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APOGEE

PEAK OF FLIGHT

NEWSLETTER

Simulating Strap-on Booster Stages In RockSim 7.0 Part 3

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Using RockSim To Simulate Strap-on Booster Stages - Part 3

By Tim Van Milligan

{ed. We're now in the middle of our series of articles on how to create parallel staged models in RockSim 7.0. In the last issue, we talked in theoretical terms how to set up the simulations in RockSim. In this article, we'll go through the process step-by-step, so your can see how it is done. We'll be starting by creating a fake motors files in the Engine Edit program.

In the next issue, we'll conclude the series of articles by talking about what happens when we launch these rockets in the RockSim program. If you can't wait for it, see the advertisement on page 6; which tells you how to get the entire article right now, including step-by-step videos that show you how to set the whole thing up in RockSim 7.0.

We'll now pick up where we left off in the last issue...}

The Step-by-Step Portion

We are now ready to walk through the process of creating the .rkt file in RockSim, and creating the two modified motors will need to trick RockSim.

To create any new motor file, whether it is a fake one, or a real one; we use the Engine Editor program -- called *EngEdit*. This comes bundled with RockSim, and you'll find it in the "PROGRAM" folder of RockSim.

Making The Phantom Sustainer Motor

We now need to make a phantom motor that will positioned in the sustainer stage of the rocket. Without a motor in the sustainer, we do not have any method to eject the parachute out of the model. The other purpose is to simulate the mass of the motor case. The propellant mass is held in the booster stage, while the case mass is held in the top stage. So when the propellant is consumed we are just left with the mass of the case; which coasts upward with the sustainer.

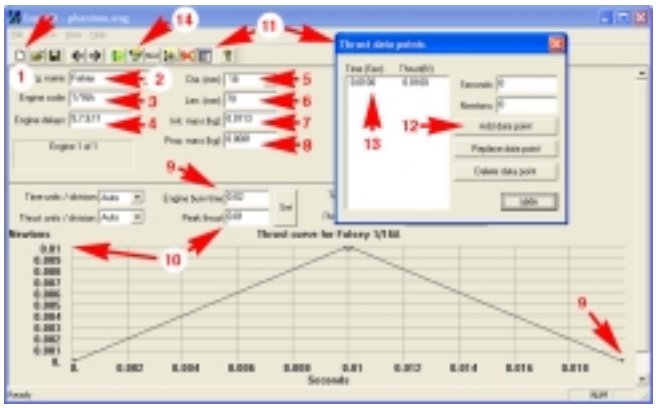

Figure 10: Step by step instructions will be given to create a fake rocket motor that will trick RockSim to running our simulation.

We're working in EngEdit program, so go ahead and launch that on your computer. Figure 10 shows you what we want to accomplish. We'll go through this step-by-step.

1. Click the New File button to clear out any old data.

2. Create a new name, because you'll want to find this engine in the file when you load engines in RockSim. The name you give it doesn't matter. It is just to help you locate the right one when you run your Rocksim simulation.

3. Give it a new engine code name. Again, it doesn't matter what you call it.

4. Create engine delays. Shown here are delays of 5, 7, 9, and 11 seconds. The times don't matter; whatever is convenient for you.

5. Enter the diameter of the motor. You'll want to select the diameter of the simulated motor. A standard size motor is 18mm, so that is what I choose.

6. Enter the length of the motor. Make sure you are using the length of the motor you're simulating. The reason is that RockSim needs to know where to put the CG of the motor. When the propellant is exhausted, the CG of the motor will be in the middle of this length.

7. The initial mass is the weight of the case alone, without the propellant. You can get the number by looking at the original Estes C6 engine file. The case weight is found by taking the initial mass of the engine, and subtracting the propellant weight. In this example, it was

Total Mass = 0.0222Kg

minus

Propellant Mass = 0.0108Kg

Result = 0.0114Kg which is the weight of the case alone.

8. For the propellant mass, we want the smallest amount possible. It has to be greater than zero. So I entered 0.0001Kg. That is 1/10 of a gram; which is a negligible amount in the RockSim simulation.

Now we're going to create the actual thrust curve for this phantom motor. We want it to be as small as possible so that

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we don't add much error into the final RockSim simulation.

9. Enter a engine burn time of 0.02 seconds

10. Enter a peak thrust of 0.01 seconds. The click the SET button. This creates a grid on the bottom of the screen.

11. You can now click on the graph to add points of the thrust curve, or you can add data points manually. Most times, you'll simply click on the graph, because it is much faster. But in this case, since we're trying to make as small a thrust profile as possible, I'm going to manually enter the middle point.

Before I go on, let me explain something. There is one quirk that has to do with the WRASP engine file format. That is the points stored in the file can only have two digits after the decimal point. So if you are making points on the graph, the EngEdit program will always round them off to just two digits.

A thrust curve must have a minimum of three points. The first point, is always assumed to be 0,0. That means at a time zero seconds, the thrust is zero Newtons.

The last point in the engine file defines when the propellant burns out — in other words, it's burn time. The engine burn time on the main screen defines this entry in the engine data file. We have it set at 0.02 seconds (step 9 above). So actually, the last data point in the data file becomes (0.02,0). That means, at time 0.02 seconds, the thrust is zero Newtons.

With two points on the graph with zero thrust assigned to them, we really don't have a thrust curve. We need on point somewhere between the start point and the end point, which does have some thrust two it. This point will define the peak thrust of the motor.

12. In the data point editor, enter 0.01 for the seconds, and 0.01 for the Newtons. Then click Add Data Point button. We've just added thrust to the motor!

13. The data will be shown in the columns on the screen, and they will have 4 digits after the decimal. This is misleading, because when the file is saved, it rounds off the number to just 2 digits after the decimal (don't blame me... I didn't create the file format. It was made decades ago by Harry Stine in his book Handbook of Model Rocketry).

This is the smallest motor file that we can make. It is just three data points.

(Time in Seconds, Thrust in Newtons)
(0,0)
(.01,.01)
(.02,0)

You're probably wondering why we couldn't make just two points? Because the middle point has to have a thrust greater than zero. That is .01 Newtons. This is the smallest thrust level, because EngEdit will always truncate to two digits after the decimal point. I just won't allow us to have .0001 Newtons. If you do, you'll get an error message when you try to compile the file.

14. Click the save to list button. Then click the save to disk button (the one that looks like a floppy disk). You'll be asked to give the file a name, and to choose a location. Make sure you select the DATA folder of RockSim. I made the name of my file: Phantom.eng

We've created one motor file. For the fake motor in the booster stage, I'm just going to modify the Estes engine data file. Since we've already gone through the steps to create a new engine file, this next one should go faster.

Making A Booster Core Motor

The purpose of the special booster core motor is to simulate the "sustainer motor" igniting on the ground at the same time as the strap-on motors.

This motor is going to be lit on the ground, at the instant the ignition button is pushed. But, we don't want the mass of the casing to drop away along with the booster stage. So we're going to duplicate the motor we want to use, and modify it by changing the mass to only reflect the propellant.

Figure 11 on the next page shows the steps to accomplish this in EngEdit.

In my case, I want to simulate an Estes C6 motor. So click the open button and find the Estes.eng file in the DATA folder of RockSim.

Use the left and right arrow buttons on the top of the screen until you find the C6 motor (Engine Code field). When you find it, click the "duplicate" button. What you just did was add a new motor into the Estes.eng data file. You now have two

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Simulating Strap-on Booster Stages

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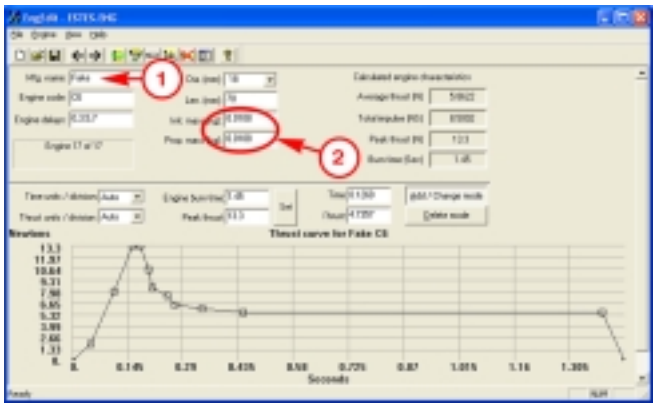

Figure 11: The fake motor in the booster stage will be similar to the Estes C6, except it won't have a case weight.

identical C6 motors.

Change the name or the Engine Code to something that will allow you to find it later (label #1 in Figure 10).

Now change the "Initial Mass" to be equal to the "Propellant Mass." What this tells RockSim is that the motor has no case weight. (Labeled #2 in figure 11)

Finally, save the engine into the list (by clicking the button with the green check-mark). Finally, save the file to the hard drive by clicking the SAVE button (the one that looks like a floppy disk).

We're done making our fake motors.

Now, run the engine database compiler program. It is in the RockSim PROGRAMS folder, and it is called "CompEng." The topic of compiling new motors is covered in e-zine newsletter #11. You can find that on the Apogee Components web site at:

http://www.ApogeeRockets.com/education/newsletter11.asp

When you are done, take a peek into the DATA folder. See Figure 12. It will show the creation dates of three files: Estes.Eng, Phantom.Eng, and RSEngine.DBS. All these should have been created today (if your computer's clock is current).

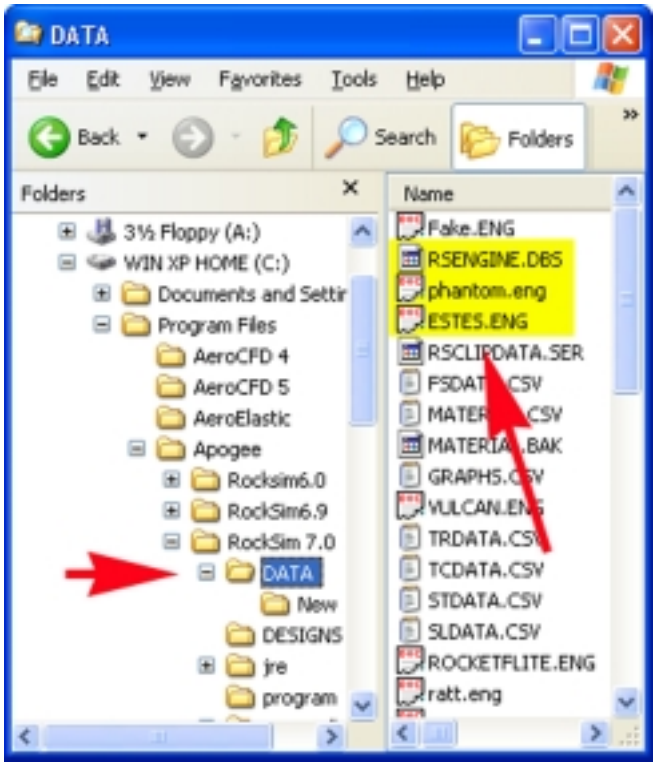

Figure 12: After creating our motors and running the compiler, peek inside the DATA folder to be sure the new motors are listed.

Designing The Rocket

Now we're ready to start designing our rocket to trick RockSim into simulating a two-stage rocket as having Strap-on boosters.

If you are familiar with RockSim, you know how to set it up to design a two stage rocket. Go ahead and build the top part (the sustainer stage) as normal.

With that done, we'll now start designing the booster stage to mimic the effects of strap-on boosters.

The booster tubes are strapped on to the sides of the

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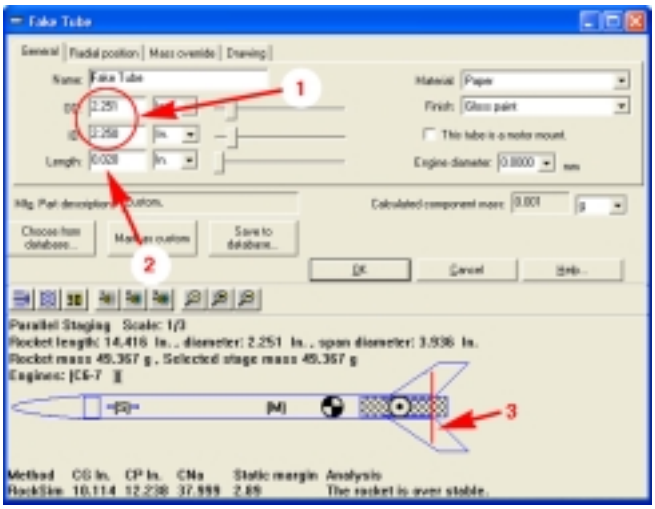

Figure 13: Starting the strap-on booster stage starts with creating a fake tube to hold the cluster engine mounts.

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sustainer tube. But the RockSim design rules don't allow for this. A two stage rocket, the booster is always (ALWAYS) below the base of the sustainer.

What we're going to do is make the booster stage a cluster mount. The motor tubes in the cluster will be moved outside of the diameter of the sustainer tube. Then, we'll move the position of the inside tubes forward.

At the very start, we'll use the same trick used in the Nike-Hercules design file. That trick is to use a very short, and very thin tube. The reason is we want it to have negligible weight.

Figure 13 shows the design screen for this trick tube. The inside diameter of the tube is determined by the cluster mount diameter. As long as it can hold the tubes inside it, you'll be OK. Since the weight is going to be negligible (because you are going to make the O.D. just a smidge bigger), you don't have to be exact with the dimension.

Now we're ready to create the cluster. You can make each tube individually, or you can use the cluster wizard.

The strap-on tubes are easy to create; as you see in Figure 14 below.

1. Change the name of the tube. Otherwise, other people looking at your design will be confused if everything is named "body tube."

2. Choose your strap-on tube from the database. Or you can enter the dimesions manually.

3. Change the length of the tubes to what you want for your strap-on boosters.

4. Change the location of the tubes. We'll manually enter a negative number here. This will move the tubes forward; and we can position in the correct place to simulate the location of the strap-on boosters.

5. Check the little box that says "This tube is a motor mount." This tells RockSim that we intend to place a motor in this tube when we run the simulation.

6. Verify that you have the size engine that will fit into this tube. Change this value if necessary.

Note: This screen shot in Fiugre 14 was taken after the cluster was created, which is why the radial position (distance off the centerline) is as shown. I did this so you could see that the tube was moved forward on the rocket. The image also shows a engine installed into the upperstage of the rocket.

Simulating the Nose Cones

The nose cone on the front of the strap-on tube isn't possible to add in RockSim 7.0. What we'll do for now is simulate its presence by adding a mass object item. Make its location in front of the strap-on tube by entering a negative num-

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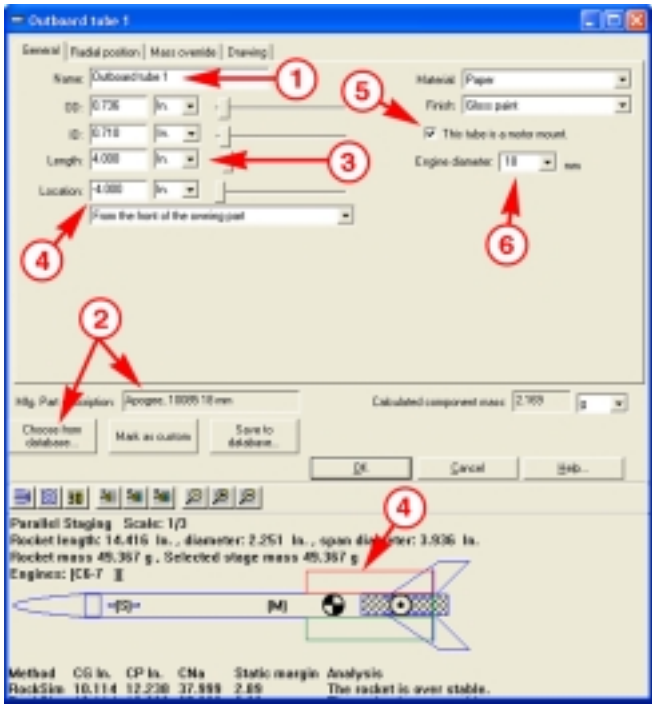

Figure 14: We're now ready to create strap-on booster pods. This image shows the final pods.

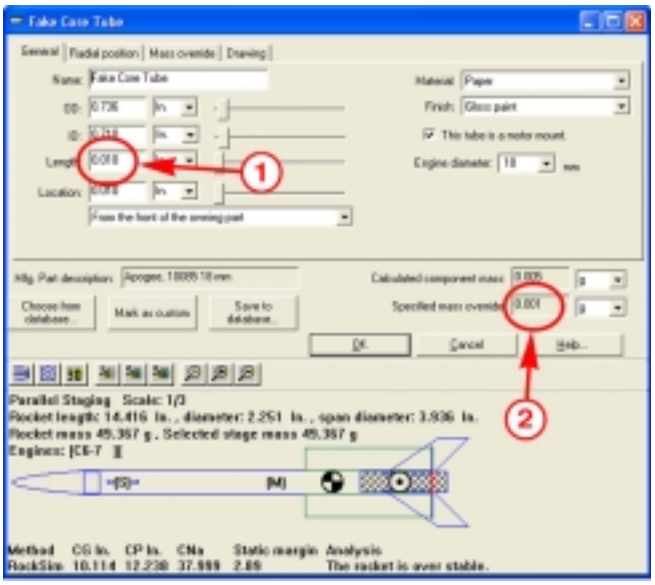

Figure 15: We'll add a fake tube to the booster stage to hold the special motor we made.

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ber in the position field of the design screen.

Before you click the cluster wizard button to duplicate this tube and create the cluster, be sure to add any internal components into the motor tube, such as engine blocks. If your booster will have a parachute, you can simulate it's weight by using a mass object. Once you click the cluster wizard button, it will duplicate the tube, and everything that is inside it. This saves time when creating a complex design like this model.

At this point, you can click the cluster wizard button. It will walk you through the steps to add similar strap-on tubes, and all the items associated with each strap-on.

There is one last tube in the fake cluster arrangement. We need to add a core tube to hold the fake motor (the one that produces thrust, but doesn't have any case weight). Again, we want to make it as small as possible to minimize the weight. See Figure 15 on the previous page.

Just like the fake outer tube that holds the cluster tubes, this tube needs to have near zero weight. That way, it won't affect the simulation.

1. After selecting the basic tube from the database, I'm

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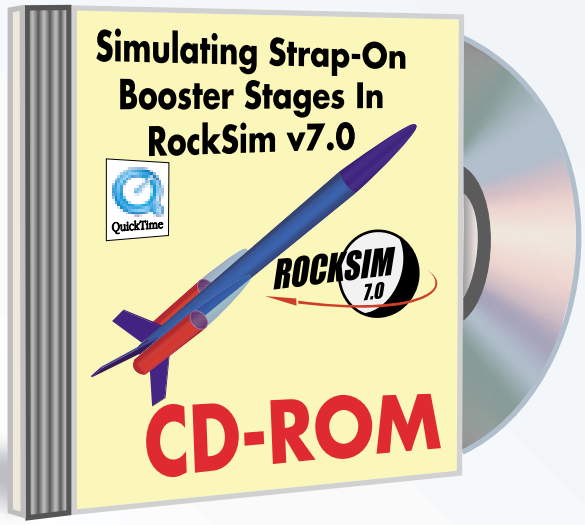
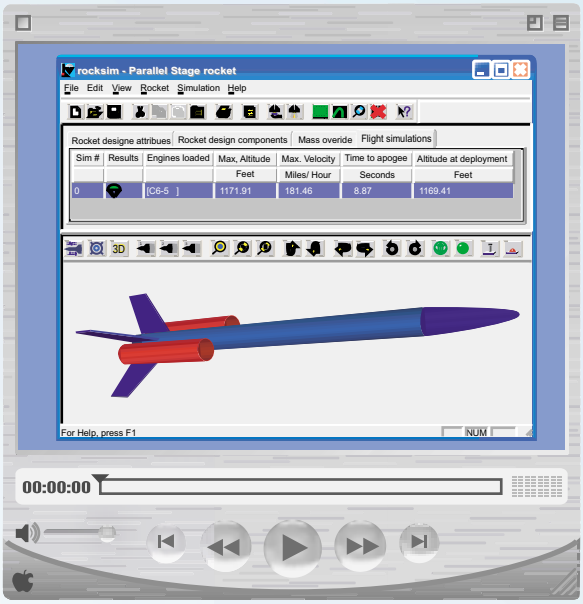
Discover RockSim Tricks & Tips As You Learn How To Simulate Strap-On Booster Stages!

Learning the techniques to simulate strap-on booster stages in RockSim offers me the opportunity to demonstrate to you some of the advaced features that I use every day. I can teach you how to make your RockSim simulations more accurate, and how to create your designs quicker.

This new CD-ROM has over 34 minutes of how-to instructional videos on it that will teach you: how to use the Engine Editor software, compiling the engine database, analyzing the simulation results, and lots of tricks and tips.





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Simulating Strap-on Booster Stages

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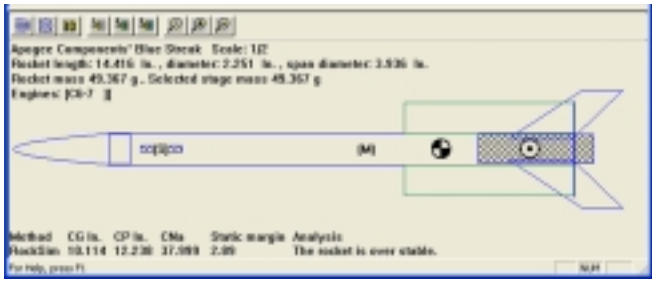

Figure 16: The 2D image of the completed rocket showing strap-on booster pods.

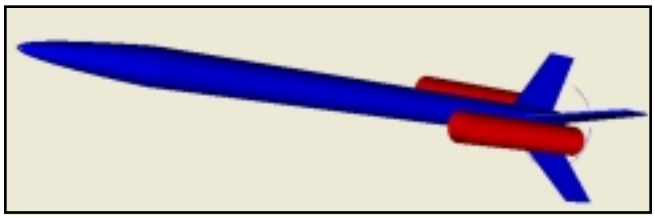

Figure 17: 3D image of the rocket. Note the tiny ring at the back of the rocket. It is the fake tube into which the strap-ons are inserted.

going to change the length to keep the weight to a minimum.

2. I could also adjust the O.D. to make it a thin-wall tube to reduce weight. But this time, I'll use the mass override. The tube must have some weight (a RockSim rule), so I'll specify the mass as 0.001 grams. That is pretty negligible.

Our design is now basically done. But there is one last thing we need to do before we install the motors and run simulations. We need to tweak the Drag Coefficient.

To be honest, I really don't have any recommendation on where you'd start with the C_d values. It will be a trial and error process. My first guess: if your upper stage has a C_d of .75, you would probably make the C_d of the booster section .85. You can tweak that later after actual flights.

You'll find the location to change the C_d's of each stage on the "Rocket Design Attributes" tab of the main screen (see Figure 8 in e-zine newsletter #109). It is located down near the bottom. You may have to shrink the view of the rocket at the bottom to make the text appear.

Since our rocket design is now complete, lets just take a couple of seconds to review some images and make sure we have everything in its proper place.

Figures 16 and 17 show the 2D and 3D views of the completed rocket. In the 3D view, you can see that there are no nose cones on the strap-on pods. You can also see the trick tube we created to insert the pods.

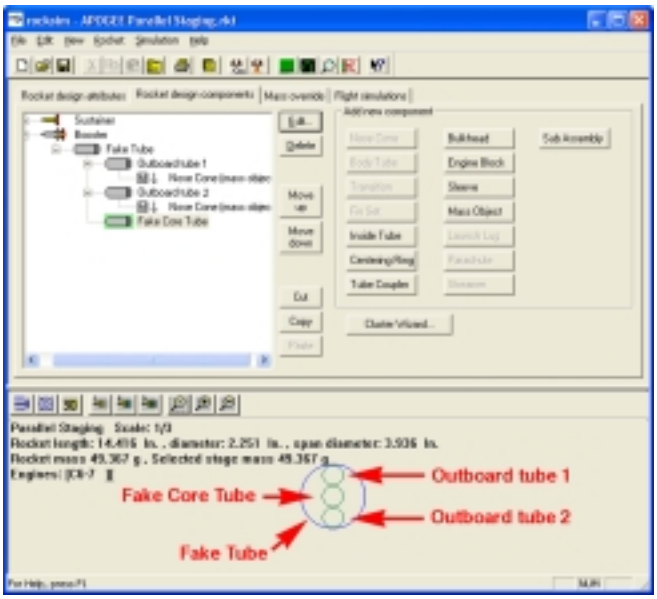

Figure 18: The parts tree in RockSim shows the arrangement of the items in the booster stage. They are shown in the bottom view of the drawing too.

In Figure 18, you can see what our part arrangement will look like for the booster stage. The base view shows the radial positioning of the strap-on pods, and how they are held in the trick tube.

Coming next time

In the next issue, we'll conclude this series of articles by running a number of different simulations and talking about Case Study #3 -- where the strap-on booster pods fall away while the middle motor continues to burn away and push the rocket higher into the air.

About the Author:

Tim Van Milligan 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 the FREE e-zine newsletter about model rockets. You can subscribe to the e-zine at the Apogee Components web site, or sending an email to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject line of the message.