PEAK OF FLIGHT NEWSLETTER

Issue 608 / September 12th 2023

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RockSim Tips: Accounting for Weight Differences

By Tim Van Milligan

Say you're putting a design into the RockSim software. You get to the end and you see that the weight that RockSim predicts (Figure 1) and your actual rocket (Figure 2) that you've built are different. Not only that, but the CG (where the rocket balances) is in a different spot too. What do you do?

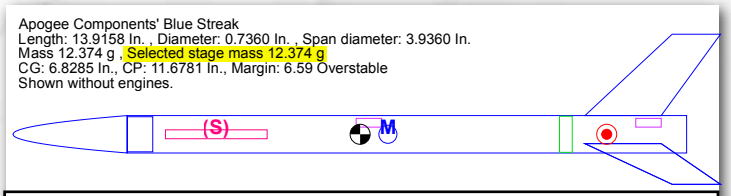

Figure 1: The predicted mass of the rocket at 12.374g in RockSim

Figure 2: Actual weight of the built rocket as measured on a digital scale.

This is a common situation, and it seems to cause a lot of confusion. The reason is there are three different ways that you can fix the situation so that your design file matches the real world rocket. We'll talk about each of them in this article.

Since there are three ways to fix it, the question that always pops up is "which one is the most accurate?"

While that is important, it is not "critical." In other words, the results when comparing the differences aren't that far off. That is good news. Which of the three methods we choose, the results are going to be "good enough" and you can confidently launch your rocket without fear.

Without worrying about perfect accuracy, you can relax and have fun. From my own perspective, we can get to the heart of the matter: "What is the fastest way we can fix it?" I'm all about doing things quickly, so that is what I'll concentrate on here.

How Does Weight Affect the Flight?

As you know, the weight of the rocket is important to predicting how high a rocket will fly. A heavy rocket will not fly as high as a lightweight one. If the predicted mass of your design in RockSim is not close to the actual mass of the built rocket, there will be two issues you will face. The first is that the predicted peak altitude won't match that of the real flight.

The second issue, which is more important, is that the ejection delay will be off as well. So during the real launch, either the parachute is going to come out too early or too late compared to what RockSim predicted. This is more important, because the best time for the parachute to be deployed is right at apogee (the highest point in the flight). That is the slowest speed during the trajectory, and parachutes like to be deployed at slow speeds because it minimizes the opening forces on the chute. If you're too early or too late with deployment, then the speed at deployment will be higher, which could cause problems. The most common are shredded parachutes, or zippered body tubes.

This is why we want the mass of the rocket in RockSim to match the mass of the real world rocket. Then we'll get a predicted altitude and ejection speed that will more closely match your actual flight.

So the most important thing is that the mass of the design in RockSim be pretty close to the mass of your built rocket. If you're concerned about this, then you are considering the right thing.

But how we adjust the mass in RockSim to match the real world rocket is not too important. We could choose any of the three methods to make the adjustment, and we'd be good enough.

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So let me tell you my favorite method, which I think is the quickest way to make the adjustment.

Method #1 - Add a Mass Object

In RockSim, there is a special component that you can add nearly anywhere in the design that is called a "mass object."

Think of a "mass object" as a lump of soft clay. It can have any shape or size. It can be like a tiny point, or something very large. It can be concentrated in one location like a sphere, or it can be stretched out to be very thin and spread over a large area. But the balance point of that clump of clay, no matter what its shape, will be a point on the rocket. You'll see the mass object designated in the 2D sideview as a circle with a M in it (Figure 3). In the 3D view, the mass object is designated as a sphere (Figure 4).

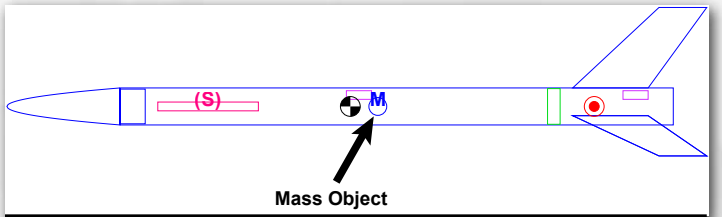

Figure 3: A mass object in the 2D view is represented by a circle with a M over it.

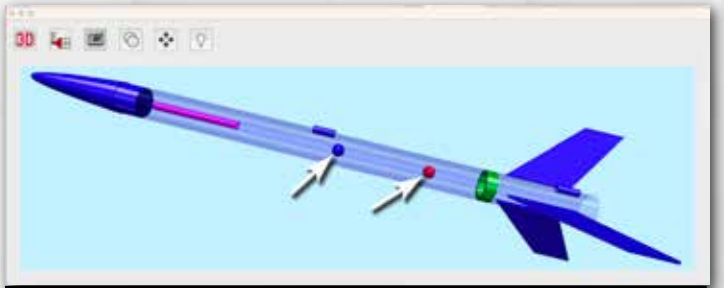

Figure 4: In the 3D view, the mass object is represented by a sphere.

In RockSim, we use a "Mass Object" whenever you have a component that you can't figure out how to model in the software. For example, an electronic component, or an egg payload. Anything that you can't figure out how to add in the program, can probably be added as a "mass object" component.

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So specifically, when you add heavy epoxy fillets onto the rocket or a thick layer of paint that covers the entire surface, you'd add it into the software as a "mass object" so that you can account for the extra weight.

There are always things in the rocket that seem to fall through the cracks, and don't get added into the design. For example, if you have a complex rocket that has an ebay, you probably aren't going to add every single tiny screw that holds the altimeter board to the sled. But the mass of those little components can add up. So you will typically add them as a single "mass object" component at the end of the design process.

This is why I typically use a "mass object" at the end of the design to adjust the final mass of the rocket, so that it matches the real world built model. It is very simple, and it takes just a few seconds. It takes into account all the odd bits that weren't input into the design (paint, epoxy, screws, glue fillets, etc).

Where Do You Add a Final Mass Object Component?

What I do is take the built model, and simply balance it on my finger to find the CG location (Figure 5).

Figure 5: Balance the rocket on your finger and measure from the nose tip to the actual CG location.

Once I have the CG location, I'll look at the rocket design in RockSim and pick the tube that is closest to where it was balancing it on my finger. That is the component to which I'll add the mass object.

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How much mass should the mass object be? That is also pretty simple. I just take the mass of the entire rocket (without the rocket engines), and subtract the current mass of the rocket that RockSim estimated. The difference is the amount of mass to make the Mass Object. If you compare the mass shown in Figure 1 (12.374g) and Figure 2 (16.5g), the needed mass is 4.126g.

Now when you add the mass object to a tube, it will put the location of the component at the front end of the tube. The next thing to compare is the CG location that RockSim has predicted to the CG location you measured when you balanced the rocket on your finger. You want the two CG locations to match.

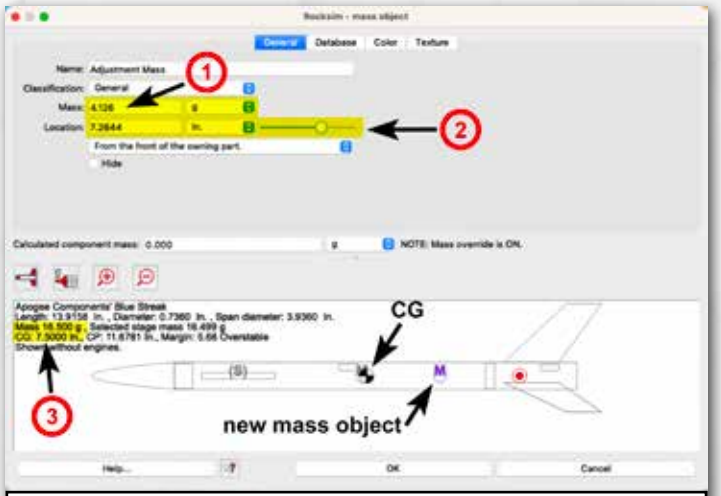

Figure 6: Add the new mass (1) so that the final rocket weight equals what you measured on the digital scale. Move the location of the mass (2) so that the CG is positioned where you balanced it on your finger. Check the values (3) that RockSim computes.

You will probably need to move the slider-bar on the "Location" of the Mass Object rearward in order to move the final CG position of the rocket design so it matches where you balanced it on your finger.

If you move the slider bar as far as it will go, and you still can't get the CG far enough rearward, then you'll have to type a number into the location field that is greater than it currently is. Note that you can enter any number into the position field, and it can also be a negative number. Just put a Location of the mass object so that the CG of the entire rocket matches that which you measured by balancing it on your finger.

One Limitation on the Mass Object

What if you need to remove mass from your RockSim design so that your predicted mass in the software matches the real rocket you've built.

This is the one limitation you have with the mass object component. You can't remove weight by adding the mass object component. You can't have a negative mass object.

So if you have to remove mass, you'll need to use one of the other two methods for accounting for a difference with predicted weight in RockSim versus the real world model you've built.

Method #2 - Mass Override

There is a tab along the top of the main screen in RockSim called "Mass Override." When you click on it, you'll get a screen that will allow you to adjust the final weight of the design very quickly (see Figure 7).

To use it, you'll need two measurements. You'll need the final mass of the rocket, and the CG location. These you'll get from real world measurements of your actual real world rocket. As we did before, you'll weigh the rocket without the rocket engine (Figure 2) and then balance it on your finger to find the CG location (Figure 5). The measured CG is always from the tip of the nose cone.

You have to enter both of these numbers on this screen. The mass goes in the left column, and the CG location goes in the right column.

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The one mistake I see a lot of people make is that they forget to put the CG location into the right-hand column. I think it is because there are five different fields where numbers can be entered, so they just get confused. But there has to be a number entered for the CG location, or RockSim will use the default location of 0.00 - which is at the tip of the nose cone. Putting the CG at the tip of the nose cone will always give you a stable rocket, but that isn't where the CG is in real life.

To repeat myself, for a single-stage rocket, you need a mass in the left-hand column for the Sustainer, and you'll need a distance for the Sustainer in the right-hand column.

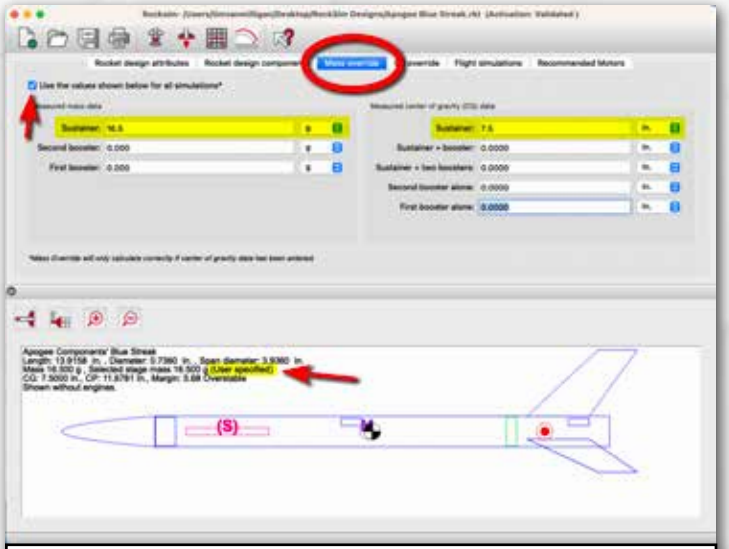

Figure 7: The mass override tab allows you to change the entire mass of the rocket very quickly. But watch out so you notice when it is turned on. The only way to tell it is applied is when the "(User specified)" note pops up in the parameters in the lower screen.

There is one more thing you'll need to do on this screen - that is to check the little checkbox in the upper left corner of the screen. It says: "Use the values shown below for all the simulations."

Until you check that box, the values you entered into the mass and CG location fields don't do anything. But once you check the box, something major happens!

When you check the box, RockSim will use **ONLY** these numbers for calculating the simulations.

So when you run a simulation, it will use the current mass and the CG location shown on the mass override screen to calculate how high the rocket will fly, and what is the optimal delay for the parachute.

This is a quick and dirty way of changing the overall mass of the rocket just before you run your simulations. And if you need to remove mass from your design so that what is shown in RockSim matches the real world mass of your built rocket, this is probably the method that I'd choose to do it.

However, it isn't my favorite method for changing the mass of the rocket. That was to add a mass object component, which was Method #1 described above.

The issue with changing the overall mass of the rocket is that it completely ignores all the individual mass values for each and every component in the rocket. So for example, you've spent a lot of time adding every part into your design. You've added the little bits, like screws and put a mass object for the paint, the fillets, and all the bulkheads into the rocket. It took you a lot of effort. But once you've checked the mass override checkbox, all that work is ignored.

In fact, if you start to add additional components to the design, like adding a payload bay tube, that is ignored too.

This is where people call me up and ask "what is happening? I've added a payload bay tube, and the next simulation I've run is identical to the last one. Why is that?"

It is because the "mass override" is turned on. Once it is "on", any additional changes made to the design are ignored. You've told RockSim to ignore everything in the rocket except the final mass and the CG location. That is what that little checkbox actually means.

The only way to tell that the checkbox is marked is that in the 2D side view, there will be a little note next to the mass row that says "(User Specified)". Again, see Figure 7 to find that little note.

Unless you see the note "(User Specified)", you don't know the mass override is turned on. And most people miss it, because it is buried in with a lot of text. I miss it myself all the time too.

It is because of this confusion that mass override can cause that I no longer recommend this method to people to adjust the final weight of the rocket.

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So how would you remove weight from the rocket if you don't want to turn on the mass override? That leads us to the final method of adjusting the mass of the rocket.

Method #3 - Adjust All the Parts Individually

This is the most time consuming method of removing mass from the rocket. But it is less confusing compared to using the mass override, and actually it is the most accurate.

What we'll do in this method, is to weigh each part individually in the real world (Figure 8), and then go into RockSim and make changes to the part so that it matches the real world. Unfortunately, once the rocket is glued together, it makes it really hard to measure the weight of each component, like each centering ring. So you really need to do this before you actually start construction of the model while all the parts are still separate.

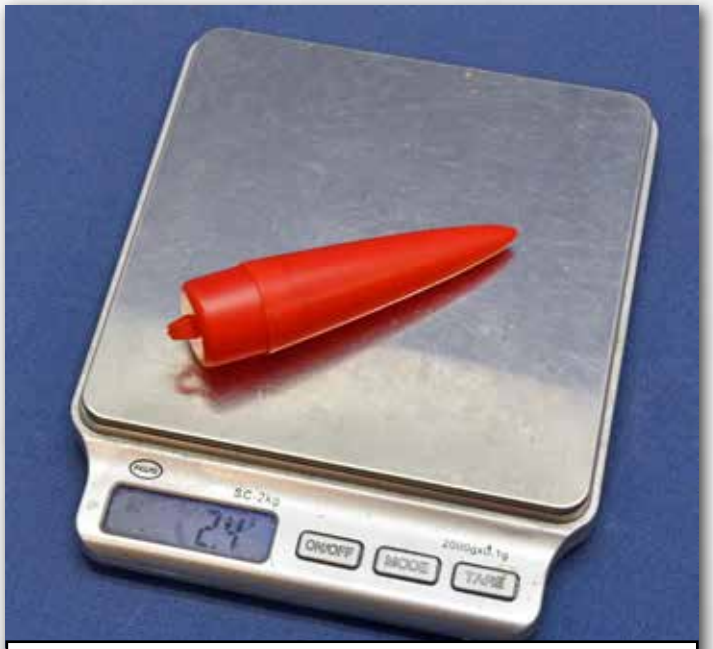

Figure 8: Weigh each component individually

Let's take for example adjusting the weight of the nose cone. You measure the mass of the nose cone (or take the mass from the value listed on the Apogee website) at 2.4 grams.

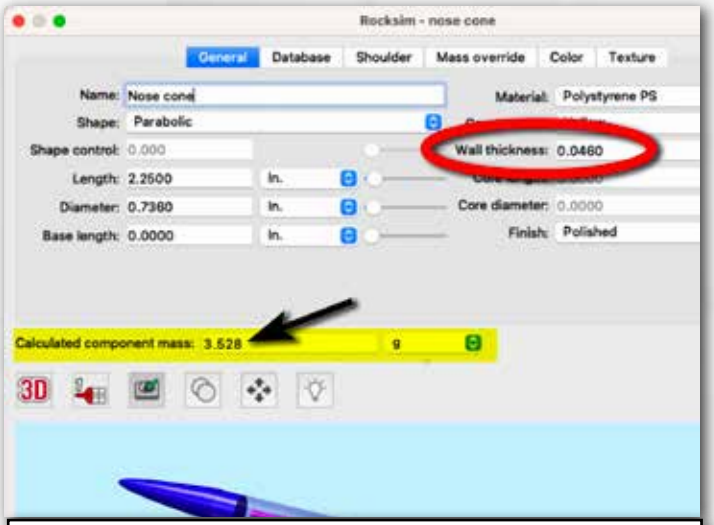

Figure 9: RockSim calculates 3.528 grams for this nose cone based on a wall thickness 0f 0.460 inches.

When you're in RockSim, you'll open the component editor for the nose cone and enter the basic dimensions for the nose and RockSim calculates the mass to be 3.5 grams (see Figure 9). You need to remove 1.128 grams from the nose.

There are two ways to adjust the component mass of the nose. You can tweak the dimensions, or you can do a "mass override" at the component level.

Using the mass override at the component level is similar to doing the mass override on the entire rocket. It is simple and fast.

But it also has the same type of drawbacks. You may forget you turned it on, and then you can't figure out why the mass isn't changing when you made adjustments to the shape of the part.

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I'd rather change the parameters of the part itself so that you don't have to remember that you've turned on the mass override.

There could be any number of parameters that could be adjusted. For example, when making a nose cone, you can adjust the wall thickness of the hollow plastic nose cone. That is typically what I do in order to get the weight to match the actual nose cone.

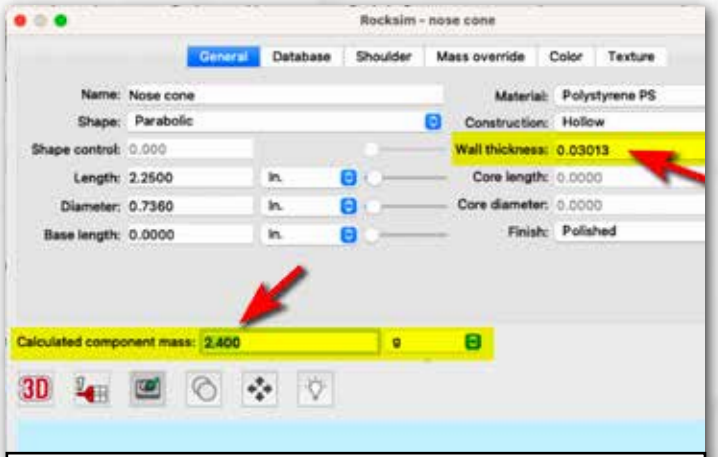

Figure 10: By adjusting the thickness of the wall of the nose, you can tweak the mass to match what you measured on your digital scale.

The unfortunate thing is that you'll have to adjust every single part in the rocket so that its mass matches the actual mass in the real world. This will take a small investment of time. But when you're done, your rocket will be the most accurate.

Conclusion

Getting your rocket mass in RockSim to match the real world mass of your built rocket is important. But it doesn't have to be hard or confusing. In this article, we presented three different ways to get the mass of the rocket to match. They were:

- Add a Mass Object
- Use Mass Override
- Adjust all the Parts Individually

My favorite, and the one I recommend to you, is to use the first one. Just add a Mass Object to the completed rocket once you have the design entered into RockSim.

The only time you might not be able to do that is when you need to remove mass from your RockSim design file. In that case, I recommend the third method of adjusting all the parts individually. It takes longer, but it will be the most accurate and cause less confusion than to use a simple mass override.

If you have any questions on using RockSim, please feel free to contact us. We'd love to help you out.

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. He is an avid rocketry competitor and is Level 3 high power certified. He is often asked what is the biggest rocket he's ever launched. His answer is that 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 an 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 also the author of the books: Model Rocket Design and Construction, 69 Simple Science Fair Projects with Model Rockets: Aeronautics and publisher of the "Peak-of-Flight" newsletter, a FREE e-zine newsletter about model rockets. You can email him by using the contact form at https://www.apogeerockets.com/Contact.