2014 Regional Competition Final Report

Thunder Rocketry Team

Fond du Lac Tribal and Community College

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Rocket “Wing and a Prayer”

May 12, 2014

This was our team's first designed-from-scratch high power rocket. The original plan was to create a 6-inch diameter rocket with pods attached to its sides that would fire rear-ejection drogue chutes to act as air brakes to bring it to a stop at an apogee of 3000 feet.

But as Rocksim designing proceeded it was clear that the weight of the rocket with the pods was too great for it to get to 3000 feet on the K530 motor we were planning to use. Also, the design was threatening to be of questionable stability. We therefore abandoned the pod idea completely and built the rocket in time to launch it in Milwaukee during the First Nations Tribal Competition in a single-deploy configuration.

Rocksim was predicting an apogee of about 3300 feet on a K530, but on launch day it turned out another team asked to use the K530 motor we had selected, and we were offered a K400 motor that was ready to go. We had made so many last minute changes that we figured it would be OK to try even though our simulations predicted a higher apogee of about 3800 feet.

In an amazing stroke of luck, the actual flight reached 3027 feet, with 1% of our 3000 foot target altitude. So, going on the "if it works, don't fix it" principle, we left the design pretty much alone but added modifications to turn it into a dual deploy rocket for the Regional launch in North Branch.

Gordon painted the rocket and replaced the shock cords with his favorite "550 cord" and invented a way to hook up the chutes so that the nose and fin can would separate at apogee to release the drogue chute, and then at 600 feet the main chute would deploy when an explosive bolt released a short holding line and the longer shock cord would pull the chute out of a deployment bag in the fin can.

We mounted a Pitot tube at the tip of the nose cone and placed the data logger inside the nose cone. It was programmed to take speed readings 20 times a second after an 1800 second delay, figuring it would take at least that long to assemble the rocket after sealing things inside the nose.

Gordon says preparation on launch day went smoothly. Both the Adept altimeter that was connected to the ejection charges and the Raven competition altimeter beeped out their ready codes and the launch was nice and vertical. However, at apogee the first ejection charge did not fire. The rocket arced over and nosed down until the motor ejection charge fired at about 1500 feet altitude.

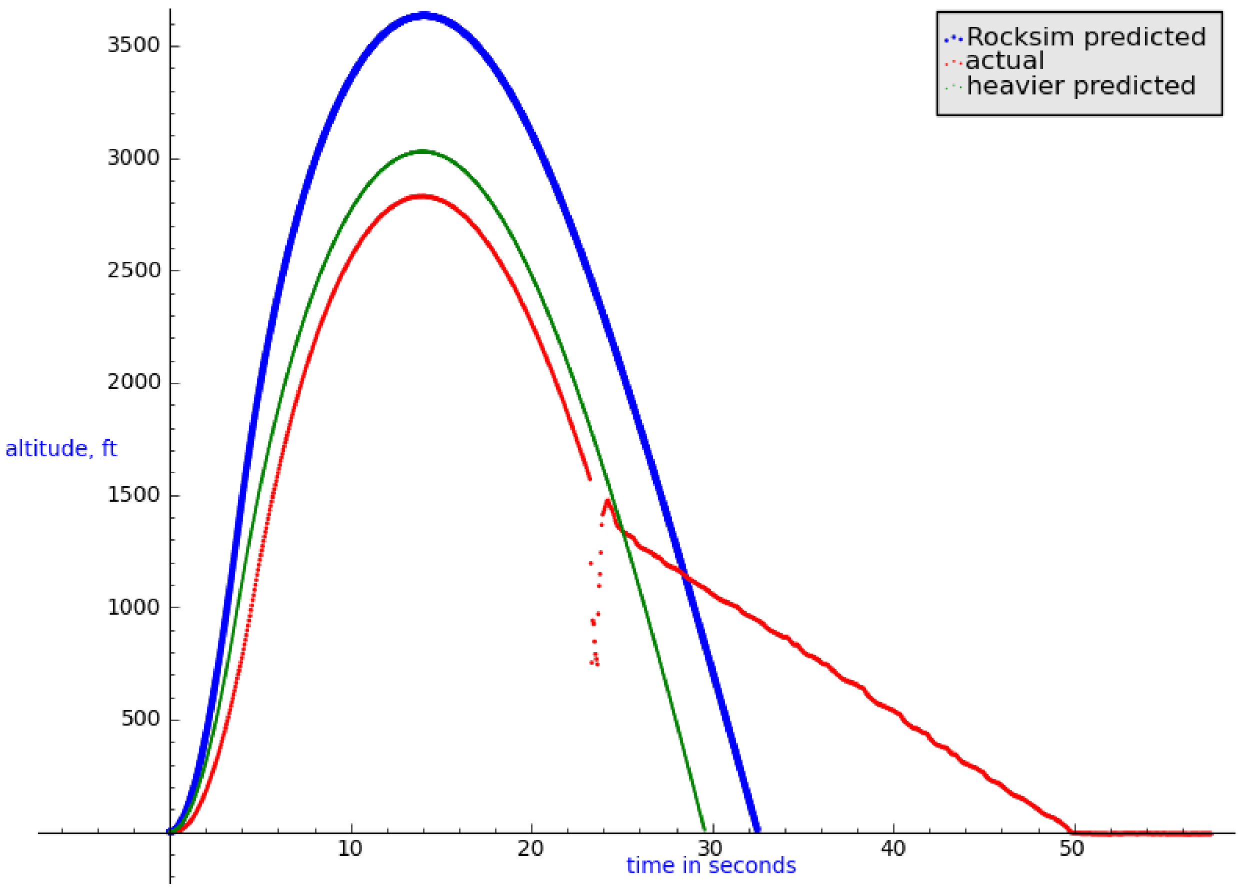
The nose cone separated cleanly, but the speed of the rocket at separation made for a very violent jerk that made the 550 cord break (or perhaps it got cut on some sharp edge) and the drogue chute detached completely and fell to the ground all by itself. The explosive bolt also was not able to handle the load and it tore in half at the same time instead of holding things together till 600 feet was reached.

The main chute was released at the same time as the drogue, and it got tangled in the harness for the 7g apogee ejection charge. This was *good* thing, though, as this was the only reason the nose and the fin can stayed tied together after the other chute got cut away. As a result the rocket descended at about 53 ft/s and landed pretty hard, burying itself in some mud and damaging one fin a bit.

Apogee reached was 2828 feet. We are pleased with that. Perhaps the added weight of the paint job contributed to lowering things from what we did in Milwaukee, or random variation in motors or atmospheric conditions could explain the difference.

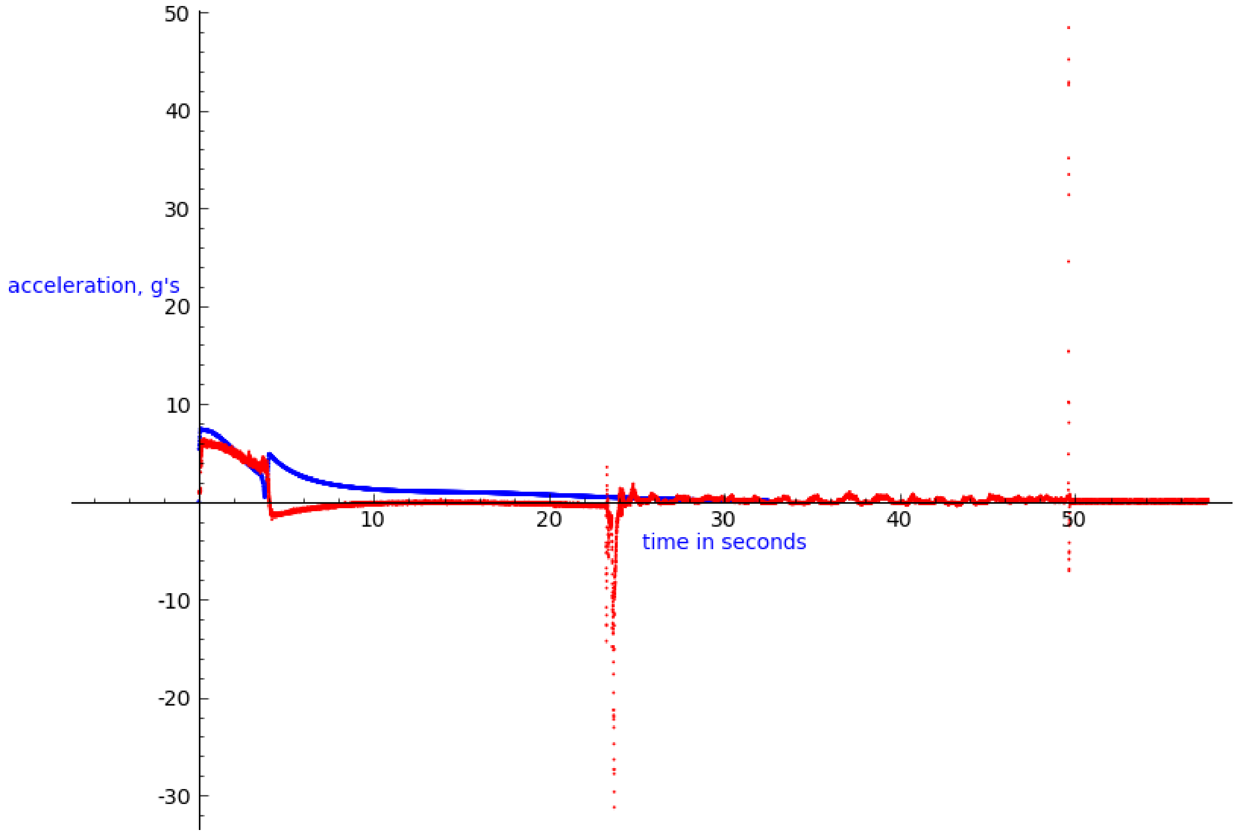
Altitude vs. time

Here is a graph of our original Rocksim prediction of the altitude (thick blue) and the Raven altitude based on pressure data (red).



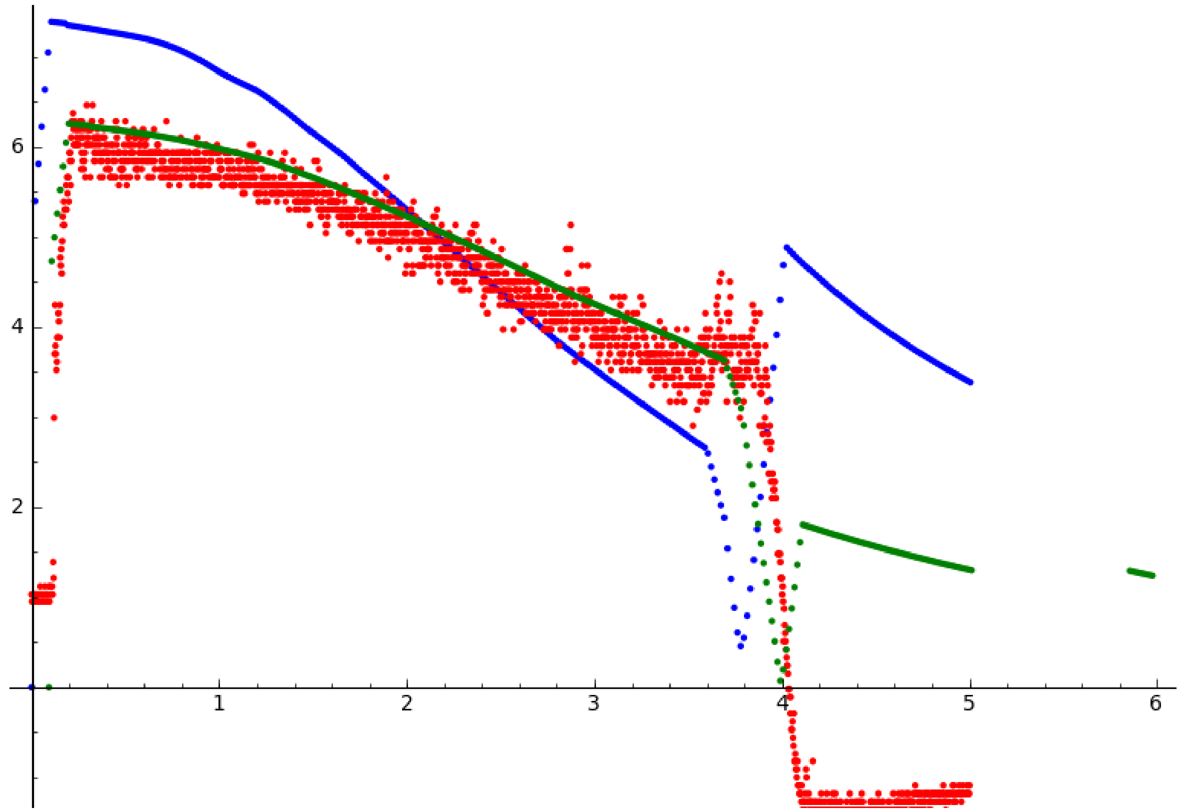
The actual altitude is lower than predicted mainly because the masses of the rocket components were not accurate in our Rocksim model. Gordon says the actual rocket on the pad weighed a little over 17 pounds (272 oz), but our simulation only had a mass of 205 oz. Steve adjusted the mass of the body tube up about 70 ozs and redid the simulation for the heavier model (green curve). This comes much closer to the actual flight performance.

Acceleration also shows much better agreement with the heavier model:



Austin was very impressed with the big spikes at chute deployment and impact with the ground. He and Steve are still debating whether the numerical values of those spikes are completely "real" or glitchy and not quite to be trusted.

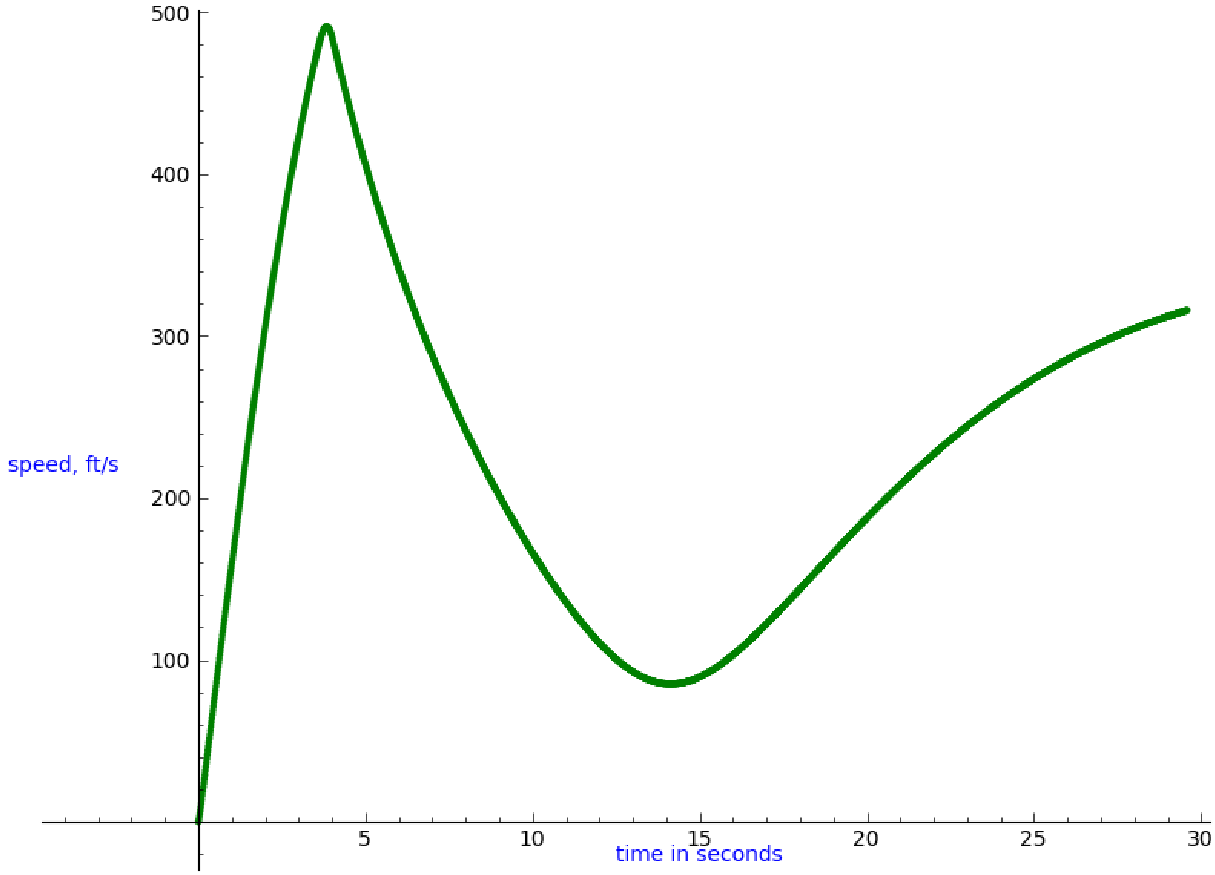
Looking at the first five seconds of data to see the motor firing shows how using a simulation of a more accurate mass gives much better agreement with reality:



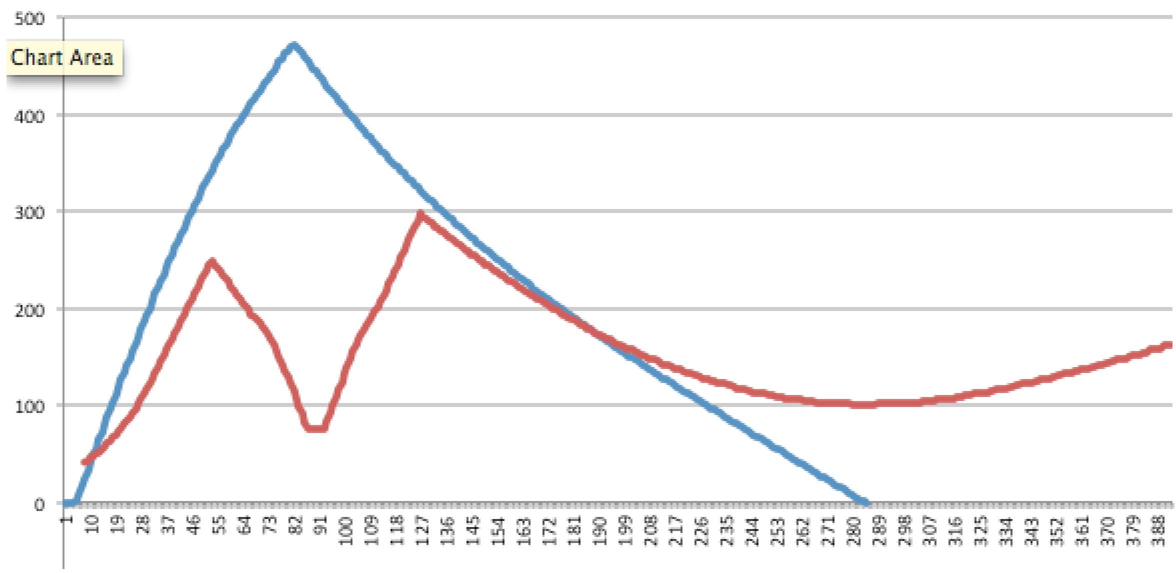
Here the blue line is the original (inaccurate) simulation, the green line is the heavier model simulation and the noisier red data is from the Raven accelerometer. Steve is puzzled as to why the real data goes to negative g's after burnout while the simulations have discontinuities and positive g's afterward.

Here's the "heavier" model prediction of speed vs. time. Velocity increases till motor burnout, and then falls as apogee is reached, but does not go to zero because there is horizontal motion still occurring at apogee at around 15 seconds.

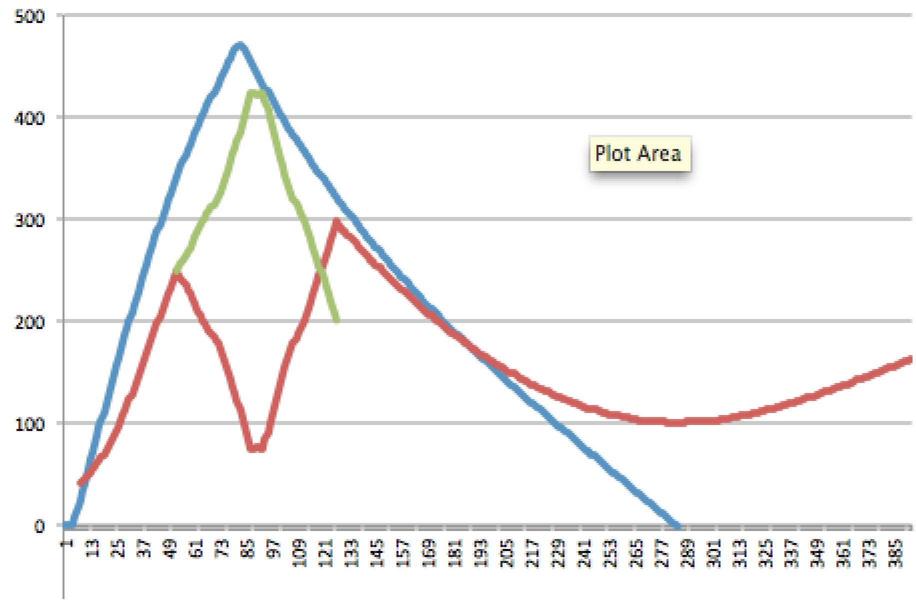
[Steve fought with SAGEmath's plotting routines for way too long trying to get the Pitot tube speed data and the Raven speed data integrated from the acceleration to superimpose on this graph, but some weird "EOF encountered during parsing" error kept cropping up … sigh.]



Here's an Excel chart of the Pitot tube speed data (red) vs. the Raven speed data (blue). Both are in ft/s.



The team has tried to come up with some sort of intelligent idea as to the downward "V" in the Pitot data. It almost looks as if you could flip it upright and get things to fit—



But that’s just weird black magic. None of us can figure out what this means. Austin thought the sensor may have “maxed out” somehow, but Steve thinks we should have seen a flat line then.

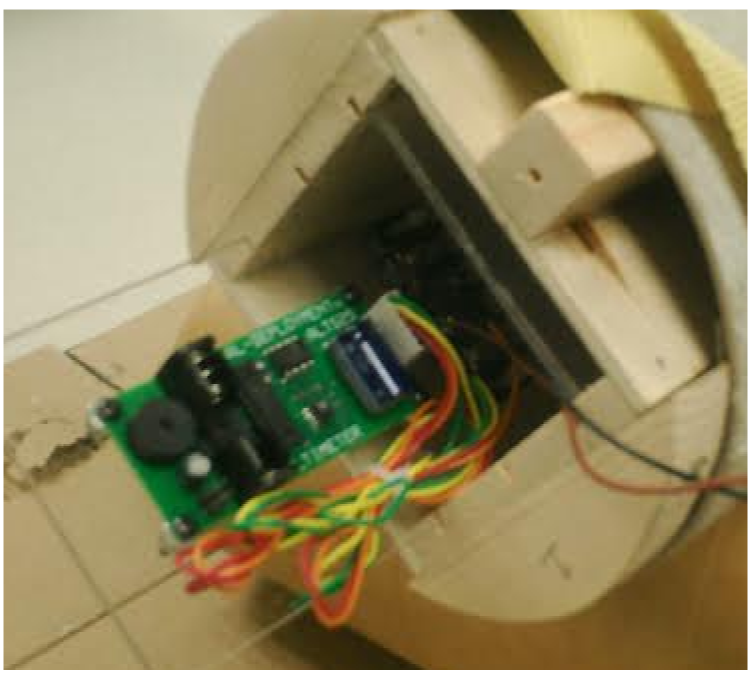
One possible source of trouble was the way we mounted the Pitot tube in the tip of the nose. We had to leave the silicone tubes from the actual Pitot tube to the pressure sensor hanging loosely inside the nose cone. Surely these got moved around and stretched (maybe kinked, too?) during launch. It does look like the “V” makes its turnaround to going back upright just when the motor burned out near 4s. That would seem to be a point in time where the tubes would spring back from being stretched during acceleration. But what triggered the first downward move of the “V”?

Why the readings vary in a more or less gradual manner instead of a sudden change is a puzzle. We plan to do a test by taking the nose cone with the Pitot sensor in it out for a drive on the freeway while tied to a car and see if we can make it do something similar.

The Pitot data is very clean on both sides of apogee, though. It even bottoms out at about 100 ft/s just like the green simulation data. That seems surprising. Doesn’t Rocksim just make a more or less random guess at horizontal motion in its simulations? Why would there be a reason for the horizontal speed at apogee to come out the same?

Design issues

The best part of our rocket design was definitely the electronics box that Gordon invented. The idea was to have an enclosure with openings along the sides that would permit the motor ejection charge gases to blow by it to deploy the drogue chute. In Milwaukee we originally set our 7g charge below the electronics box, but there was concern that it would blow the whole box out the body tube. We changed that plan after Steve asked whether the idea was dumb, and Frank quickly said, “Yeah, that’s dumb.” But the box did survive the motor ejection charge with no problem.



There’s enough space to slide in three boards with components mounted to them, so we have room for expansion. We will stick with this design.

Ejection charges

Both homemade ejection charges failed to fire. Steve made a 7g (approximately) charge for the apogee chute by filling 5.5 cm of a1/2 inch cpvc tube with black powder and JB Welding an ordinary model rocket igniter from Hobby Lobby in one end. He tested similar (smaller) charges using a 9V battery placed directly across the leads and they worked fine in his basement.

Maybe the 12V battery in the Adept altimeter couldn't provide the current needed? We are not sure. Another theory was that perhaps the igniter leads got shorted together? Steve tried to be careful to avoid this, but we should have tested the resistance before using the device. Maybe we can design a simple circuit that would light an LED in our electronics package when things are OK for future use.

Gordon at first thought he may have hooked up the charges "backwards," but after recovering the rocket and safe-ing the sytem he found things were wired up correctly. Again, some way of visually verifying when the setup is as it should be would be a good idea. Either that or use connectors that are simply impossible to connect any way except the correct way.

Steve found an Apogee newsletter online with a design for an explosive bolt made from a toilet seat bolt that is drilled out and filled with black powder and Gordon invented a neat way to use this to release a line that would pull the main chute out of a deployment bag at 600 ft altitude. The idea was that the intact bolt would hold the nose cone and fin can together and when the charge fired and the bolt split in half, the 2nd chute would be pulled free.

Steve made a few bolts and test fired one bolt but instead of splitting, it just blew the epoxy plug out of the end. So for the one Gordon used on the rocket he weakened it more but thinning the walls of the bolt. This made it too weak to take the jolt of the nose cone tugging on it after ejection, and it just broke in half right away.

This idea needs more work.

Cheap fins

Steve tried making the fins out of cheap $10 Home Depot 1/4 inch plywood with one side reinforced with Bondo and fiberglass mat. Gordon coated the fins with epoxy as well, hoping to strengthen them even more. That wasn't enough to survive either of our two landings without damage. Still, the cracked fins were easy to repair.

We had explored the idea of having a local plastics company make fins out of polycarbonate for us but they had a rather long list of jobs in line ahead of us and we were in too much of a hurry to do things the “right way.” Sigh. This lesson has been experienced more than once...

Conclusion

The team did more work and started earlier on design issues this year than any other. We are quite happy with our results. Gordon, Robert and Austin had a great time at the launch and came back fired up to do more right away.

During the summer we hope to make it to some of the Tripoli MN club launches and fly “Wing and a Prayer” again and iron out the bugs.

—for the Thunder Rocketry team,

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