Apogee Components

PEAK OF FLIGHT

NEWSLETTER

How to Simulate Canted Rocket Motors in RockSim

A short course on how to modify rocket motor files.

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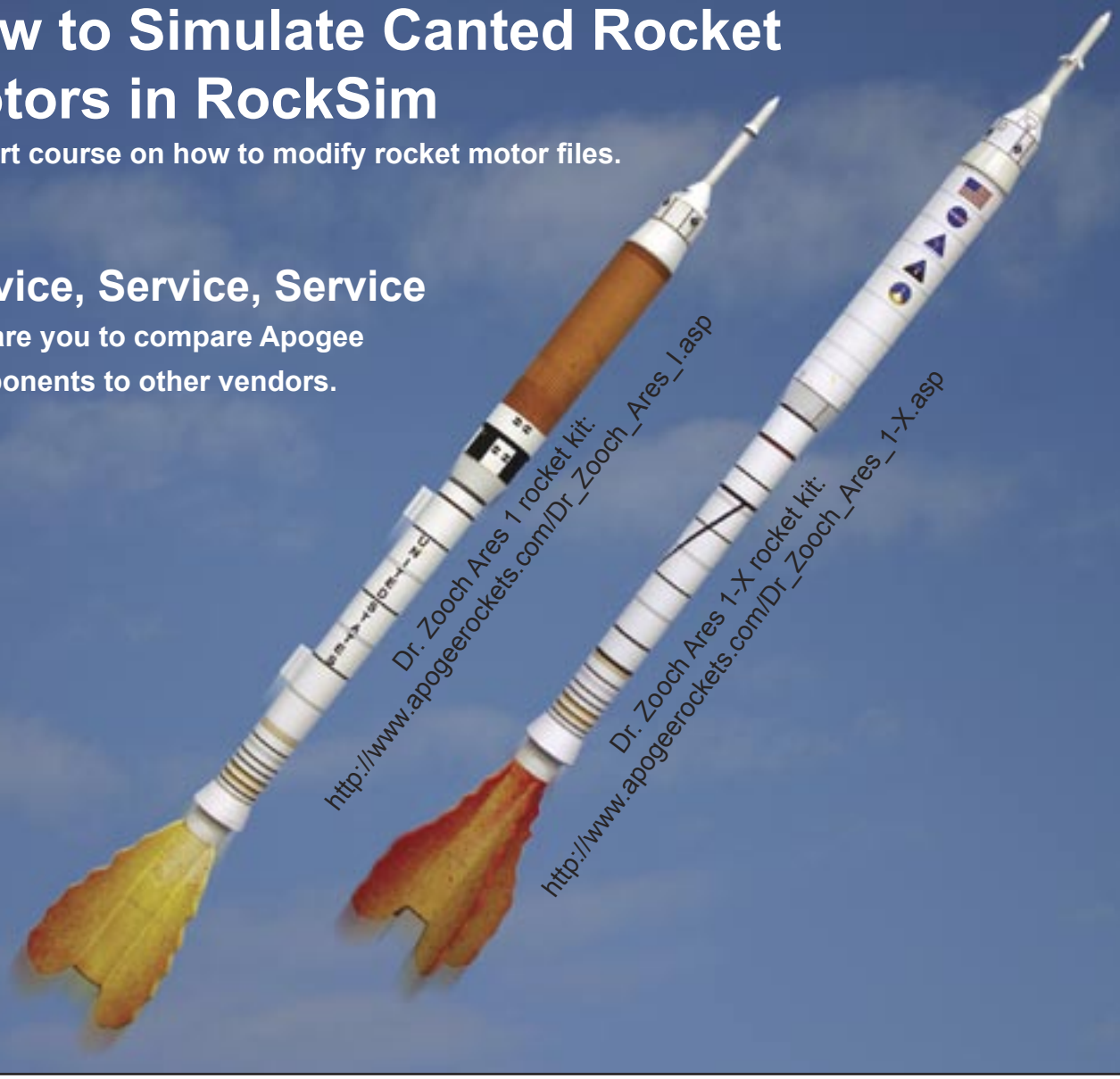

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The Effect on Altitude from Canted Rocket Engines

By Tim Van Milligan

Ed Chess writes: "When modeling a rocket like the Sunward Aerospace The-Screamer kit, where the engine mounts are canted, I realize I can't build/display that in RockSim. However, I was wondering if there was a way to account for the canted engine thrust vectors and adjust the altitude calculations?"

Image 1 shows a lift-off shot of the Sunward Screamer kit (http://www.apogeerockets.com/screamer.html). You can see that the engines are canted by the way the flames are angled.

This is a great question from Ed, because it showcases the educational aspects of rocketry that make it so useful as an exciting teaching aid. If I were a teacher, particularly for trigonometry or physics, I'd present this problem to the students for them to solve. It is a real-world rocketry problem that makes them use the math skills they learn in school.

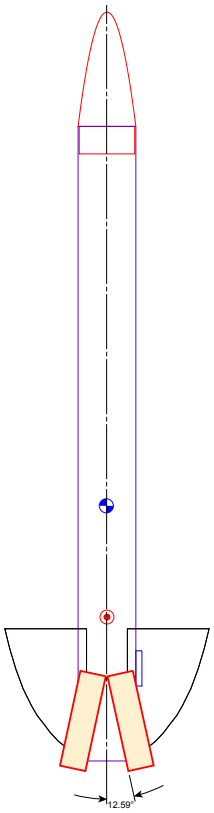

Image 2: Scale drawing of the rocket to determine the engine cant angle.

Unfortunately, RockSim (www.ApogeeRockets.com/rocksim.asp) does not allow for canted rocket motors. It assumes that all the engines are parallel to the centerline of the rocket. Actually, it is more than that. Even though the rocket engines are off to the side, the thrust produced by the motor is assumed to run through the centerline of the rocket. This is why the rocket simulation will indicate that the rocket should still fly straight if you have the engine positioned a large distance away from the centerline. In real life, it would cause the rocket to rotate because of off-axis thrust.

With the Sunward Screamer kit, since both motors are angled toward each other by the same amount, the side force gets cancelled out. That means if both motors ignite, the rocket will fly straight. We can simulate this in RockSim.

Image 1: The canted engines on the Sunward Screamer rocket look cool, but they reduce the efficiency of the flight by a small amount. Photo by Les Mann.

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It won't fly as high as RockSim suggests because the thrust force is not parallel to the centerline of the rocket. It will be diminished somewhat. How much? That is what we want to find out in this article.

Basically, it is possible to adjust the simulation to account for the loss of thrust because of a canted rocket engine. But it will take a little bit of trigonometry and then manipulation of the thrust curve using the EngEdit software that comes bundled with RockSim.

The process begins by determining the angle that the engines are canted. So you'll need to make some measurements of the rocket and create a scale drawing. Once the scale drawing is made, you can use a protractor to measure the cant angle of the motor mounts.

I took a model and made some quick measurements on it, and made a scale drawing that is shown in Image 2. Using a protractor, I measured the cant angle, which is approximately 12.597°.

The next step is to modify the thrust curve of the rocket engines. In this case, I will show you how to modify the data file of the Estes C6 motor.

To prevent your engine data file from getting messed up, you should duplicate the original engine data file, and then modify the duplicate. Be sure to give it a different name when you save it, so you can tell the new engine file from the original one.

Open the duplicate engine data file using the EngEdit software. You'll find the program in the RockSim program folder.

Once the file is opened, you'll see something similar to Image 3. At this point, I had started the modification process by deleting all the other engines in the data file, and I changed the motor code (name) and the comments. But the thrust curve is untouched.

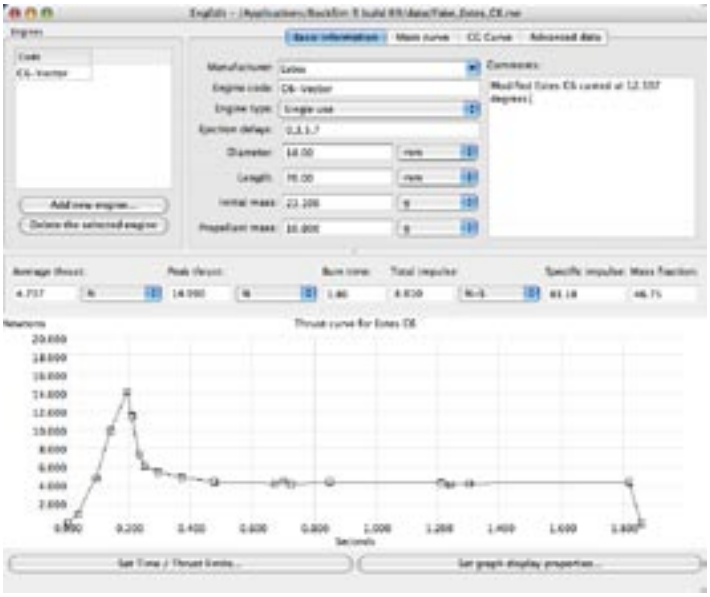

Image 3: Thrust curve of the rocket engine data file before modification. Note the total impulse number.

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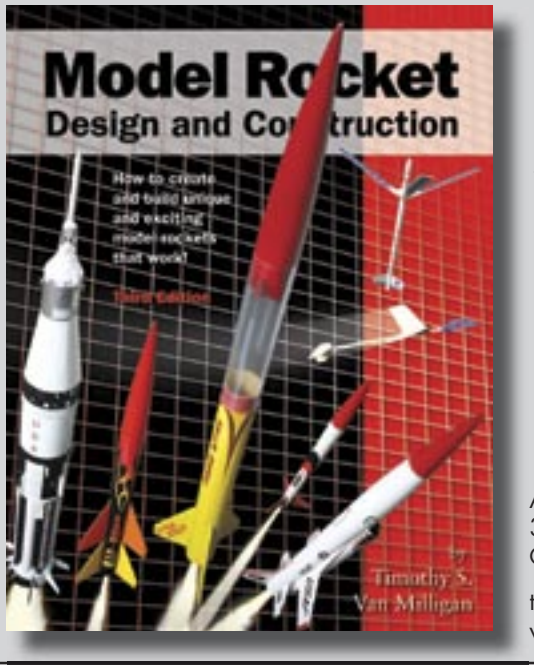

Model Rocket Design and Construction

By Timothy S. Van Milligan

New 3rd Edition Now Shipping!

This new 328 page guidebook for serious rocket designers contains the most up-to-date information on creating unique and exciting models that really work. With 566 illustrations and 175 photos, it is the ultimate resource if you want to make rockets that will push the edge of the performance envelope. Because of the number of pictures, it is also a great gift to give to beginners to start them on their rocketry future.

For more information, and to order this hefty book, visit the Apogee web site at: www.ApogeeRockets.com/design_book.asp

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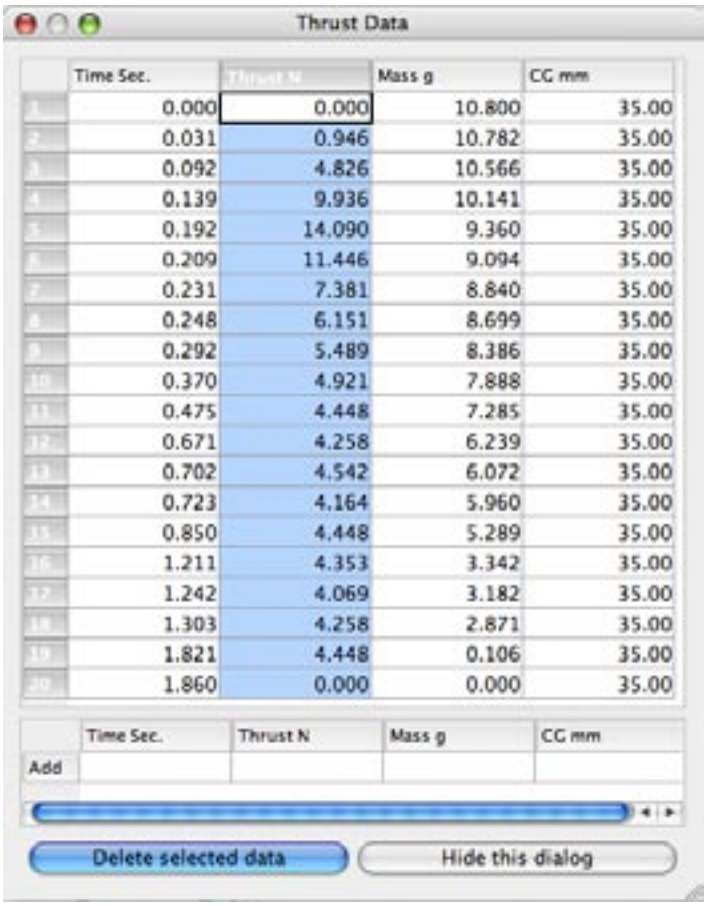
From the view menu of EngEdit, select the option to view time-ordered data. This will bring up a window that show the locations of the data points on the thrust curve. You then write down all the thrust level data in a column format. I put it in a spreadsheet program, so that I could store it easier.

Next comes the complicated step. You have to multiply the thrust level by a number to come up with the thrust of the canted engine. The equation is simple though. Multiply each thrust value by the cosine of the cant angle. In this example, using a cant angle of 12.597°, the cosine of that angle is .9759. I'll multiple that number by the thrust value. I did this in the spreadsheet, which is shown in image 5. By the way, writing a formula to compute the cosine in the spread sheet is harder than doing it on a calculator, so I would recommend doing it on the calculator to save time.

Remember, multiply every number in the Thrust column by the cosine value of the cant angle. When you are done, click on the "Hide this dialog" button, and that will take you back to the image of the thrust curve.



	Time Sec.	Thrust N	Mass g	CG mm
1	0.000	0.000	10.800	35.00
2	0.031	0.946	10.782	35.00
3	0.092	4.826	10.566	35.00
4	0.139	9.936	10.141	35.00
5	0.192	14.090	9.360	35.00
6	0.209	11.446	9.094	35.00
7	0.231	7.381	8.840	35.00
8	0.248	6.151	8.699	35.00
9	0.292	5.489	8.386	35.00
10	0.370	4.921	7.888	35.00
11	0.475	4.448	7.285	35.00
12	0.671	4.258	6.239	35.00
13	0.702	4.542	6.072	35.00
14	0.723	4.164	5.960	35.00
15	0.850	4.448	5.289	35.00
16	1.211	4.353	3.342	35.00
17	1.242	4.069	3.182	35.00
18	1.303	4.258	2.871	35.00
19	1.821	4.448	0.106	35.00
20	1.860	0.000	0.000	35.00

	Time Sec.	Thrust N	Mass g	CG mm
Add				

Image 4 (right): Thrust data of the C6 motor. You'll modify the second column labeled "Thrust N."

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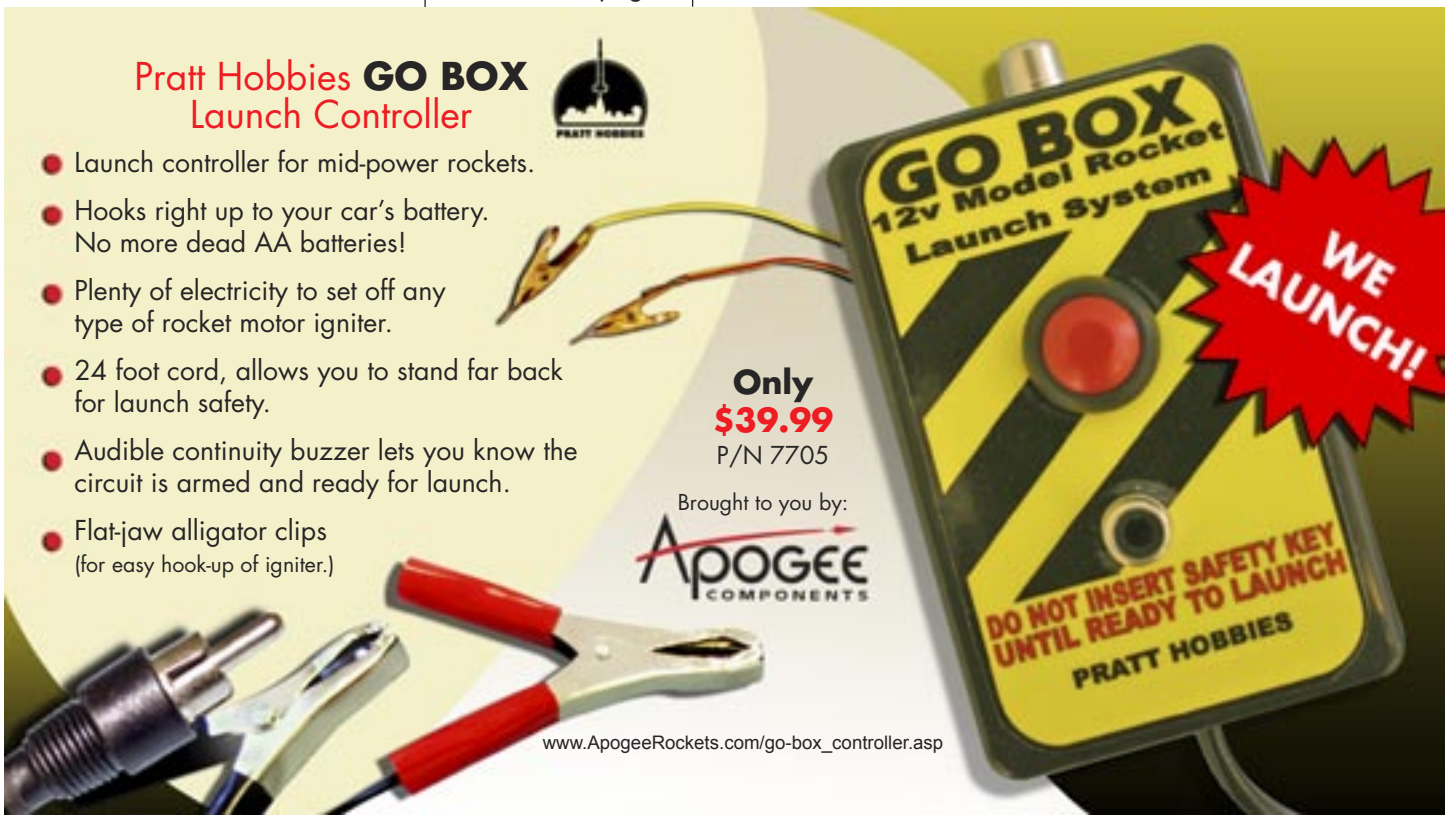

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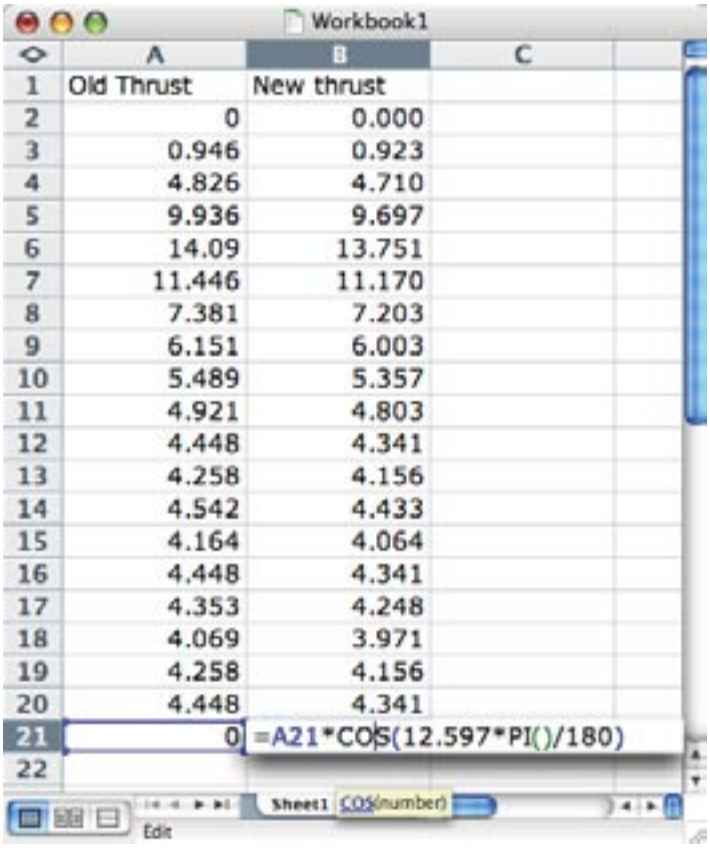
When you get back to the main screen, it will appear that nothing happened. The shape of the thrust curve has not changed much at all. This is normal. All you really did was move each point on the curve down a small amount. To confirm things, note that the Total Impulse of the motor did change. In this example, it went from 8.81 N-s to 8.598 N-s. You'll note that this value is down by the same factor that you used to shift all the points down (the cosine of the cant angle).

Now save the file, and then start up RockSim. Your first task is to reload the new engine data into RockSim. If



	A	B	C
1	Old Thrust	New thrust	
2	0	0.000	
3	0.946	0.923	
4	4.826	4.710	
5	9.936	9.697	
6	14.09	13.751	
7	11.446	11.170	
8	7.381	7.203	
9	6.151	6.003	
10	5.489	5.357	
11	4.921	4.803	
12	4.448	4.341	
13	4.258	4.156	
14	4.542	4.433	
15	4.164	4.064	
16	4.448	4.341	
17	4.353	4.248	
18	4.069	3.971	
19	4.258	4.156	
20	4.448	4.341	
21	0	=A21*COS(12.597*PI()/180)	
22			

Image 5: Spreadsheet that shows the old thrust (from Image 4) and the new thrust level.

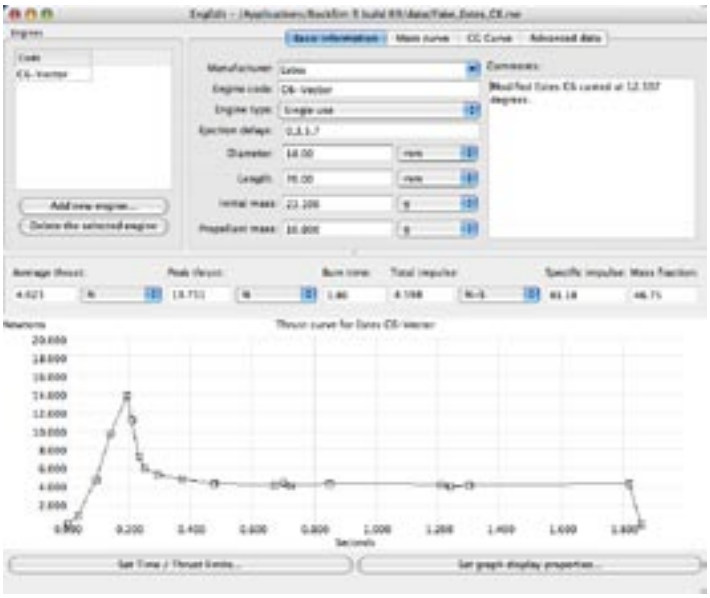


Image 6: The thrust curve after modification. The shape is the same, but the total impulse is down slightly.

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Two Bernoulli's

Bernoulli Principle: A physics principle that states the pressure exerted by air perpendicular to its direction of travel decreases with an increase in velocity. This is the theoretical principle upon which airplane wings work. An airplane wing's airfoil is unsymmetrical, its upper surface having a greater curve than its lower surface. This causes air flowing across the upper portion of the wing to speed up, since it must cross a greater surface area in the same length of time. The increase in air velocity on the upper surface causes the air pressure in the region just above the wing to be reduced. The higher pressure below the wing presses upward on it, creating lift.

Bernoulli Lock: A phenomenon similar to the Krushnic Effect where the rocket seems to be "glued" to the pad at liftoff. This afflicts larger, flat-bottomed rockets launched too close to pads with flat blast deflectors. The exhaust gasses escape at great speed through the small annular space between the rocket and the pad creating a venturi which generates a low pressure region at the base. This pressure deficit can be significant, and if it is greater than the thrust being generated by the motor, the rocket won't go anywhere! This is quite possible as a 2" dia.rocket has, potentially, over 45 lbs (200 N) of "suction" available to hold it back, while a 3" rocket has over 100 lbs (460 N)! The old Centuri "Point" (pictured) was an infamous Bernoulli locker when launched from an Estes Porta-Pad with its perfectly matching round blast deflector.

These two definitions can be found in EMRR's Rocketry Glossary.

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Canted Rocket Engines

you don't know how to do this, you can watch a Quicktime video that shows the process at: http://www.apogeerockets.com/RockSim_tutorials.asp

After the engine data files are brought into RockSim, you can open up your rocket design file and start running simulations to see the difference between a canted engine rocket versus the straight motors.

You will note that the canted engines do make the rocket fly to a lower altitude. But it is not the cosine of the cant angle multiplied by the altitude of the uncanted flight. It will be different.

The reason for the difference is that the trajectory is controlled to a greater degree by the shape of the thrust curve than the total impulse. While it didn't look like the thrust curves were changing, (Images 3 and 6), they are different enough that it changes the trajectory. The lower kick coming just as the rocket lifts off is the biggest factor in the change in trajectory.

If you would like to download the modified engine data file for the Estes C6 that is canted at the 12.597° angle, you can do so at: www.ApogeeRockets.com/education/downloads/Canted_Screamer.zip

Conclusion

As you saw in this article, canting the rocket engines can be simulated in RockSim, but it does take a little bit of work. Is there a simpler way, you ask? Yes. Apogee's 6-Degree-of-Freedom program called RockSim Pro (http://www.apogeerockets.com/RS-PRO.asp) does allow for canted rocket engines. In that case, you don't have to modify the engine data file at all. You just specify the cant angle along the X-axis when you load the engines, and run the simulations.

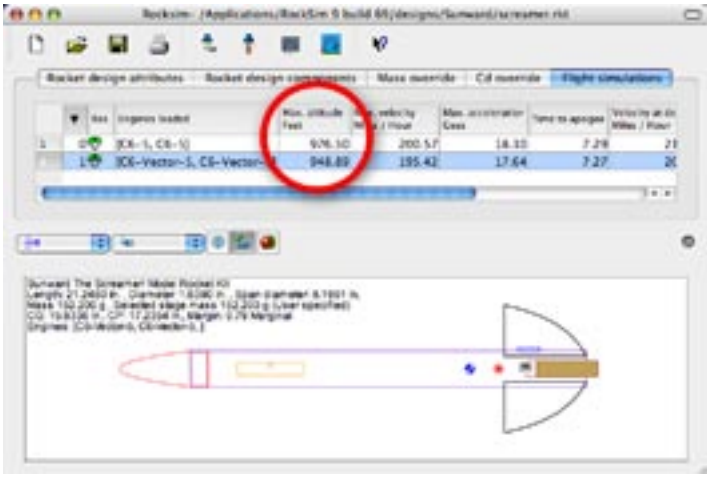

Image 7: Comparison of the altitude differences between canted and straight rocket motors.

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.

The Apogee Difference: Service, Service, Service

By Tim Van Milligan

With the national economy the way it is, I see ugly things happening in a lot of businesses. In order to keep expenses down, many companies are cutting back on staff and are offering fewer services to customers.

Personally, I think this is the wrong approach to take. I believe customers like you are very aware of how precious money is, and you don't want to have reduced service when you do spend your money. Why would you hand over money to a company and then have them treat you with such low esteem? It doesn't make sense.

I just want to make you aware of this, because when you buy from Apogee Components, we feel honored that you selected us. It is a very big deal to us, and we want you to know that we do appreciate it and we won't brush you off like those other vendors.

I believe that excellent service is something you want and deserve. I'll go further and say that if you don't get good service from us, you'll take your business to someone that will give it to you. Friendly service is just as important to you as the value of the merchandise you are buying. Am I right? I believe that the products you buy and how you are treated (before, during, and after the sale) are linked together very closely. And during tight economic times, the link is even closer together.

That is why we haven't reduced our level of customer service. In fact, we increased it last year. We are the first company that I know of to offer same day shipping on purchases. Not only that, we guaranteed it! If you order by 2 p.m. our time (Mountain Time Zone), we'll get your order out that same day, or we'll refund half of the shipping costs. To be honest, we did have a few people that did receive refunds. But I meant that guarantee, and I am bound and determined to keep my word to you.

Shipping items quickly is only a tiny part of what we do for you as part of what we define as "excellent customer service." I'd like to give you some examples so that you can compare us to other companies.

First, we have a real person answer our telephone — imagine that? During business hours, you won't get a voice-mail system when you call us (even though we do have that feature on our phone system). You deserve to talk to a real person that can help you, not a machine that asks you to leave a message.

When a new staff member starts working at Apogee, they are shocked to learn that I actually want people to call us on the phone. Where these people worked in the past, they did everything to discourage customers from calling direct. That's why voice-mail systems were created in the first place, right? But here at Apogee, your calls and email messages are not an interruption in our day -- they are the purpose of it.

I feel that we can take care of customers better if we can actually talk with them on the phone. More than that, they also get to experience a human-to-human bond, which they don't get when they order by internet.

Second, our customer service policy dictates that we guarantee that you will get only the right products that you need for your rocketry project. What does that mean, you ask? Let me give you an example.

Many people that call us on the phone do not know very much about rockets. Because of our technical expertise, it would be very easy to talk them into buying all kinds of accessory items. We'd make a huge sale. But by the time they received their order and realized that they didn't need half of what they got, we would have lost a customer. I'd rather have a customer for life, because I plan for Apogee Components to be around a long time.

So we start each conversation by asking the customers what kind of project they are working on. Based on their answers, we give them specific recommendations on the minimum number of items that will help them achieve success in their project.

This helps the customer save money and it keeps our expenses down too. We don't have people returning items to us because they bought something they didn't need. To be honest, on those very rare occasions when an item is returned back to us, I want to know why. I want to know what information was missing that caused them to buy the wrong item. I don't want unhappy customers.

I'll let you in on a secret related to this. Apogee gets calls all the time from credit-card processing companies. They want to get our business to process the credit card transactions that come through our web site. In order to

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Service, Service, Service

give us a quotation on their fees, one of the first questions they ask us is how many "charge-backs" we get a month. I couldn't figure out why this question was even asked.

A charge-back occurs when a customer calls their bank to dispute a charge on their credit card. It is costly to the processor because of the extra work involved for them to satisfy the customer and their bank.

After looking into this question, I found out that many companies are providing such poor service that their customers are incensed by it. They are going to their bank and demanding their money back. So the bank does a charge-back on the card and yanks the money away from the store.

But this never happens at Apogee Components because we go out of our way to make sure that you are delighted with your dealings with us. That's why I couldn't figure out why they were asking me for a number of charge-backs. Then it dawned on me; obviously charge-backs must be very common with other businesses.

Insuring that customers get only the appropriate items goes beyond just helping those that call us on the phone. When an order comes to us via our web site, we scan over the items ordered and see if everything matches. For example, if someone orders a small rocket kit, and a high-power launch pad, we sense that the two may not work together. We immediately contact the person by phone or email and ask them why they are getting two items that don't go together. Maybe they wanted a deluxe launch pad, but they didn't know that they didn't need a high-power one. We then recommend that they get the smaller one, which will save them money. While we didn't maximize our profits, we ended up making a happy customer, and we're sure they'll recommend us to their friends.

Another thing that happens all the time is that a customer may order the RockSim software twice. Why twice? They order it the first time and quickly fall in love with it (since it is such a great product). Then a year or two later their computer dies. Thinking we must me like other software vendors, they reorder RockSim a second time. We are honored that they love the program enough to order a second time. But it wouldn't be right to take their money in this situation. We contact them and inform them that we can't accept their money, and then issue them a refund and send the information to download and reinstall RockSim. If you've done business with Apogee for a while, there is a good chance that this, or something similar has happened to you. Am I right?

It is because of this policy that we refund nearly 10 per-

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cent of our revenues back to customers. For us, it is simply the right thing to do as part of customer service.

A third thing that we do differently from other companies is that we take time during our weekly staff meeting to talk about any customer service issue that arose during the week. It is important to me that we know what caused the issue. Only then can we formulate a new system or procedure to prevent it from happening to other customers.

How can everyone say they have great service?

It amazes me that every company in the world will say (with a straight face) that they provide great customer service. My question is, to whom or to what are they comparing their service?

Good customer service doesn't just happen, even when you have great people like we do. It has to be planned in advance. I'm guessing that most businesses haven't sat down and planned out the things that they'll do to ensure the customer feels they received good service. I've written down what I believe are the things that we must do to keep you and our other customers happy. You've read four of them so far. I've got 24 others that I haven't mentioned.

What I want to point out in this article is that these 30 things are what I consider the bare minimum just to keep you happy with your current purchase. In order to earn your repeat business, we have to do much better. We set a very high standard, and I want it even higher.

I agonize over this issue. Why? Because it is fun to build and fly model rockets, but it shouldn't be a chore to order them. And when you do buy a rocket, I want it to be from Apogee Components.

My goal is more than just to make you a happy customer. First of all, I want to eliminate any doubt that you have in your mind about Apogee Components. I want our reputation to be synonymous with the peak of integrity. For you, there should never be even the slightest risk of doing business with Apogee Components. It should always be sure thing.

My second goal is that doing business with Apogee should be more than a transaction. It needs to be an experience that you love and will want to do again and again. Please let me know what we have to do to get you to that level.

In conclusion, there are a lot of things that make Apogee Components different from other rocketry suppliers. I think when you get down to it, they all revolve around providing good customer service - making sure you are delighted when you do business with us.