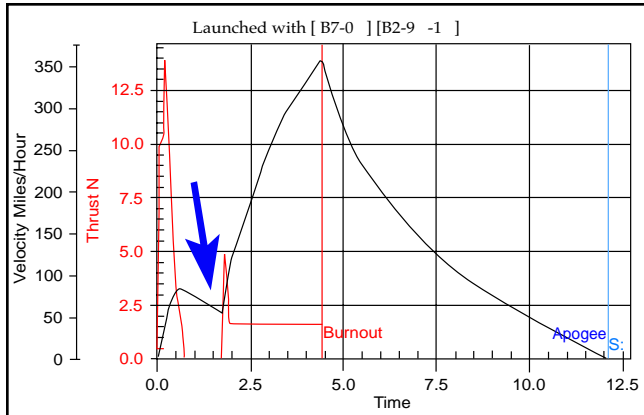


figure 5- drop the rocket's speed by using delayed staging.

Why does delayed staging increase the altitude of the rocket?

Before answering that, I want you to dig out your book the "Handbook of Model Rocketry" by G. Harry Stine. There is a classic graph in the chapter on multistage rockets that illustrates a common misconception.

The graph I'm talking about shows that you get maximum altitude when you stage at peak velocity. Any other combination (such as delayed staging) would result in a lower altitude.

This graph is totally accurate – BUT – it is only true if you are launching from a planet that has no atmosphere (such as the moon). If you are launching from the earth, the atmosphere interacts with the rocket. This interaction creates "aerodynamic drag."

Drag robs our rockets of performance. To make matters worse, the faster we travel, the more it takes away from our altitude. If we travel twice as fast, the drag is four times as great.

So to get the highest altitudes, we actually want the rocket to travel slow. Otherwise we're fighting drag; wasting the energy that the rocket engine creates.

This leads us to delayed staging as a way of increasing the altitude of the rocket. Take a look at Figure 5. This shows us a graph of the velocity of the rocket. You can definitely see that the rocket actually slows down between the burnout of the booster motor, and the ignition of the upper stage motor.

This is what we want – to limit the speed of the rocket, so that it doesn't waste its energy fighting drag.

There you have it. A method of increasing the altitude of the rocket without making any changes to the model itself. Well... this isn't totally true. To get this altitude, we have a new optimum mass that we have to strive to build toward. Again, compare figures 3 and 4. The optimum altitude mass dropped from about 11 to 9 grams. But while the optimum mass has changed, we haven't done anything externally to the rocket to make it fly higher.

At this point there are probably a lot of unanswered questions that are popping up in your brain. Such as:

1. What is the "optimum delay" when using delayed staging technique?
2. Does this delay change when you change the motors?
3. Does all this apply to high power rockets too?

I'm going to leave it to you to run your own simulations in RockSim to see the results for yourself. It is a lot of fun to run computer analysis of these types of things. And you will learn a lot of new and useful information.

And just when you think you've got it all figured out – and when you're starting to believe that only optimum mass and delayed staging make a difference... I'll throw some more variables at you to make it interesting. Here are a host of other factors you may have to consider too:

1. Wind.
2. Launch rod angle.
3. The rocket's drag coefficient.
4. The method of launching (piston launcher, rail launcher, or rod).
5. Mass distribution within the rocket.

All these variables will affect the optimum mass of the rocket. So before you can build your rocket and add or remove mass to get it to the optimum, you have to do a little more homework.

If your interested about these factors, and how they affect the optimum mass of the rocket, I recommend you read Apogee Technical Publication #15. As I said at the beginning of this ar-

cont. on pg. 8

OPTIMUM MASS - SQUEEZING OUT EVERY INCH OF ALTITUDE

cont. from pg. 4

ticle, it goes a little more in depth on this subject. If you want to become a full-fledge rocket scientist, it is something that you'll have to eventually dig into. You can order this publication from the Apogee Components web site using our secure on-line ordering system and your credit card.

Summing It All Up...

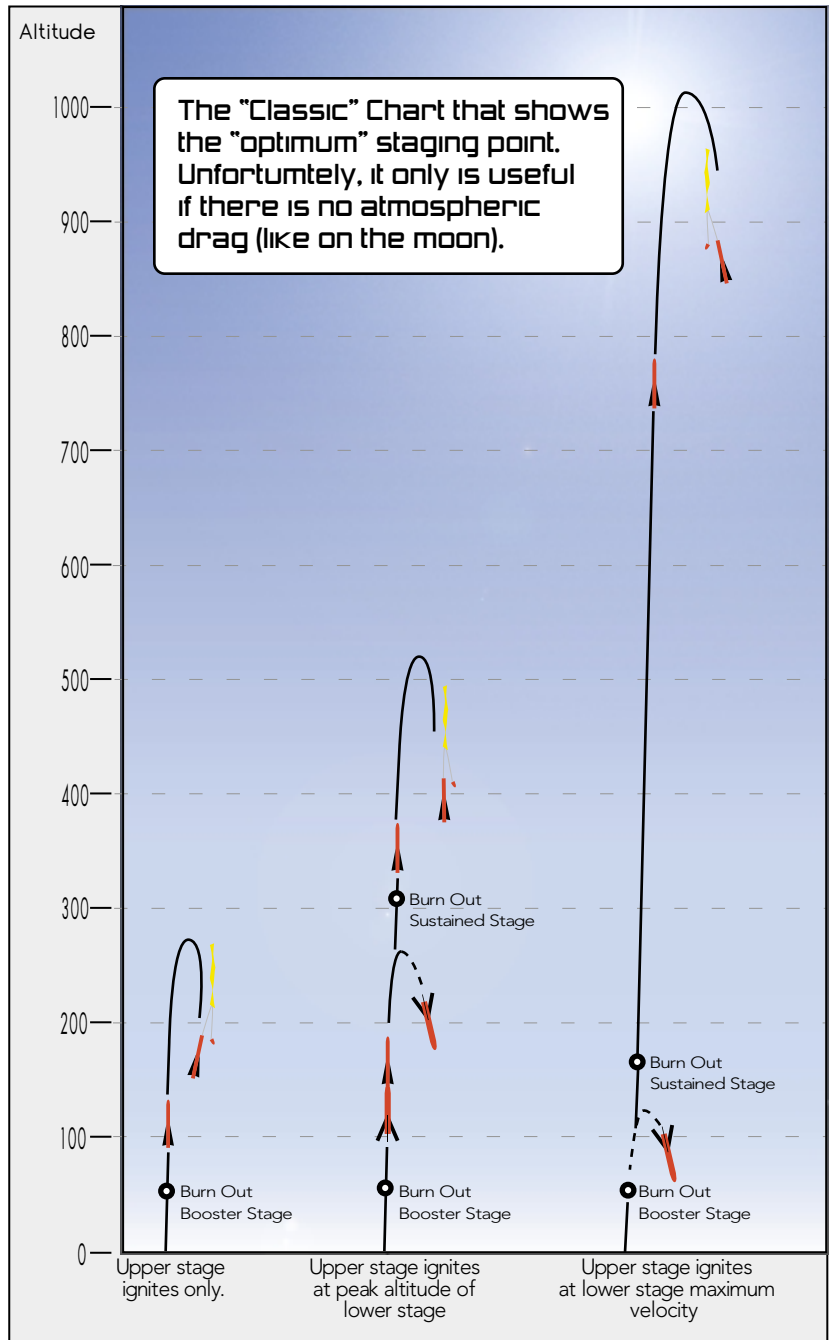
In conclusion, you should now know the difference between optimum mass for altitude, versus the useless optimum mass for the longest coast time. They are different. When you build your model, make it weigh the optimum mass for greatest altitude.

You should have also learned in this article that the optimum mass is not the "end-all" number. There are other things you can do to get even more altitude from your rocket. This includes things like delayed staging.

Finally, we really haven't said all that could be written on this subject. There are a host of other factors to consider too that will affect your rockets peak altitude. The only way to figure them all out is to run RockSim computer simulations. It may take some time, but in the end you'll know a lot more about your rocket, and come to appreciate the complexity of a simple rocket launch.

About the Author:

Tim Van Milligan is the owner of Apogee Components (<http://www.apogeerockets.com>) and the new 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 the FREE e-zine newsletter about model rockets. You can subscribe to this e-zine at the Apogee Components web site, or sending any message to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject of the message

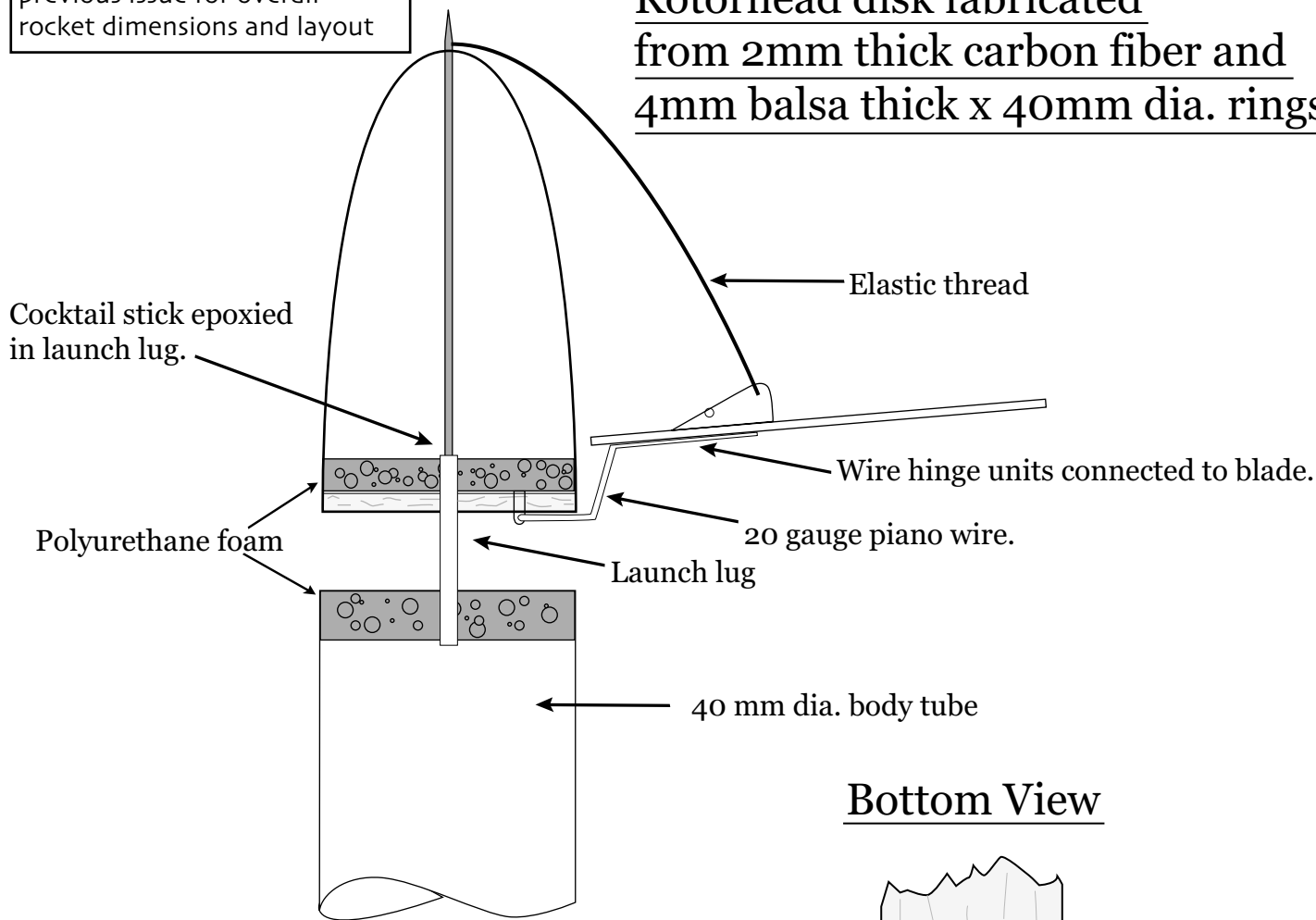




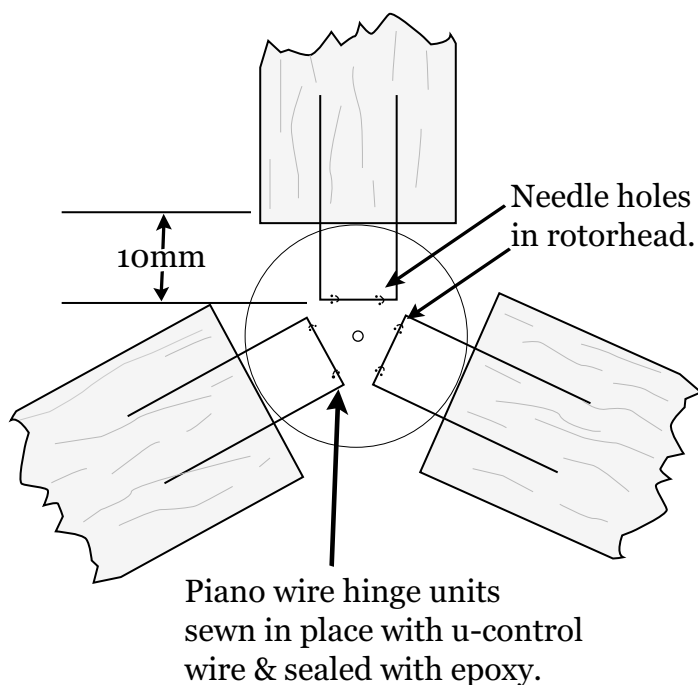
Spin Doctor Hinge Detail

see spin doctor plan in the previous issue for overall rocket dimensions and layout

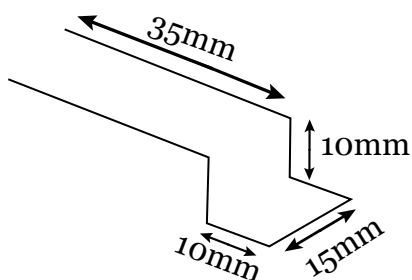
Rotorhead disk fabricated from 2mm thick carbon fiber and 4mm balsa thick x 40mm dia. rings



Bottom View



20 gauge piano wire hinge units. (3D view)



Plan by:
Stuart Lodge, June 2002
FA1 Category S9B,
Gyrocopter Duration



Apogee drawing by:
michael glockson