Dallas Area Rocket Society (“DARS”)

James Gartrell
408 Driftwood St.
Rockwall, TX 75087

WWW.DARS.ORG

SHROUDLINES
A Dallas Area Rocket Society Production

SHROUDLINES

A Newsletter of the Dallas Area Rocket Society

DARS
NAR Section #308
Jul/Aug
2004

Volume 13, Issue 3

Dallas Area Rocket Society (“DARS”)

Member - National Association of Rocketry (“NAR”).

Special points of interest:

- One of the local TARC teams is raising money for their participation by selling custom made decals, fins, and centering rings. Check out the cover story, Rocketguts.com, for more details! Support your local TARC team!!
- Ever wonder why that altimeter-based ejection charge didn't work as planned? Dave Schultz condenses his 1st place NARAM R&D project for us. See the article beginning on page 2.
- Don Magness did a kit review of one of Art Applewhite's saucers. I was so impressed that he would provide a review of a competitor product, I gave you all a peek at his new Freebird kit. See the insert on page 6.

Inside this issue:

Rocketguts.com

By Robby Hardesty

Every year, thousands of students join together with high hopes and aspirations of success in the Team America Rocket Challenge (TARC), an annual rocket competition held in the Great Meadows, Virginia.

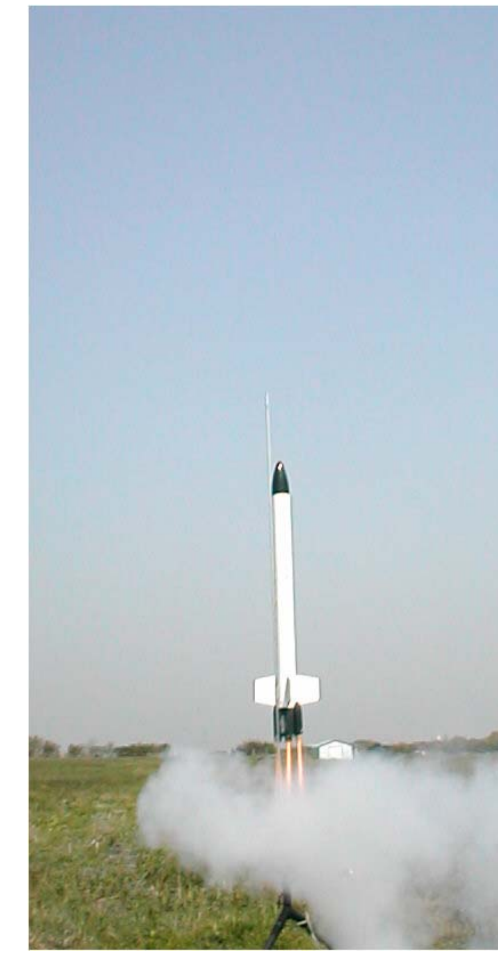
In previous years, objectives were set for teams to construct a dual-stage rocket that traveled to a precise altitude carrying a payload of two raw eggs. Teams competing in the 2004-2005 competition are to design a rocket vehicle carrying a payload for a precise duration of time; bonus points will be awarded for two stages or for two eggs, rather than the standard single stage or single egg.

Three teenage boys, Matthew Udomphol, Marvin Edwards, and Robby Hardesty, residents of Dallas, Texas, make up one of these many teams aiming for the hefty scholarships awarded to the top ten finishers, and a chance to learn more about the incredibly interesting world of rocketry.

Interest in the competition began when Matthew's 9th grade science teacher, Mike Krueger, mentioned that Greenhill School, where the boys attend, was looking for a science-related competition in the Upper School. Matthew instantly remembered about TARC, having seen a short broadcast about the competition a few years prior on CNN. In fact, he had already pushed to start a team in the middle school, but was soon discouraged after hearing about the incredible amount of money needed to fund a TARC team. After looking around for a teacher sponsor, he finally found Michelle Williams, Upper School chemistry teacher, and all of the components of a team began to fall into place.

Robby Hardesty and Marvin Edwards were quick to team up with Matthew and were ready to represent Greenhill School in the ‘04-’05 TARC competition.

In an attempt to provide funds, the three boys created Rocketguts.com, an online store providing custom centering rings, fins, and vinyl decals at very low prices. The idea of an online store came one day while the team was at Marvin's father's shop, Four Seasons Decorations (www.fsdonline.com). Marvin's father, George Edwards, had a CNC table router that the team was using to cut out centering rings for one of their first rockets. Amazed by the quality of the finished product that could not be achieved by a laser cutter, the boys decided to open up a store that could provide rocket builders everywhere an easy alternative to big businesses that seemingly ignore the individual customer, and offer to the public an easy way to purchase custom rings, fins, and vinyl decals. As a small, privately owned store, Rocketguts.com has the ability to value each customer as a very special individual; quality and customer service come first.



A TARC practice launch takes to the air. Photo by James Gartrell.

(Continued on page 5)

Improving Apogee Detection, Part 1

David Schultz, NAR 63255

A few years ago, Dave Schaefer sent me the altimeter data recorded during his level 3 certification flight. The data showed that the altimeter had fired both its apogee and main outputs after the rocket was on the ground and Dave was trying to determine the cause. This started me on a path where I learned a lot about how altimeters work, their limitations, and a better method of determining when apogee occurs.

The Problem

Figure 1 shows the flight data recorded by an RDAS for Dave Schaefer's level 3 certification flight. What really grabbed my attention was that the RDAS fired both of its main and apogee charges after the rocket had landed! This was caused by a combination of the recovery system configuration and a design flaw in the RDAS.

Figure 1, RDAS data from Dave Schaefer's Level III flight. Vertical red lines indicate RDAS flight events. (Editor's note: Since I don't know whether Neil will be able to print the newsletter in color, I've added a legend in the charts below to identify the red lines to which Dave refers).

The RDAS firmware had a built-in bias (in order to prevent early deployments), which typically resulted in late deployments. (Note: The RDAS firmware has been updated to remove this bias. New versions come with it and the new firmware can be installed by the user into older models.) After the recovery system of Dave's Nike-Smoke deployed, the nose (and altimeters) was in a "nose up" attitude. This should have resulted in zero acceleration being integrated but because of the system bias, a slight positive value was used. This continued until the rocket landed and the accelerometer was laying sideways, Then the integrated velocity decreased and when it reached zero, the apogee charge was fired followed closely by the main charge. This was not what Dave was expecting.

You can also tell from the spike in the acceleration just past apogee when the barometric RRC2 altimeter fired its charge. The RRC2 was also late by a couple of seconds.

Shortly after Dave's successful level III certification flight, I flew my new RDAS for the first time along with an AltAcc2. This flight was unusual in that the rocket developed a rather large pitch oscillation that actually affected the pressure data. (see Figure 2) Notice that both the AltAcc2 and RDAS were quite late

(Continued on page 3)

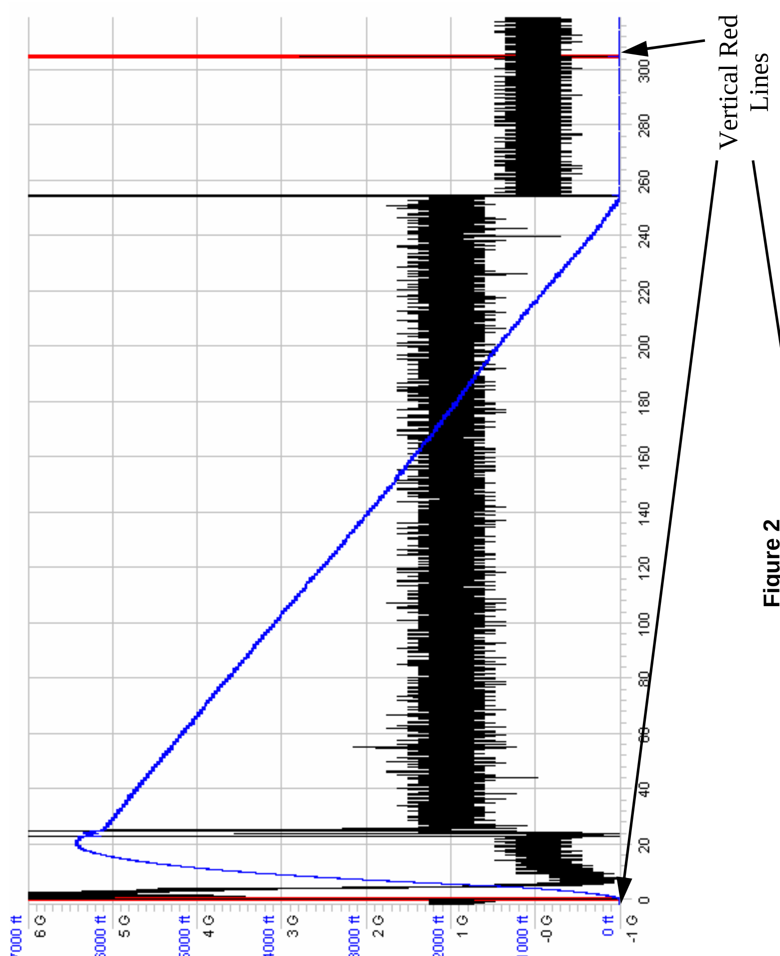


Figure 1

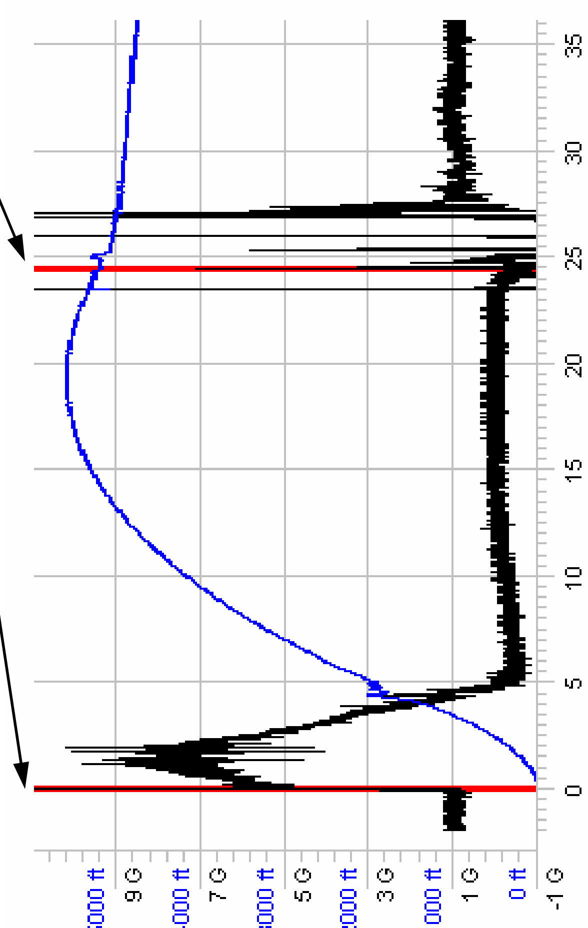


Figure 2

DARS OUTREACH SCHEDULE

DATE	EVENT	CONTACT
10/3, 1:30pm—?	Little Elm Rocket Roundup	George Sprague
10/9, 10am-5pm **10/10, 1pm-5pm**	NSS Exhibit at Love Field	George Sprague
10/23, 11am-2pm	Launch close to Erwin Park	George Sprague
10/30, 8:30am-3pm	Exhibit—Garland, Scout leadership show	George Sprague

DARS LAUNCH SCHEDULE

DATE	EVENT	CONTACT
9/25-26	McGregor Sport Launch—McGregor	Rags Fehrenbach
10/16-17	Shoot for the Stars Sport Launch—McGregor	Tony Huet
11/13-14	Turkey Shoot Sport Launch—Windom	Bob Wilson

MEETING INFO By James Gartrell

Our meetings for the rest of the year are scheduled on:

- October 2;
- November 6; and
- December 4.

Be sure to add these to your calendar, and especially the meeting on December 4 which is the date for election of officers for the next year. We are also planning a date and place for a Christmas dinner, which will be set at the October 2 meeting. Come by. We'd love to hear from you.

DARS

The Dallas Area Rocket Society is a non-profit chartered section of the National Association of Rocketry ("NAR"). Its purpose is to promote the hobby of consumer rocketry in the Dallas/Ft. Worth metropolitan area.

Membership in DARS is open to all interested persons. Membership in NAR is encouraged, but not required. Annual dues are $10.00 for individuals and $15.00 for families. The entire family, including children, are welcomed to the meetings.

The club meets on the first Saturday of each month at 1:00 p.m.

Meetings are held in Plano, TX at:

Plano Late Night Bingo
1805 Ave K (18th and K St.)
Plano, TX 75074

Exit off Hwy 75 to East Plano Parkway (just north of George Bush Turnpike—Hwy 190) and go east, turn left on K St., and turn right into the shopping center just north of 18th St.

Stay connected! All of us will reach greater heights with your attendance at the club meetings.

Kit Review—Art Applewhite 10” Delta Saucer

By Don Magness

Parts:
Top Shroud - 2 pieces of cardstock
Bottom Shroud - 1 piece of cardstock
Center - 1 piece of foam core
1 - 4” 38mm motor tube
8 - Drywall tape strips

Okay, I finally did it. I bought one of Art Applewhite's saucers. It's my Level 1 backup. I bought a PML Io and finished it, planning on certifying Level 1. Well, with all the rain we've been having, I had time to think about it. I really want to certify Level 1 soon, so why not have a backup. Voila! Enter Art's saucer. There's just something cool about certifying Level 1 with a saucer. Who knows, if I qualify with my Io, I may use the saucer for Level 2! I'll probably get some grief about certifying with a saucer. Anyway, if you haven't gotten one of Art's saucers, I highly recommend them. Here's how I built mine.

Assembly begins by cutting out the top and bottom shrouds. The top shroud comes in two pieces. I had a minor alignment issue here, aligning the center hole edges left the outer edge out of alignment by about 1/16”. There are two seams on the top shroud, so I had to trim the outer edge even in two places.

The instructions call for using Elmer’s glue to join the shroud seams. I substituted Aline’s Tacky Glue since it has less shrinkage than Elmer’s and is less likely to wrinkle the paper as it dries.

Once the shrouds are formed, it’s time to cut out the center section from the foam core. This is the most difficult part of the kit. Using a fresh X Acto knife blade is a must for this step. (Why do they call these things X Acto knives? In my hands, they’re more like Approximate-O knives.)

Cutting the inner and outer circles took 3 passes each. The first pass cut through the top paper layer. The second pass cut through the foam and the third pass cut through the bottom paper layer.

At this point, the outer edge of the foam core has to be cut to a 30 degree bevel. This just takes time and a little extra care. Any waviness in the edge can be smoothed out with sandpaper.

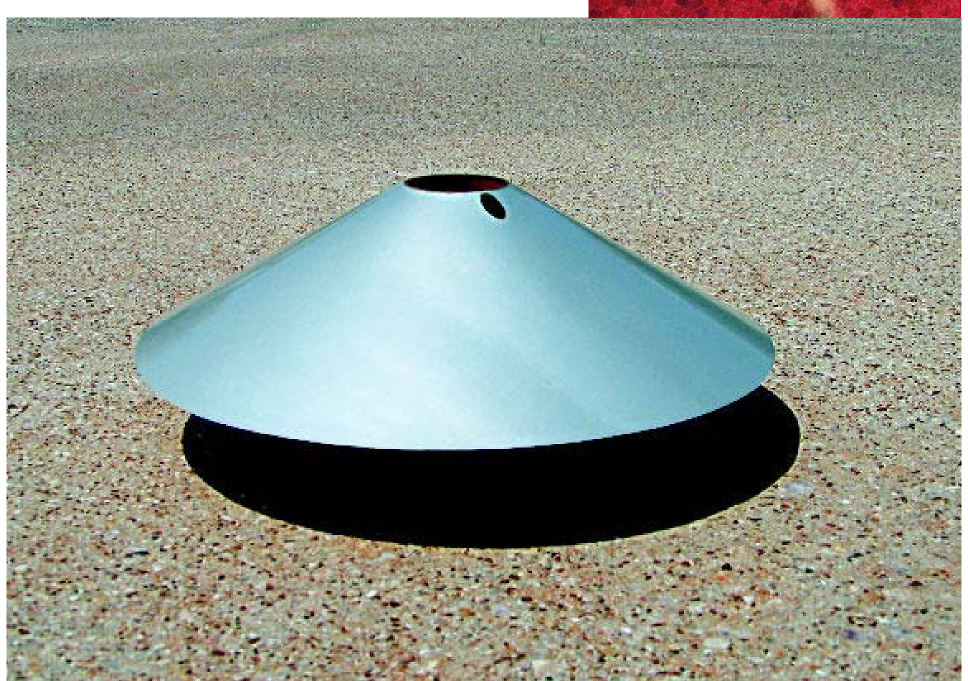
The motor mount is glued to the top shroud, I put the foam core temporarily in place to keep the motor tube aligned while the glue set.

After the motor tube has been installed, the 8 strips of drywall tape are placed on the inside surface of the top shroud in an overlapping pattern. The entire surface of the top shroud is then painted with slow setting epoxy. The foam center is put into place before the epoxy sets. I used a dowel to keep the launch rod holes in the top and center aligned.

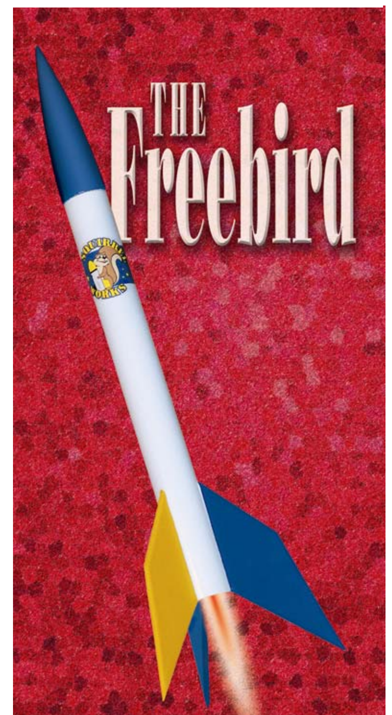
Once the epoxy has set, a glue fillet is run around the motor tube and the foam core. The last step is mounting the bottom shroud. Again, I used a dowel to keep the launch rod holes lined up.

The saucer can be coated with a clear enamel to protect the finish. This kit can easily be assembled in an evening. A big plus for this design is that it’s a great rocket to launch late in the day when you’re tired of those long recovery walks in the blazing Texas sun. I really enjoyed building this kit, I’ll be getting some Qubits soon.

Below: The finished saucer. Photo by Don Magness. (Editor’s note: Nice job, Don!!)



NOTE FROM THE EDITOR:
Since I get to beta test Don and Terri’s kits, I sometimes get the inside scoop about their latest kits. Check out the photo below of the newest addition to the fleet of kits offered by SquirrelWorks. It’s called The Freebird. The kit was designed in celebration of their 1-year anniversary selling kits. It is provided free (hence, the name) to customers who purchase two or more of their kits in October. Very cool!! If you haven’t visited their site lately, It’s worth the visit. www.squirrel-works.com



(Continued from page 2)

Figure 2. RDAS data from my flight. Acceleration spike at 23.5 seconds is from AltAcc apogee charge.

Two flights using three different altimeters that did not perform as well as expected. Two of the altimeters used only acceleration to determine apogee and one altimeter used only barometric pressure. Just what was going on?

To get an idea of what the problems are requires an understanding of just how altimeters detect apogee. The barometric and acceleration altimeters behave in two distinctly different ways.

Barometric Apogee Detection

Barometric altimeters measure air pressure and since air pressure decreases with altitude, this is actually a measure of the rockets altitude. The basic technique to detect apogee is to look for an increase in pressure that would normally indicate that the rocket was descending. However, that is not always the case.

When a rocket exceeds the speed of sound, a shock wave is formed at the leading edges of the rocket. This shock wave causes the pressure field on the rockets body to change and because the altimeter vent ports are located on the body, the pressure sensor sees these changes too. The most popular way of handling this is through the Mach inhibit timer. This is a programmable timer that inhibits operation of the apogee detect software until a set length of time after liftoff. This relies on the flyer understanding the performance of his rocket and programming the correct time, which doesn’t always happen.

Detection of apogee with a pressure sensor requires some compromise. On the one hand you want the apogee event to occur as close to apogee as possible. On the other hand you do not want to fire the deployment charges too early. If you wait for a large enough decrease in altitude so that it is obviously not noise or something else, you will wait until several seconds past apogee. The reason for this is that the altimeter has to convert the pressure reading to a digital number.

An Analog to Digital Converter (ADC) changes the continuous analog voltage output by the pressure sensor into a discrete number that the micro-controller in the altimeter can use. The ADC’s resolution is measured by the number of bits in the resulting number. 8 bit ADC’s can measure 256 distinct voltage levels and 10 bit ADC’s can measure 1024 levels. (These are the most common ADC’s used by altimeters.) This translates into approximately 100’ (8 bit) and 20’ (10 bit) altitude resolution at low altitudes. (Because the relationship between pressure and altitude is non-linear, this resolution gets worse as altitude increases.) Figure 3 shows what the pressure data from the RDAS (10 bit ADC) looks like near apogee.

Figure 3. RDAS barometric data at apogee.

Figure 3 shows that picking the time of apogee is not easy because the sensor has a fair amount of random noise that complicates things. Getting a sample that is below the peak sample previously recorded is obviously not going to work because this happens all of the time. Even using two counts below the peak is not going to work well as shown by the data just past 18 seconds. Using a criteria of 3 counts below peak would result in deploying at 21.5 seconds which is about 2 seconds past apogee.

If you were using an 8 bit ADC and had filtered the pressure signal so it had very little noise, (see Figure 4.) you would have to wait until you measured a value that was 1 bit lower in altitude than the peak. That translates into about 100’. Since the rocket is traveling slow enough at apogee that drag forces are typically negligible, the only force acting on the rocket is gravity, which is 32 ft/sec/sec. It is fairly easy to work out that at 1G, it takes sqrt(2 * 100ft/ 32.2 ft/sec/sec) = 2.5 seconds to drop 100 ft. from apogee at which time the rocket has a downward velocity of 80ft/sec.

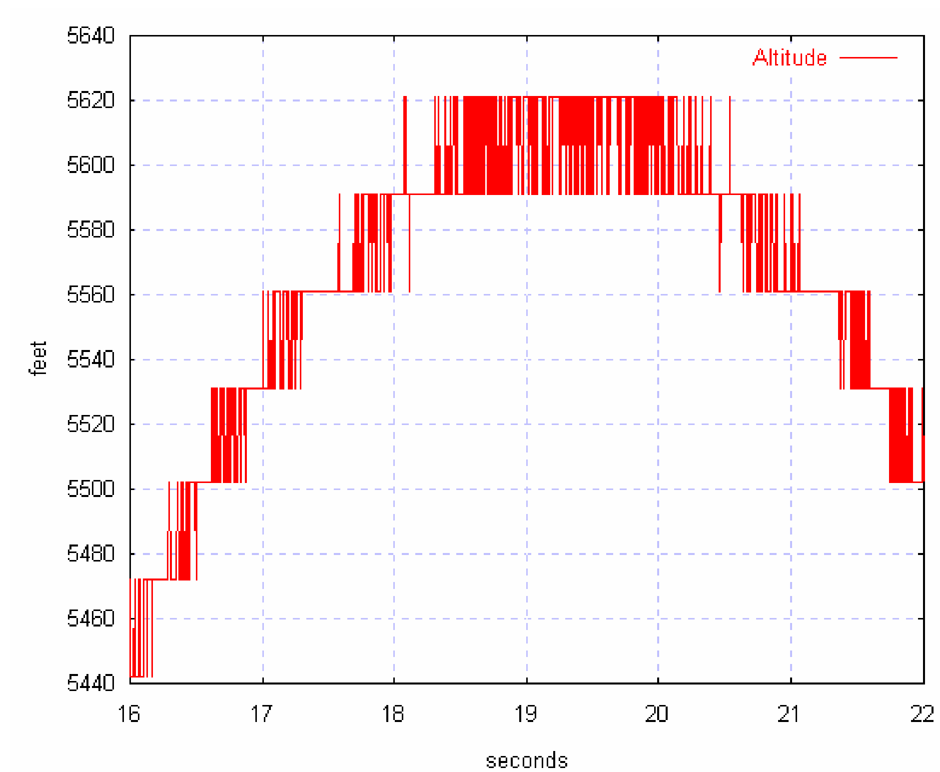
It is possible to significantly improve this by using a digital filter to remove the noise (and also increase the resolution). But deployment will always be somewhat past apogee and transonic effects must still be worked around.

Barometric altimeters have three basic limitations:

1) Do not detect apogee until after it has happened.
2) Must include a Mach inhibit timer or some other work around for transonic effects.
3) Altitude is limited by measurement

(Continued on page 4)

Figure 3



(Continued from page 3)
range of sensor.

Integrating Accelerometer Apogee Detection

Acceleration based altimeters use a single accelerometer to measure the acceleration on the rockets longest axis. It then integrates this reading to derive velocity. The errors in the acceleration reading fall into two categories, random and bias.

Random errors are mostly caused by the inherent sensor noise and average out to zero over time and therefore will cause no problems for the integration. They are a potential problem for determining the 1G offset but are also an opportunity.

Bias errors are those errors that do not average to zero over time. Sources for these errors are: 1G offset error, sensor misalignment to vehicle, and non-vertical flight.

The altimeter integrates the acceleration by measuring the current acceleration, subtracting the value for gravity, and then adding the result to the running sum. So at each sample, the value of (At - G0) is added. (At is the current measurement and G0 is the acceleration due to gravity.) Because the acceleration due to gravity is used in every sample, it is pretty obvious that we need an accurate value for this.

The acceleration due to gravity is determined by the altimeter just prior to launch.. Because the value output by the accelerometer changes with temperature and age, this 1G offset must be determined just prior to launch. It must also be determined with very high accuracy.

If there is an error of 1/10 of 1G in the value integrated it can result in large errors in the time of apogee. In a hypothetical flight with a 5 second motor burn and 15 second coast with a 1/10 G error, the integrated velocity will be off by 64ft/sec at apogee. Therefore apogee deployment will be two seconds early or late depending on if the error was positive or negative. A typical altimeter that uses an accelerometer with a range of +/-50G with a 10 bit ADC will have a resolution of 1/10 G. (Note: Setting the launch rod/rail to an angle other than vertical also introduces error. The maximum error is about 5% at the maximum allowed angle of 20 degrees.)

A 10 bit ADC is going to have an average error of 1/2 bit (assuming a perfect ADC) in all of its readings. So it looks like we have to live with a +/- 1 second error in apogee time. However, because the sensor has random noise in its output, it is possible to improve the resolution beyond that provided by the ADC.

Since the sensor outputs a signal that has zero mean random noise, if we average a large number of samples, we will get the correct value. If we store the reading from our 10 bit ADC in more than 10 bits and use the extra bits to represent the fraction, we can improve the resolution and accuracy of the 1G offset value to the point where it will not be a problem. For example, adding 16 samples together and then taking the average (dividing by 16) results in adding 4 more bits of resolution. If we use sample sizes that are powers of 2, we don't even have to do the division. We just need to remember which bits are the integer portion and which are the fractional portion and be sure we line them up before adding and subtracting.

Bias errors cannot be corrected and will accumulate since there is nothing to correct them. The main error is from treating two vectors (magnitude and direction) as scalers (magnitude only). See figure 4 for a graphical depiction of this.

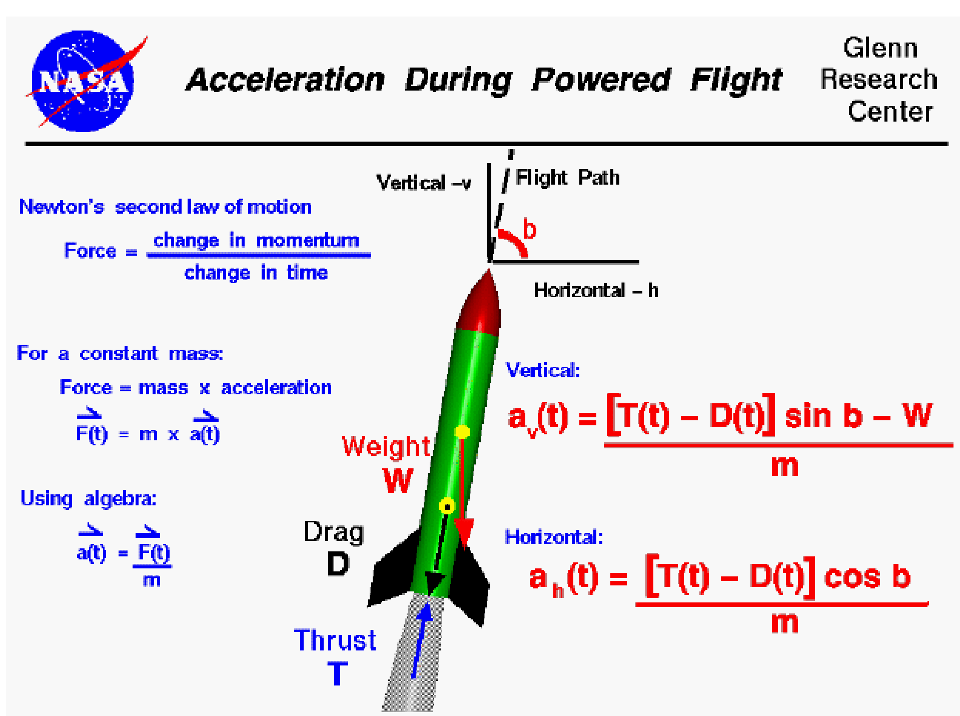
Figure 4. From http://www.grc.nasa.gov/WWW/K-12/airplane/rktapow.html

There are two ways of thinking about what an integrating accelerometer is doing: determining vertical velocity or the rockets longitudinal velocity. Because apogee occurs when the rocket is at its maximum altitude (vertical velocity is zero) lets consider the vertical velocity viewpoint first.

Gravity always acts in the same direction (down) but the measured acceleration could be in any direction. Because there is no way (without adding more sensors) to determine the direction the rocket is pointed, both are assumed to be acting in the same direction.

If the rocket is not flying in a vertical direction, not all of the motors thrust goes into increasing the vertical velocity. Therefore the integrated velocity ends up being larger than it should be which will result in a late deployment. Not all of the drag is acting in the vertical direction so now the velocity is decreased more than it should be resulting in early deployment. It might seem that these two effects would cancel out but they do not.

Figure 4



They would cancel only if by great good luck, the magnitude and duration of the two errors were identical. The boost phase error depends on the thrust curve of the motor and flight path. The coast phase error depends on flight path and drag. Fortunately on most flights the difference between the rockets direction of flight and vertical is pretty small. The difference increases as the rocket approaches apogee and "arcs over" but drag is pretty small at this point so the contributed error is also small.

If we can't get deployment at apogee, can we at least get deployment when the rockets forward velocity is at a minimum? This takes us to the other viewpoint. Now thrust and drag are acting in the direction we want and gravity is the problem. We are still subtracting gravity as though it is acting in the same direction as thrust and drag. But unless the rockets flight is exactly vertical, this is not the case. Part of the effect of gravity will be acting to pull the rocket to one side. Thus the value we are subtracting from the running sum is always larger than it should be. Which results in deployment before the rockets velocity has reached a minimum.

If the rockets flight angle is far enough from vertical so that apogee is reached prior to deployment, things get worse. Not only is the magnitude of the value we are using for gravity wrong, it is now acting to speed the rocket up instead of slow it down.

An accelerometer-based altimeter will only provide a deployment event at apogee (or minimum rocket velocity if you prefer) by luck. But transonic pressure problems don't affect it. Barometric altimeters can get close to apogee (but will always be a bit late) but have problems with transonic flights and cannot work beyond a certain altitude. (Because of limitations in the pressure sensor.)

What if there was a way to combine the best features of each type of sensor?

Next time: The Kalman filter

(Continued from page 1)

The team has already received a few orders, spanning from four small rings, to 120 fins, to a few vinyl letters. They can complete any task, small or large, and in the process, make their customers happy, evident by the multitude of positive feedback received by the small company.

Tom Priest, owner of Rockethead Rockets (www.rocketheadrockets.com), wrote, "Just received my BT 80 with a 3 18mm cluster. All I can say is WOW!!!! They fit the tube perfect and the cluster is also perfect. We are looking at using these in a kit. We are also looking at using them for some of our fins. They are great on prices and the service is great. I am going to send some samples of the fins that I had cut by another vender (not from here) and see what they can do. The price is a quite a bit lower than I am paying right now. If you need centering rings or fins this is the place to get them."

Another happy customer, Pete Simka, wrote, "Great ring cutter! I only had one other ring cutter in mind and he blew me off over and over again. These guys cut 'em fast and mail 'em fast! The rings fit my tubes precisely. I can't wait to build!!! Price was right too. No problems shipping or paying and I'll gladly do business with them again! Great job and great asset to ROL AUCTIONS!!!"

Jason Toft (NAR# 82997), very satisfied with his order, wrote to Rocketguts, saying, "I recently received my custom 1/2" 9 ply centering rings from Rocket Guts. They are TOP NOTCH! I highly recommend that you get your parts from them. They can do anything you need them to, and in a hurry! Kudos to Rocket Guts!" To read even more feedback from satisfied customers, simply click on the "Customer Feedback" on their website.

If you are interested in helping the team's fundraising efforts by ordering centering rings, fins, or vinyl decals, the store can be reached at rocketguts@aol.com. Team members are normally able to respond to e-mails within a few hours. During the summer, they are able to ship the custom goods in about 3 days; meanwhile during the school year they will only be able to cut orders with a minimum of $25 value, and can ship goods only on the weekends. Everything cut on the CNC router table has a tolerance of .001"; almost any material beside thick metal can be cut, including Lexan, birch plywood, and more. Centering ring orders are required to have all specifications to within .001". Fin orders are preferred to have scale drawings and can be sent to them via regular mail. Vinyl orders only require a true type font, which the team can download, and a given height for the letters. Rocketguts.com stocks over 30 different colors. All orders are priced on material cost, time, and quantity.

Matthew and Robby stopped by the meeting to display their products. George Sprague holds up one big centering ring for the photo, as Terri Magness chats with Matthew. The decals and parts are high quality. If you need that custom decal or part made, give them a chance. I think you'll be well pleased, and you'll be supporting a really good cause. Photo by James Gartrell.