Flying 1/2A Altitude

Thoughts, Ideas, Strategy, and a Plan!

by Dan Wolf

Note: This article and plan originally appeared in the March/April 2021 issue of Sport Rocketry magazine. Since then, the FlightSketch Comp altimeter was NAR Contest Approved. If using the Comp instead of the ALT-BMP altimeter, the fins need to bigger or nose weight added as the Comp weighs 1 gram less than the ALT-BMP and the rocket may not be stable (based on experience at NARAM-62, but 2nd flight took 1st in Team Division with 242 meters.

1/2A Altitude is one of the NRC (National Rocketry Competition) events for NARAM 62. It is one of the seemingly simplest events to fly. Any 13mm rocket will work. Except it has to hold an altimeter, and for it be competitive you probably need to use a piston, and the boost needs to be straight, and the recovery system has to deploy or at least it has to come down safe, and you have to find it, and you have to bring it back or at least the part with the altimeter, and the altimeter has to read out properly, and with the only good motor for the event being the Estes 1/2A3-4T, the ejection delay is too, and, and, and. Suddenly this simple event has a lot of things to be considered before just shoving a 1/2A3-4t in your Estes Bandito and launching it. To win this event you need to think about things like surface finish, weight, what altimeter to use, how to hold the altimeter in your rocket, etc.

I work with a group of 5 A divisioners and we meet monthly (until the virus hit). I came up with what I thought would be a competitive design and had them build it. It was a 7" 13mm body tube with 15 mil G10 fiberglass fins (fin material from ASP Rocketry). The "cool" part was a nose cone design that holds the Adrel ALT-BMP altimeter. See figures 1 and 2 for how that works. It uses an Apogee Rockets 13mm styrene nose cone. The shoulder part of the cone is replaced with a 1" length of Balsa Machining Service C5 coupler tubing that is glued into the nose cone. Three holes are punched in the bottom of the coupler. These align with vent holes placed in the body tube. The shock cord is attached to one of the holes.

I was pretty pleased with this arrangement in that there was not both a nose cone joint and an altimeter bay joint. Also with the ALT-BMP, from the outside it is just a simple "3 fins and a nose cone" 13mm rocket (no larger tubes). But then came test flying. On the day I tested it I had a friendly challenge with fellow WOOSH member Tom Disch that I could beat him in 1/2A Altitude. His model used a MicroPeak and the body tube of the altimeter section was bent to fit the Micropeak. Surely my "superior" design could beat that. I was in for a disappointment. Tom's entry flew to 171 meters and mine only managed 164 meters on my BMS tube model. I also had a polished Blackshaft tube version. Maybe it would fly higher. We'll never know because I forgot to reset my ALT-BMP before that flight. So Tom won the challenge but he was not happy with his altitude either. Looking at the National Scoreboard, there were already 5 higher flights, 4 in C and one in D division. Two were over 220 meters!

During the pandemic, WOOSH has been having Wednesday night zoom meetings about NAR competition. After that launch, we had a lively Wednesday discussion (along with a great demonstration of Rocksim given by Tom). It was clear that the basic problem with my original design was that it was way too heavy and draggy. The simulations showed that even with the settings at "polished finish", you would not break 200 meters with a rocket that weighed 14 to 16 grams (full up launch ready). Once the mass was reduced to 12 grams or less, it appeared to be viable. Of course the X factor is how much extra altitude you can get from your piston that the simulation doesn't show. I had thought a good piston could result in a higher flight than Rocksim predicts by as much as 30%. But both mine and Tom's piston flown rockets didn't go much higher than the simulations. After that meeting, my "Operation 200 meters" began. I was determined to join National Scoreboard leaders Steve Krystal and Glenn Feveryear in the "200 meter high club".

My original design is the white rocket in figure 3. A 7" 13mm body tube and 15 mil thick G10 elliptical fins. Root chord of the fins was 1" and the span 1.25". Open Rocket showed a stability margin of 2 calibers. Way over stable. The reason is I had started from an A Altitude plan with no altimeter that I placed with at NARAM 45. Since this rocket is for 1/2A and has the Adrel

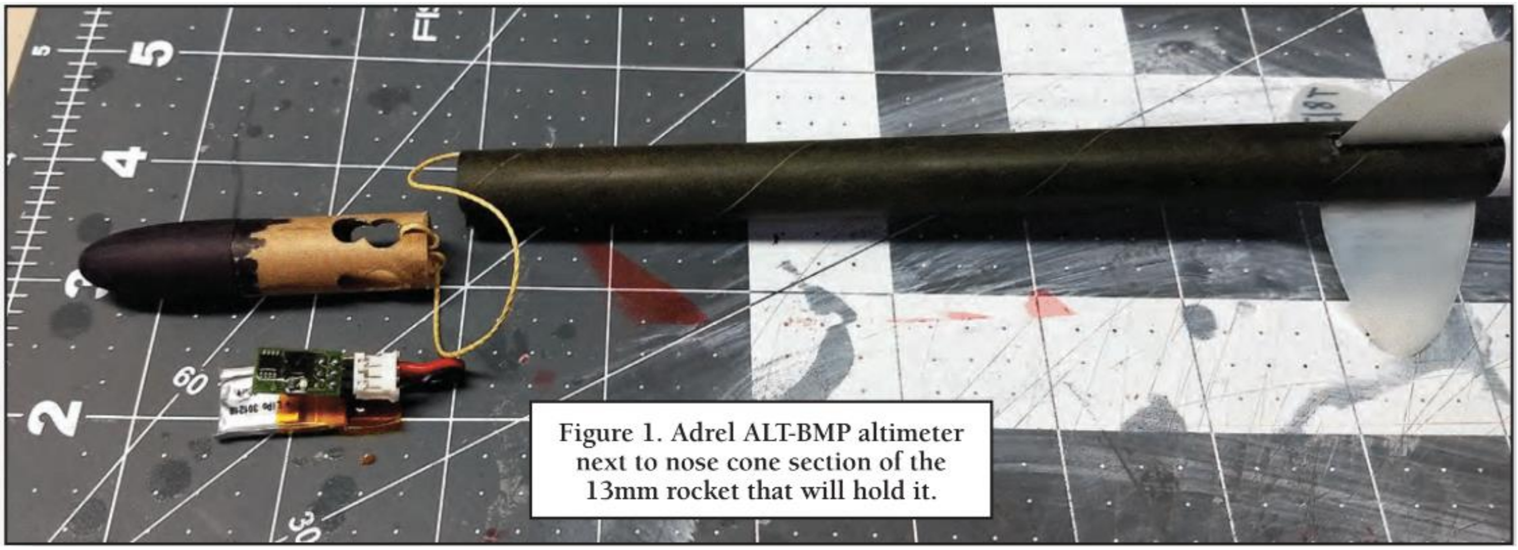


Figure 1. Adrel ALT-BMP altimeter next to nose cone section of the 13mm rocket that will hold it.

altimeter in the nose, it is over stable. Open Rocket reported an altitude of 165 meters. Very close to my actual flight. I was expecting 20% to 30% more since I was using a piston. That would have put the flight in the 200 meter range. A simulation showed that ejection actually occurs *before* apogee but Open Rocket doesn't stop the ballistic flight path. So perhaps my piston did help a little. It is also likely that the ejection occurred earlier than the simulation shows. The simulation assumes the full 4 seconds delay for the 1/2A3-4T. Estes delays usually run short. NAR S&T data shows the actual delay of the motors tested was only 3 seconds. With the motor burn turn time that means ejection occurs at around 3.4 seconds in flight and per the simulation, the rocket would be at an altitude of 145 meters. So, assuming the simulation has an accurate model of my rocket, there is a piston benefit of around 13% (also assuming not much altitude increase after ejection). Of course the simulation may be more optimistic about the drag on my rocket. I selected "polished" finish (least drag) in the sim. Switching to "smooth paint" from polished lowered the altitude by 4 meters to 161m. With the early delay, I felt this was in the ballpark (+/- 10%) of a simulation that matched my flight.

The first improvement I thought of trying was simply to shorten the body tube. That is the black rocket in figure 3. After numerous iterations of "what ifs" I settled in on a 5.5" length body tube. Stability dropped to 1.3 caliber and the mass dropped from 14.1 to 13.5. That simple change resulted in an increase of 10 meters in simulation altitude to 171m. Still not close. For the next step I made the fins as small as possible and still have 1 caliber of stability. Changing the fins to 2cm elliptical brought the mass in the simulation down to 12.8 grams and the altitude to 188m. Better, but still not 200m and with the too short of delay, I was unlikely to achieve 200 meters with this somewhat haphazardly arrived at "optimal" design. I needed to get more mass out, and/or reduce drag while keeping the rocket stable. From the test launch and Zoom meeting, I knew Tom was using 10 mil (0.01") thick G10 for his 1/2A Altitude rockets. This would both lightened up the rocket and reduce drag. So I switched to 10 mil G10 in my sim and observed that I could also make the fins smaller and still keep the rocket stable because the thinner fins reduced the weight at the backend of the rocket and the CG moved forward. After some trying different fins sizes out in Open Rocket, the fins ended up being elliptical with a 16mm root chord and a span of 21 mm. That also brought the mass down to 12.5 gms.

Figure 2. Adrel ALT-BMP now fully installed in the nose cone with extended shoulder.

I made one final change to reduce weight. That was peeling the inside layer of paper out of the body tube. Bernard Biales published an article in the Jan/Feb 1972 issue of Model Rocketry magazine about this. You can read it here: http://www.ninfinger.org/rockets/ModelRocketry/Model_Rocketry_v04n04_(01-02)-72.pdf That took another 0.5 grams of mass out so the final mass of this optimized version is about 12 grams and simulates at 205m altitude. However, it looks like ejection occurs at around 175 meters. See the simulation of the new design in figure 4. Would the piston help to push it over 200m even with the too short delay?

I decided to build this version and see if I could break 200 meters. But

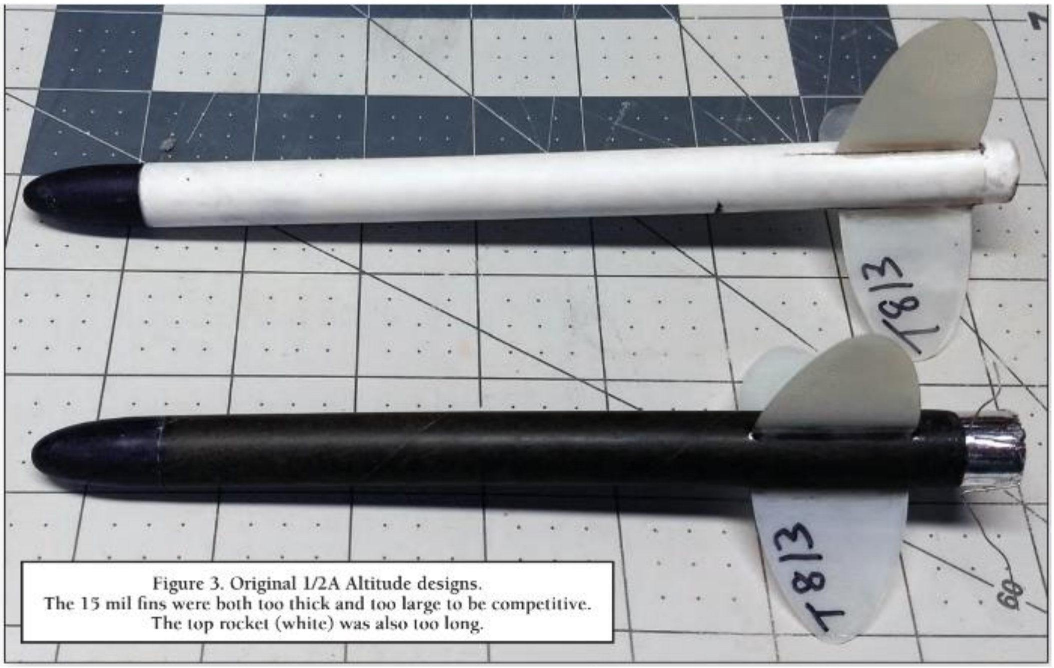


Figure 3. Original 1/2A Altitude designs.
The 15 mil fins were both too thick and too large to be competitive.
The top rocket (white) was also too long.

our WOOSH launches were shut down due to the pandemic! Finally, Wisconsin reopened and at the WOOSH NRC launch on June 6 I was able to try "200 Meters or Bust" as I called his design. The boost was good but not quite perfectly straight up. However, at ejection the body tube separated from the nose cone/altimeter. Fortunately, the streamer was attached to the nose section. The body tube with spent engine tumbled in safely. It only weighed about 5 grams.

I was truly happy when I saw that the ALT-BMP reported an altitude of 213.7m. After temperature compensation the actual altitude was 221m! More than the simulation! A hot engine or a good piston launch? Perhaps both. Using the NAR S&T data for the delay, the simulation data says the altitude was 182 meters at a 3 second ejection delay. It also shows the velocity at ejection was 24 m/s. This is a little fast and probably was a factor in the shock cord breaking. More on that in a bit.

In our WOOSH Zoom meeting, we also discussed weighing engines and using the heaviest one. There are two ideas here. One, the extra weight is due to extra propellant, and two, the extra weight is due to a longer delay element. Both of which are desirable. Of course it could be due to a heavier nozzle, heavier casing, extra ejection charge, or extra clay in the cap. Research projects in this area seem to be inconclusive. Nevertheless, I chose the heaviest 1/2A3-4T I had handy to make the flight. It weighed 6.8 grams which is the S&T published weight. But my other 1/2A3-4Ts weighed 6.4 to 6.6 grams. Is this difference in the "noise"? I'll let you decide. Figure 5 is a picture of the "200 Meters or Bust" rocket after recovery and with the flight card. Notice the peeled body tube is pretty toasted at the engine ejection point. It literally fell apart when I tried to remove the motor, but it had served its function.

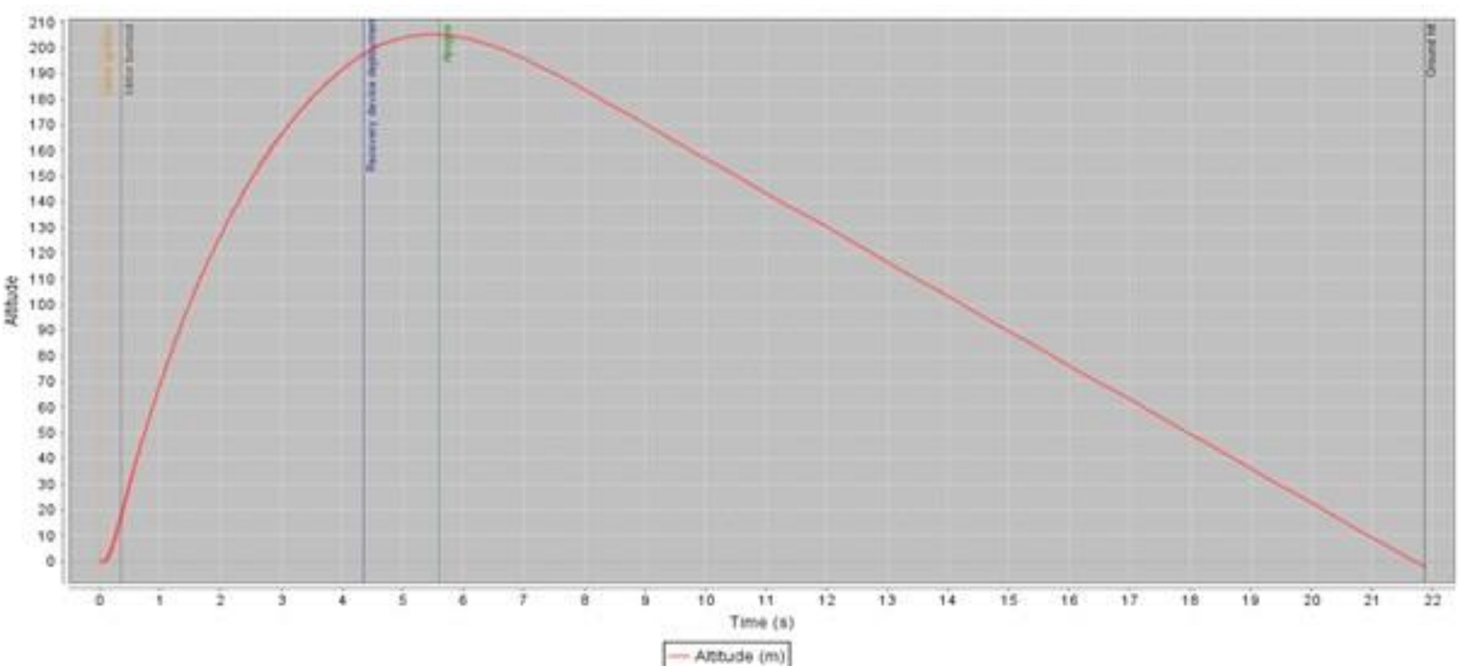


Figure 4 Simulation of "200 meters or Bust" 1/2 Altitude rocket. Weighing 12 grams, it simulated to an altitude of 205 meters, but Open Rocket does nor factor in early ejection or using a piston

Now getting back to the shock cord break… I had started out using 135 pound Kevlar, but found the approximately 30” foot piece I was using weighed 1.5 grams! So I switched to 65 pound Kevlar which weighed around 0.4 grams and it wasn’t up to the task. Some ideas to deal with it breaking: 1) Make sure the streamer stays with the nose cone and altimeter like it did on my flight, or 2) Don’t attached the shock cord to the rocket at all, just to the nose cone/altimeter section and let the booster free fall. It will be unstable or stable in the wrong direction and it will descend tumbling or like a Space-X booster. Either way, the mass of 5 grams (includes the spent motor casing) will be no cause for safety concern (featherweight recovery). With that concept, the engine block can be removed to save more weight. This will work if the engine is tightly friction fit *and* that there is wrap or two of mylar tape on the protruding end of the motor to fit it tightly into the piston tube. That tape will serve as an engine block.

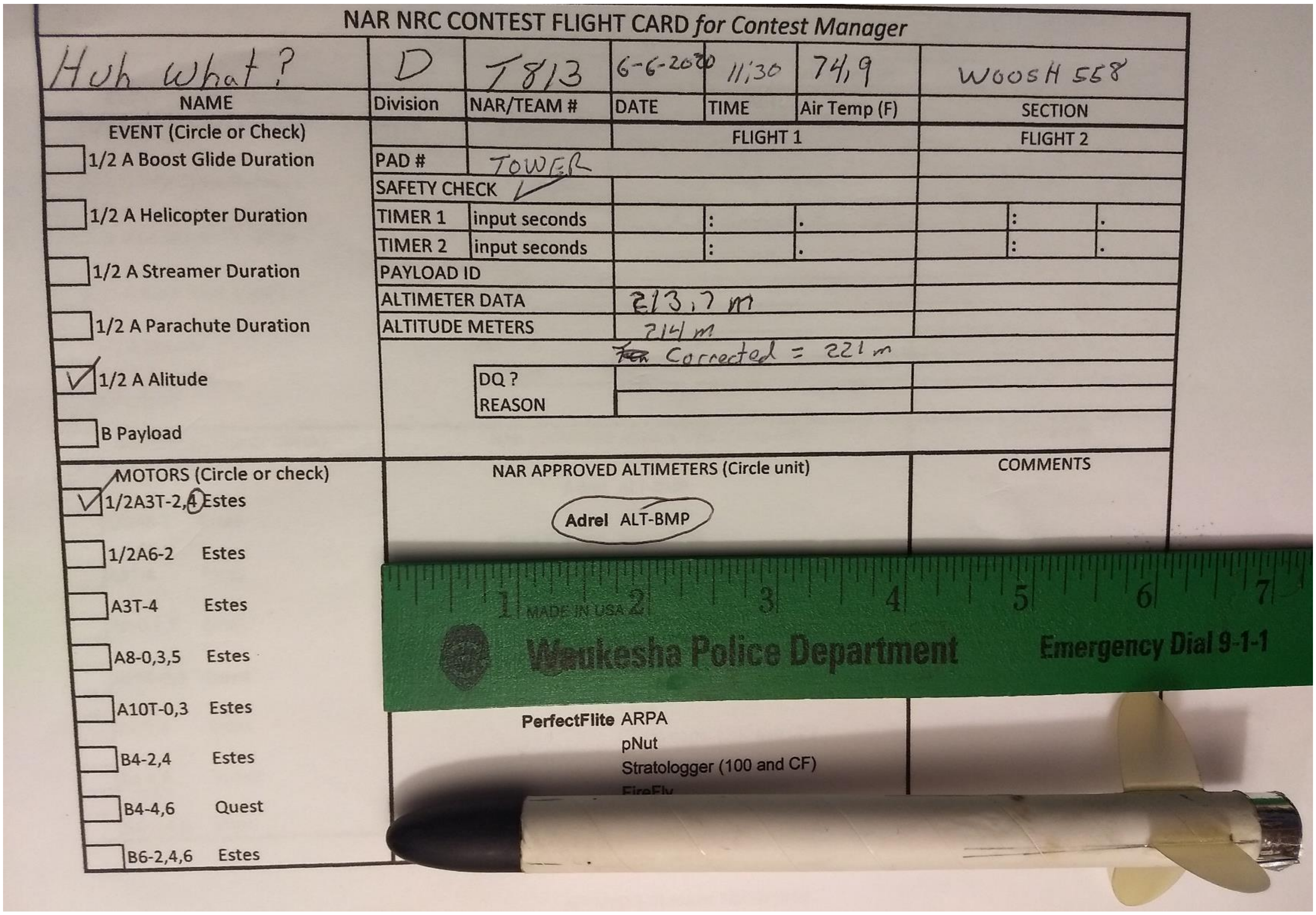


Figure 5 Picture of the "200 meters or Bust" rocket after launch with scale and flight card. Mission accomplished as the rocket achieved an altitude of 221 meters! – ***Update, same design reached 242 meters at NARAM-62 to finish 1st in Team Division.***

Eliminating the internal engine block will save a few tenths of a gram in weight too. This is the plan I will use for my next flight. The downside is you risk losing the booster so use markers to color it a bright color.

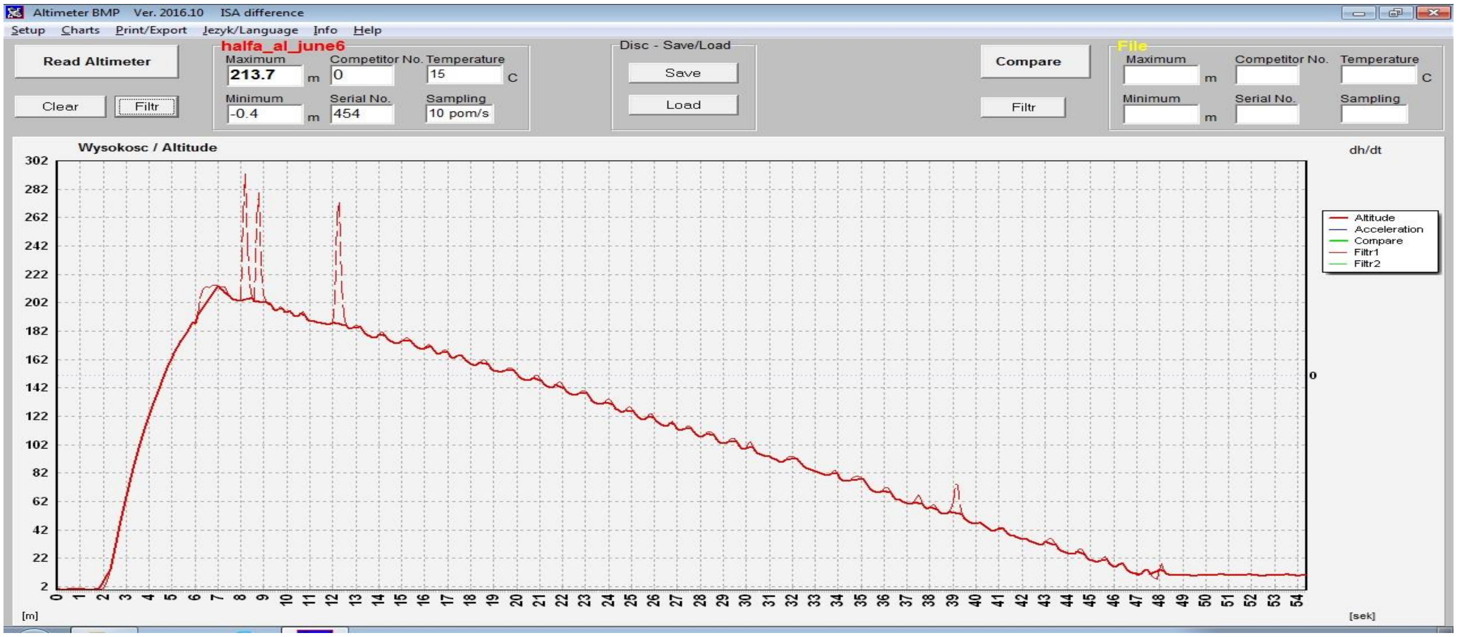


Figure 6 Plot from altimeter data download data. Spikes in the data are caused by exposure of the sensor on the altimeter to sunlight as the nose section rotates on descent. The Adrel filter function removed those so an accurate altitude reading can be made.

"200 Meters or Bust" Plan and Building Notes

An adjacent page shows the plan for my "200 meters or bust" design. Here are some build and flying tips.

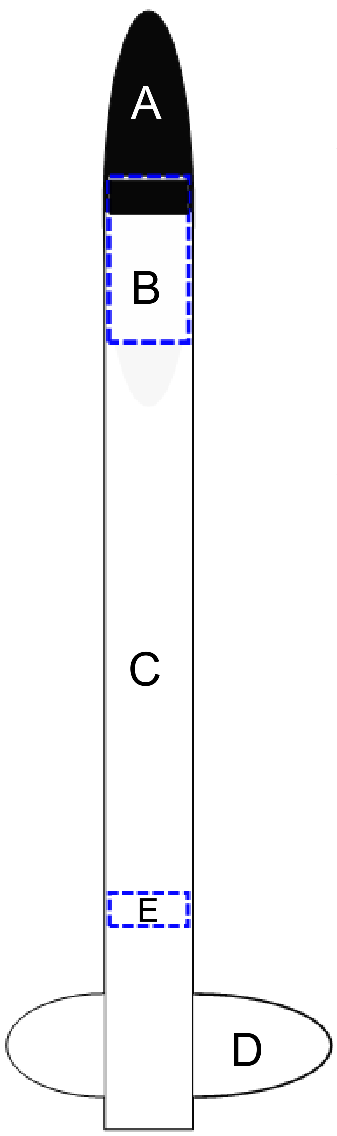
1. For Kraft paper tubes I sand a slightly longer than needed length tube, starting with 240 grit sandpaper, then 400 grit, then 600 grit, 1000 grit and 1500 grit sandpaper. The tube comes out pretty smooth doing this. Perhaps not polished, but not too bad for a few minutes work.
2. After sanding I cut some off of each end to make the tube the proper length with the tube ends nice and clean.
3. Next I peel out the inside layer of paper. I find that some tubes peel more easily than others. In particular, I find the Balsa Machining Service T5 tubes very difficult to peel successfully. Since this tube is only 5.5" long, it is a little easier but my success rate is still low. My best luck these days has been the old Totally Tubular tubes that eRockets later sold (they may be back in stock, but I don't know if they are the same ones). The ones I have may be the original TT tubes that sat through several temperature cycles in Jim Fackart's barn. This may have weakened the glue in the paper layers, making it easier to remove the inner ones. Fortunately I still have some of those old tubes around. Estes BT-5s used to peel well and even could be "Super Peeled" per Bernard's article, but I haven't tried it with them for a while. Another option may be to sand the inside of the tube to remove extra paper.
4. For fin attachment, I use my simple fin jig. See the Jan/Feb 2020 issue of *Sport Rocketry* for details on it. CA for attachment and tiny epoxy fillets.
5. Use whatever shock cord strength you are comfortable with. I will continue to use the 65 pound strength due to weight and allow the booster to tumbled in.
6. The altimeter fits fairly snug in the nose cone section, but a wrap of tape over the back end is prudent to keep it in place. I forgot to do that on my 221m flight and the altimeter was half way out when I recovered the model!
7. Fold the battery and altimeter unit so that the sensor is on the inside and all the way up in the nose to shield it from sunlight as much as possible. Even with that, the sensor may still get some exposure to sunlight. That will cause spikes in the data on descent as the sensor gets exposed to the sun. The filter button in the Adrel software will remove those. See figure 6.
8. Finally, this design is optimized for 1/2A3-4T motors and with an ALT-BMP altimeter in the nose. It will be unstable with an A3 motor or without the altimeter installed.

I hope you decide to build the 200 meters or bust. If you do, let me know. Good luck and have fun joining the 1/2A Altitude 200 meter club!

200 METERS OR BUST

1/2A Altitude (altimeter) Plan

Designed by: Dan Wolf



PARTS LIST:

A. Apogee Rockets 13mm vaccuum formed nose cone
B. Balsa Machining C5 tube (1")
C. 13mm body tube (5.5")
D. Fins - Make from ASP Rocketry G10-010 (10mil)
E. Optional engine block

Not shown:
Shock cord and streamer (keep light)
Adrel ALT-BMP Altimeter (placed in nose cone and C5 tube)

Target mass fully loaded with motor, wadding, and altimeter (< 12 grams)