

ISSUE 164 - JULY 28, 2006

# APOGEE

## PEAK OF FLIGHT

N E W S L E T T E R

### Are Your Altitude Measurements Reliable?



#### INSIDE:

- Accuracy vs. Precision When Tracking Rockets.
- Stabilize Your Parachute.
- Web Site of the Week.
- Rocketry Safety: Test Your Knowledge.

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## How Accurate are Your Altitude Measurements?

by Bernard Herman

I read with interest the article "Succeeding In A Science Fair" by John Manfredo in Issue 160 of *Peak Of Flight* newsletter. It struck home since I recently went through the process with my own fifteen-year-old daughter trying to help her understand the basics of rocketry, writing procedures and some of the principals I will attempt to explain in these articles. That both of us survived is more a testimony to our love for each other more than our patience or ability to explain/understand each other.

As I was reading the article, I couldn't help but wonder about the discrepancies between Jake's (the boy with the science fair project in the article) calculated and recorded heights. I couldn't reconcile the differences in my mind, and for the most part, without knowing more about his procedures or the accuracy of the Max-Trax™, won't ever be able to. Given due care, I would expect the numbers to be closer. Maybe a better procedure would have been to station observers at different distances along a baseline for the same launch and then compare the results.

On the other hand, I am concerned with some of the procedures I have found in the literature I have read on determining the height a rocket attains. Having been a land surveyor for many years, I thought this would be a great way to combine my vocation with my hobby. Before my daughter's science fair project, I never really concerned myself with measuring the height my rockets attained. That they went up and came down in one piece and were recovered was more than enough thrill for me. In working with my daughter, a more exact number was needed than "they went up pretty high."

### Terminology

As mentioned previously, I am a land surveyor, therefore my terms may be a little different than most of the other writings on this subject. Instead of mentioning an elevation, I will refer to vertical angles. Instead of an

azimuth, I will refer to horizontal angles. While in general usage, these terms may be interchangeable, to me they are specific terms with specific relations.

For example, azimuths are horizontal angles all read from a fixed reference, normally a north bearing.

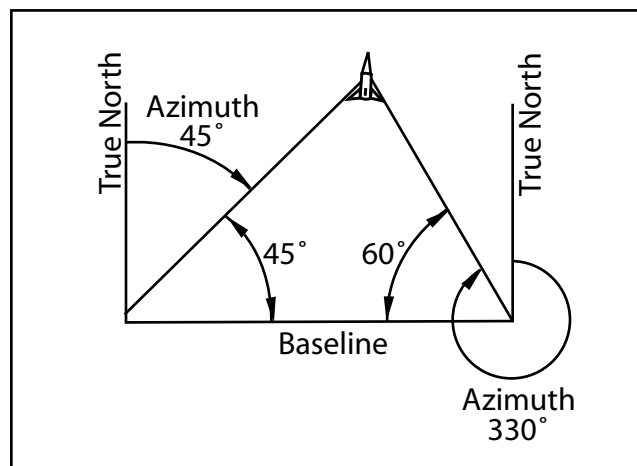


Figure 1

### Accuracy vs. Precision

Jake's assumption was that his calculations were off due to an accuracy issue (being able to determine the vertical angle by observing the rocket at apogee). Increasing the baseline distance could help this issue. However, at the same time, it may aggravate the situation through a precision dilemma.

Accuracy deals more with mistakes made in observations. Did I actually record the vertical angle at apogee? Did the wind affect my plumb bob during the reading? Did I read a 6 as a 9, or vice versa? etc. Precision, on the other hand, deals with the tools we use to measure and approximate numbers.

### Exact and Approximate Numbers

Confused yet? You probably aren't alone. Most people aren't used to dealing with "approximate" numbers. Mathematics, for these people, has been mostly about exact numbers. The numbers we count with are exact numbers. The number of children someone has is an exact number. The number of pennies in a dollar is an exact number. Six times four equals twenty-four, in

*continued on page 4*

### About this Newsletter

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*First Annual Apogee Components'*  
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*CONTEST RULES*

1. The products in the pictures should be any items that we sell on our website, whether it be kits (Apogee or otherwise) or scratch-built rockets using our parts. The key is that they must be items that we sell on our webstore.

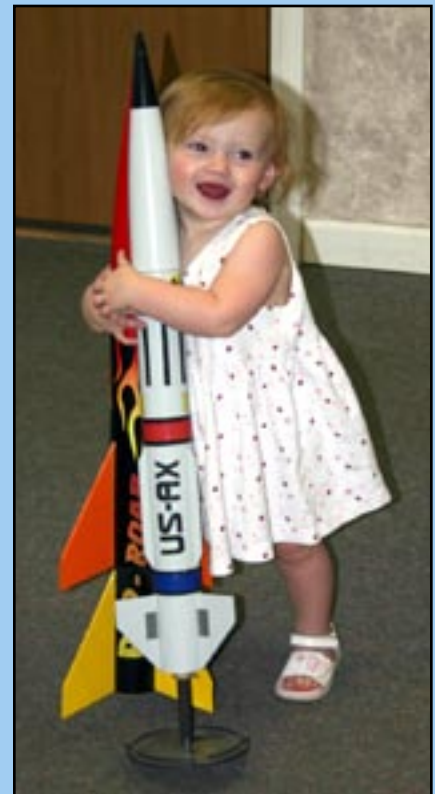
2. The pictures should include people with the rockets and may be adults, children, and anybody in between. You may enter more than once!

3. The photos should show some kind of action in them. Examples of this would be rockets taking off, customers setting up rockets on pads, people waiting and watching for the rockets to take off, etc. Photos that would not be a good choice are those that simply have customers or kid simply holding a rocket.

4. Pictures should be sent by e-mail to [johnm@apogeerockets.com](mailto:johnm@apogeerockets.com). They should be as high of a resolution as possible for good photo quality.

5. By submitting a photo you grant permission to Apogee Components, Inc. to post your photo on our website. Your photo may or may not be used on the web.

6. The photos need to be submitted by July 14, 2006 in order to be eligible.



While this is very cute, we'd like to see action shots!

*PRIZES*

First Place: Full Version of Rocksim 8.0 (a \$99.95 value)

Second Place: Building Skill Level 2 CD (a \$21.15 value)

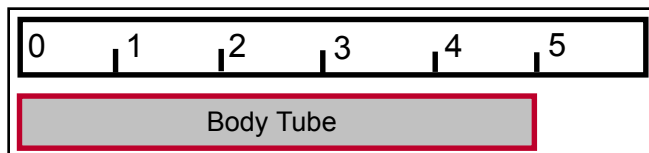
Third Place: Building Skill Level 1 CD (a \$14.78 value)

Honorable Mention: Everyone walks away a winner with Apogee!

All other entries will receive a special mystery prize!

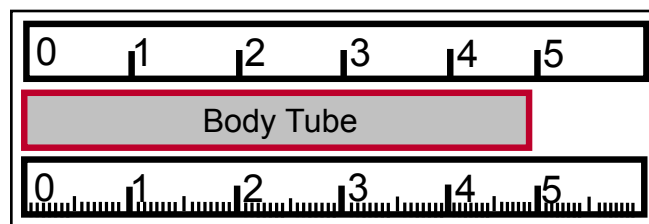
general math, is an exact number.

Anything we measure, however, is an approximate number and can never be anything else, no matter how precise we get. Imagine we are measuring a body tube with a ruler that has markings at one-inch intervals. We measure five inches and cut it. (see figure2 )



**Figure 2**

Then we find our ruler marked in sixteenths and want to check the tube. This time we measure four and 15/16ths inches. (see figure 3)



**Figure 3**

Even if we measure five and 0/16ths inches, could we find a ruler with divisions small enough to read other than just five inches? Probably.

### What time is that angle?

Most of us know that in a full circle there are 360 degrees. From there, we can divide a degree further into 60 parts known as minutes. We can then take a minute and divide it even further into 60 parts known as seconds (akin to hours, minutes and seconds). Thus 45 and a half degrees is 45 degrees, 30 minutes or 45°-30'. 90.00833 degrees would be 90 degrees 0 minutes 30 seconds or 90°-00'-30".

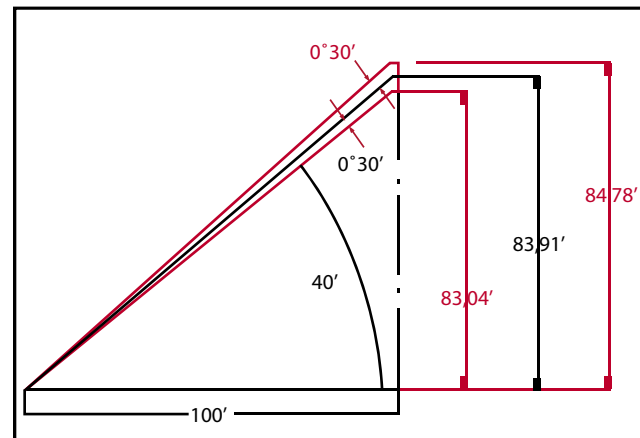
### Precision

Do we have to be this precise? Not for what we're doing. Consider this, with a five hundred foot baseline, a vertical angle of one second of a degree would come out as 0.002' or about 1/32nd of an inch difference in the height.

Most protractors generally available have markings to the nearest degree. This gives a precision of plus or minus 1/2 degree or 30 minutes (half of the smallest direct reading of the instrument we're measuring with).

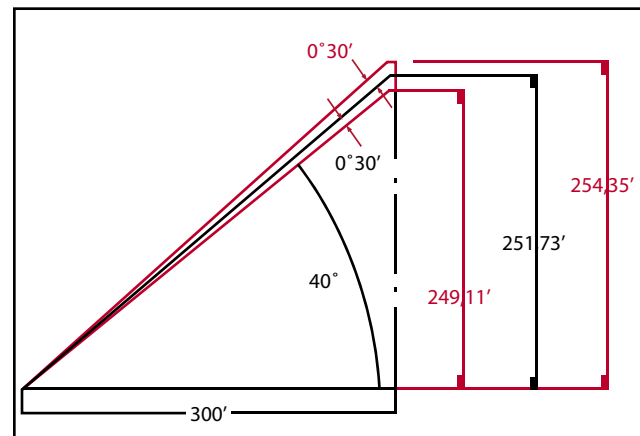
Multiplying the baseline distance by the tangent of

the precision number (1/2 degree), we find that a 100.00 foot baseline has a precision of plus or minus 0.87 feet. Using a vertical angle of 40 degrees on a one hundred foot baseline, we get an apparent height of 83.91'. Applying our adjustment, the actual height is somewhere between 83.04' and 84.78'. (see figure 4)



**Figure 4**

If we increase the baseline distance to 300.00 feet, our precision is now plus or minus 2.62 feet. Again using a vertical angle of 40 degrees, our rocket actually attained a height somewhere between 249.11' and 254.35'. (see figure 5)



**Figure 5**

Increasing the baseline distance makes this error even greater, meaning there is a larger degree of uncertainty in our altitude.

### Getting Precise

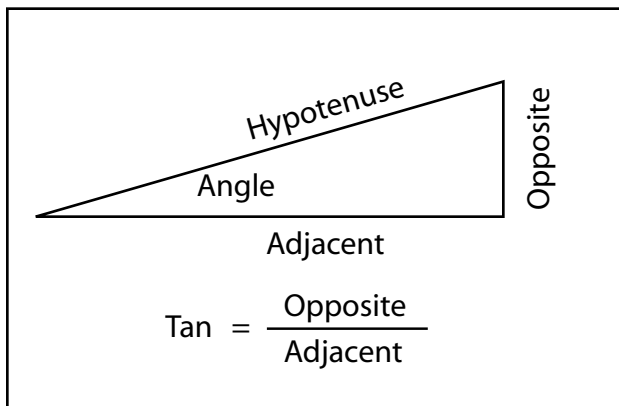
So, how precise do we want to get? Most of the

*continued on page 5*



time our readings are rounded off to the nearest foot. Our readings therefore should be plus or minus \_ foot. If this is the case, we can do some simple calculations to figure out how precise we should make our angular readings.

The first thing we should determine is the length of the base line. For the sake of accuracy we want our readings to be around forty-five degrees. This means that our baseline should be equal to the height we think our rocket is going to attain. We can find this possible height by many different means, one of the best being by using the RockSim™ program. For the sake of ease in our future calculations, we use the nearest hundred foot. Dividing the opposite side of a triangle by the adjacent side gives us the tangent of an angle (See figure 6).



**Figure 6**

Therefore, dividing 0.5' (half of our precision value of 1') by the baseline distance will give us the tangent of the angle we need to get the precision we want. Using this formula, we get the following approximate minimum reading angles (refer back to figure 4 and 5).

| baseline   | 100'  | 200'  | 300'  | 500'  |
|------------|-------|-------|-------|-------|
| min. angle | 0°15' | 0°10' | 0°05' | 0°03' |

### Another Fundraiser?

So how do we get this precision? Do we need to have another fundraiser to buy or rent the instruments to measure the vertical angles? Not necessarily.

While buying, renting or borrowing a surveyor's or building contractor's theodolite or total station (an instrument that measures angles and uses an Electronic Distance Measuring device to measure distances) may be an option, these devices are expensive and require

special care, not to mention training on how to use them. Also the optics are not always conducive to tracking an object in flight (the field of view can be too small at shorter baseline distances).

To keep costs down, first examine the protractors you plan on using for your scratch built theodolites. Try to find one large enough that they show parts of degrees also. For even more precise readings, a vernier scale could be added to the design. This device helps break down the divisions. How to design and use one is the topic of maybe a future article

### Conclusion

In this first part, we took a look at the numbers we use and how to use them better.

If you have ever been the victim of a "track not closed", you may have fallen victim to a precision error. While the precision of the readings may not be the only reason, we can now see how on a 300-meter baseline, there is the possibility of over a five-meter error from just one source without anyone doing anything wrong.

We like to think of hobby rocketeers as a scientific breed. Yes we have lots of fun pushing a button, listening to the roar, then chasing them down. Our hobby though, is based on science. In science numbers mean a lot. How we state them, how we use them all mean something. If we are going to brag about how high our rockets fly, we should be able to do so with a greater degree of certainty.

### About the Author

*Bernie Herman has worked in the land surveying field for over twenty years. He doesn't consider himself a BAR since he never gave up rocketry since his mother bought him his first model rocket kit in 1973 at the age of ten. He has been married for over seventeen years. He has five children, three girls and two boys.*



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## TIP OF THE FIN

How can you keep your parachutes from from swaying upon descent? I hope to show you some ways to try to avoid this problem.

To start off, in photo 1 you will see that by checking each line's length, you might find that some are shorter, which will make one side lower than the other. This results in air spilling out of one side and causing the 'chute to sway. One

**Photo 1**

of the main reasons for the difference in length is the way the lines are tied on the parachute. In photo 2, this can be checked by noting how much extra string is hanging off. If they are uneven, then the re-

**Photo 2**

sult will be uneven lines and swaying. Once all the lines are together you will see how they become twisted (photo 3). There is no way around this when the

**Photo 3**

lines are attached in the usual way (tying them into the holes that are next to each other). To avoid the twisting, tie lines to holes next to each other and then on the opposite side. The third pair of lines will be tied directly across the parachute from each other. This is shown on the left. Also, as seen below, attaching a fishing swivel to some Kevlar line

**Photo 4**

and then to the 'chute will help immensely.

If you need parachutes or lines, please visit our "Building Supplies" section at [http://www.apogeerockets.com/building\\_supplies.asp](http://www.apogeerockets.com/building_supplies.asp).

**Photo 5**

## QUESTION AND ANSWER CORNER

This issue's question comes to us from Ian Cinnamon, who writes, "I recently purchased the Saturn 1B rocket kit and I had some trouble filling in the seams on the body tubes. I primed them, sanded them, primed them again, and lightly sanded them with wet/dry sandpaper. When sanding with the wet sandpaper, the body tubes began to uncoil and break at the seams. When sanding earlier (the first time), I did notice the tubes felt weaker. I tried repairing the tubes with thin CyA glue. After painting, most seams were easily visible. What did I do wrong?"

When wet sanding, great care must be taken in order to not get the tube too wet. The first suggestion I made was that you should view the videos with steps 37 and 38 in the supplied instruction CDs. These are the techniques that we use here at Apogee, especially the one with the Fill n' Finish. When you say that the tube split at the seams, that would indicate to me that the

tube may have gotten too wet during the wet sanding process. What I do to avoid this is to sand over a sink with the water running slowly. I wet the 400 grit sandpaper, but before touching the tube I get most of the water off with a good shake. The remaining water is more than enough to sand with and it doesn't get the tube too wet. Also, periodically, make sure you dry the tube off with a rag. This will aid in preventing the tube from becoming too wet. The basic procedure for finishing the tube is: fill, sand (repeat if necessary), prime, sand, fill, prime, wet sand, main color coat, clear coat (if desired).

Hopefully, this will help when you are going to finish tubes in the future. Sometimes the easiest way to learn is by going through the mistakes. If your tubes got messed-up, though, there are plenty of tubes to be had at [http://www.apogeerockets.com/body\\_tubes\\_and\\_rings.asp](http://www.apogeerockets.com/body_tubes_and_rings.asp). Take a look and see what we have to offer! Thanks for the great question Ian!

## NAR Rocketry Safety Code Quiz

by "Mr. Rocket" (aka - Tim Van Milligan)

This started out as a quiz for students about the NAR safety code. At first I wanted to test them on their reading the safety code. But the more I thought about it, I felt it was more important for them to understand the principles behind the code. In other words, I wanted them to think about what they were doing, and why these things are mentioned in the safety code. The questions came from some of the more common unsafe things that modelers have told me they have done. They violated the safety code, and they may not even have known it. So here is a little quiz about the safety code. Maybe it will help you or someone you teach rocketry to. Feel free to use this when teaching others about rocketry. Safety is no accident. It is important, and we can't ignore it. For answers, see: <http://nar.org/NARmrsc.html>.

What is the NAR safety code?

- A. Rules intended to prevent accidents when building model rockets.
- B. A set of common-sense guidelines to prevent injury and accidents when launching model rockets.
- C. More government regulations that take away our freedom to have fun and only end up making rocketry more expensive for everyone.

What is the purpose of the launch lugs?

- A. To give the rocket a cool look, just like the rockets NASA flies.
- B. To slip over the launch rod, which guides the rocket until it reaches a stabilizing flight speed?
- C. They help stabilize rocket a high speeds as described in the "Von Karman theory of aerodynamic stability."
- D. The NAR Safety Code does not mention launch lugs.
- E. Both B and D.

What is the maximum launch angle permissible in the NAR Safety Code?

- A. 30° from vertical
- B. 45° from vertical
- C. 60° from vertical
- D. The launch angle that results in the "closest-to-the-launch-pad-recovery" so you don't have to walk to far to retrieve the rocket. It is determined by using the RockSim software.

Are "shoulder mounted" launch tubes (like a bazooka or stinger missile launcher) permissible in the NAR safety code?

- A. Yes
- B. No

For "C" size rocket motors, what is the closest you can be to the launch pad when launching the rocket?

- A. Rockets always go "UP" not sideways. So as long as you aren't standing over the pad, you're not in violation of the safety code.
- B. 10 feet.
- C. 15 feet.

What is the purpose of the blast deflector?

- A. To keep the launch pad from tipping over on windy days.
- B. To provide something solid for the rocket to push against so it can rise up into the air.
- C. To keep the engine's flame from hitting the ground, where it might start a grass fire.

When is it permissible to use a match and a fuse to ignite a rocket engine?

- A. Only when your launch controller's batteries are dead, and you have no other way to set off the engine.
- B. After a heavy rain shower has really soaked the grass on the launch field and the possibility of a grass fire is remote.
- C. It is never permissible.

Why shouldn't you use metal for nose cones, body tubes and fins?

- A. Air flowing over metal creates a static-electric charge; making the rocket more susceptible of getting struck by lightning.
- B. The glare of the sun reflecting off metal would blind spectators during the launch.
- C. Because metal shows up on radar, and it would spook airline pilots into thinking someone is trying to shoot them down.
- D. Because metal makes the rocket heavier and increases the potential of piercing objects it might strike should the launch take an unplanned course.

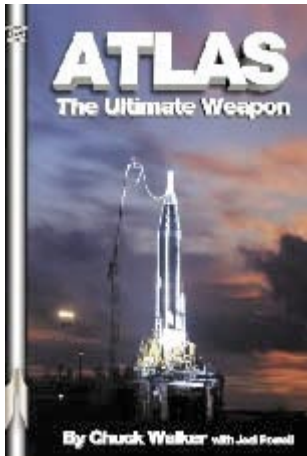
Why shouldn't you launch rockets into clouds?

- A. You could trigger cloud-to-ground lightning
- B. You lose site of the rocket, and then you don't know where it came down.
- C. You can't see aircraft flying above or in the clouds, and you could pose a hazard to those within the aircraft.
- D. All of the above.

[continued on page 9](#)







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Is gluing the nose cone onto the rocket permissible in the NAR safety code?

- A. Yes
- B. No
- C. Trick Question: The NAR Safety Code does not say. As long as the rocket returns safely via a recovery device to the ground and is intended to fly again, it is permissible. So it depends on the rocket design.

Why does the NAR Safety Code say not to retrieve rockets from power lines?

- A. You could get electrocuted.
- B. You could fall down and get hurt.
- C. Trick Question: The safety code does not give a reason.
- D. All of the above

Are home-made engines permissible in the NAR Safety Code?

- A. Yes
- B. No
- C. The Safety Code does not say.

Are fire-crackers stuffed into a model rocket permissible in the NAR Safety Code?

- A. Yes
- B. No
- C. The Safety Code does not mention fire-crackers.

Extra Credit

What is the minimum length for the launch rod?

- A. 36 inches
- B. 48 inches
- C. The NAR safety code does not say.
- D. Long enough for the rocket to reach a speed sufficient for the fins to provide aerodynamic stability before the model leaves the launch rod. Typically this is around 35 to 40 miles per hour.
- E. Both C and D

Why should you always follow the NAR Safety Code?

- A. It minimizes the chances of accidents occurring, keeping you safer.
- B. By following the safety code, we demonstrate to government officials that we aren't terrorists, or out-of-control lunatics. They don't need to outlaw rocketry because it is done in a respectful and sane manner.
- C. It helps keep insurance rates down for both consumers and manufacturers. This in turn keeps the costs of motors down.
- D. All of the above.



## WEB SITES WORTH VISITING

This issue's website worth looking at is that of R. Baker, which can be found at: <http://astrocam.aea6.k12.ia.us>. It contains information on aerial photography from the aspect of both camera rockets and camera R/C planes. I want to focus in on the camera rockets in particular.

Begin by taking a trip back through memory lane as you take a look at the roots of the Astron

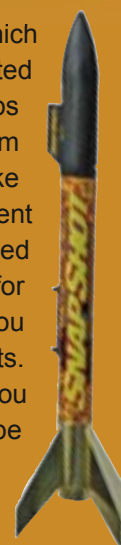


camera rocket called the "Camroc". In 1972, this rocket had a price tag of a whopping \$6.75! The camera unit was mounted atop the Astron Delta

rocket. Next came the "Astrocam". The design changed and the price, too. The film cover had a glitch with the way it was designed in that the cover would pop off quite often on landing. Also, the fins were always caught in

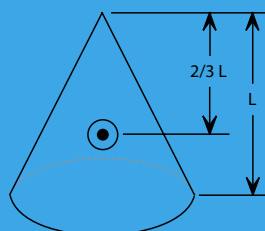


the blast of the rocket motor, which resulted in warped and melted sections of the fins. You will find tips here on how to combat this problem and others if you have one of these like I do. Last, but not least, is the current version is the "Snapshot", which changed slightly in the fin shape and cover design for the film. This is the one that we carry, which you may purchase at [http://www.apogeerockets.com/estes\\_snapshot.asp](http://www.apogeerockets.com/estes_snapshot.asp). In addition, you will see on this site that the camera may be mounted on the Estes Ionizer, Code Red, Tidal Wave, Gold Strike, and Maniac. Try one out; they're a blast!

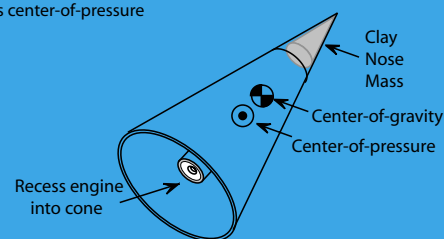


## DEFINING MOMENTS

Besides the relationship between the center-of-gravity (CG) and the center-of-pressure (CP), the shape of the rocket also plays a role in the stability. A **Cone-Stabilized Rocket** is a rocket which does not need fins to be stable for flight. If the rocket is generally cone-shaped, it may not need stabilizing fins at all. Cones have an inherent stability and the CP is located  $2/3$  of the way back from the tip toward the base of the cone. So if the CG is forward of this location, the rocket will be stable. For this to occur, move the CG forward. Add mass to the nose in front of the recovery device, and/or recess the engine into the base of the cone. You can learn about this and much more when you purchase "Model Rocket Design and Construction"! Buy now and as a special combo-deal, you can get the Rocksim software along with this book and save \$12.95 off of the regular price! See [http://www.apogeerockets.com/Rocksim\\_combo.asp](http://www.apogeerockets.com/Rocksim_combo.asp) for additional details!



The location of a cone's center-of-pressure



Finless rocket in the shape of a cone. Note that the CG must still be ahead of the CP for a stable flight

Cone Rocket Illustration from Model Rocket Design and Construction [www.apogeerockets.com](http://www.apogeerockets.com)

