UNIVERSITY OF ILLINOIS

Flight Readiness Report

Team Parasitic Swag

4/12/2013

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1. Introduction

The 2013 Wisconsin Space Grant requirements for the April 27th competition included constructing a single stage high powered rocket to reach an altitude of 3000 feet, deploy a parachute successfully, and land without damage. The process in accomplishing this task is described in the following pages, which includes initial design and analysis, as well as construction of the various sections of the rocket. After the initial design and build process, the team was able to provide additional data with a test launch. This test launch would give a more accurate value on the coefficient of drag added to the rocket. The iterative method used during Rocsim would build as the error increased, so a more accurate model could be built with actual experimental data. Finally, the report could be written with a suffice amount of build progress and data collection.

2. Design Requirements and Solutions

a. Rocket kit

When choosing the rocket kit, a large factor is the material. It was decided that cardboard would be the best option due to the low level of difficulty in working with the material. While this material is not as strong as a more expensive fiberglass or plastic, cardboard is sufficiently strong for the needs of this competition. The Excel Dual Deploy rocket kit from Binder Design, a 4” kit that is 71” in length, is well within the limits imposed for the competition.

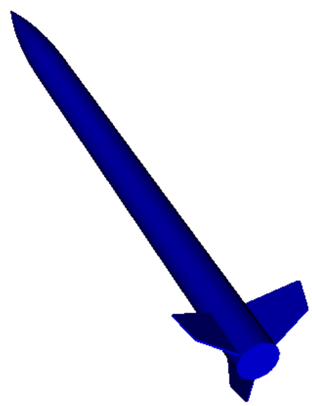


Figure 1:3D model of Rocket Kit

b. Aerodynamics

A Ogive-shaped nose cone, paint with glossy finish, and beveled fins were chosen to reduce drag as much as possible.

c. Deployment System

Deployment system options were limited to the amount of powder that was needed to safely eject both the drogue parachute and the main chute from the rocket frame. Since each of the chutes was different diameters, different sizes of black powder were to be used on each side of the dual deployment kit. From the avionics bay, two ez matches were inserted into the deployment section of the avionics bay. Once the altimeter detected the pre-set altitude, the circuit board would send a current through the wire and set off the appropriate charge. In this case, the drogue chute would be deployed at apogee, while the main chute would be deployed at an altitude of 600 ft.

Recovery System

The stock kit supplied us with a 12" drogue and a 36" main chute; however through simulations it was determined that the main chute would not fulfill performance needs. The decision was made to include a custom high performance parachute, the SkyAngle 44", which delivered a descent rate of 23 ft per second. The 36" stock chute only offered a descent rate of 40 ft per second, which would increase the chances of damage to the rocket upon impact.

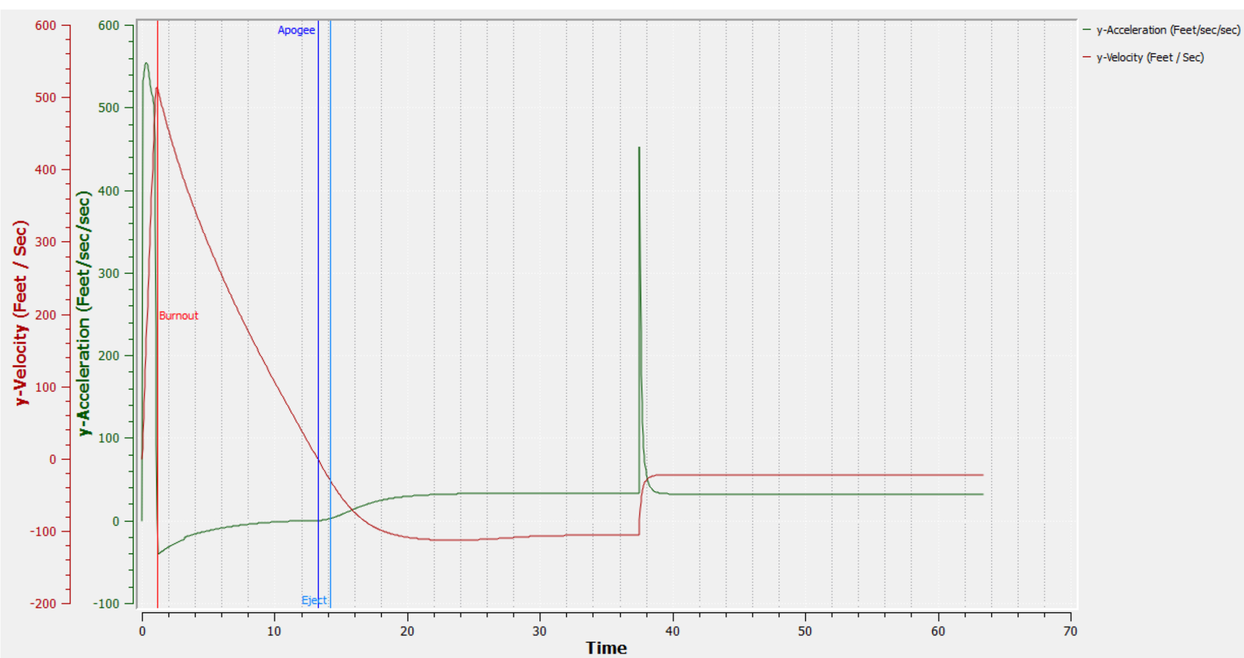


Figure 2: Acceleration and Velocity Plot

3. Analysis of Design Solutions

a. Weight Design Analysis

With a stock build, the following data were calculated for various wind speeds in mph (in "Comments" section):

Max. altitude Feet	Max. velocity Feet / Sec	Max. acceleration Feet/sec/sec	Time to apogee	Velocity at deploym Feet / Sec	Altitude at deploym Feet	Comments
4004.79	726.14	742.02	14.32	0.02	4004.80	Calm 0-2
4002.56	726.09	742.04	14.32	8.25	4002.55	Light 3-7
3958.76	725.14	742.40	14.23	37.23	3958.75	slightly 8-14.9
3905.38	724.01	742.86	14.12	54.42	3905.36	Breezy 15-25
3862.83	723.11	743.23	14.04	64.78	3862.84	Very Windy 20-30

Seeing that the stock altitudes were much higher than what the competition demands, ballast was added to lower the altitude to as close to 3000 feet as possible. A metal pellet-epoxy mixture was created in the shape of disks to fit into the frame of the rocket. For the last two wind conditions, breezy and very windy, two disks totaling around 2.11 lb sufficed, however for any wind speed below 15 mph more weight was required. For these we created two additional weights of around .2 lb each.

Figure 3:Creation of Metal Pellet-Epoxy Disks

b. Recovery Design Analysis

A configuration that was decided was to use a dual deploy kit with a drogue released at apogee and a main chute released at about 600 ft. This configuration helps to minimize the total drift due to wind. As can see in the charts below, with the main chute deploying at 600 ft, there is a large reduction in drift.

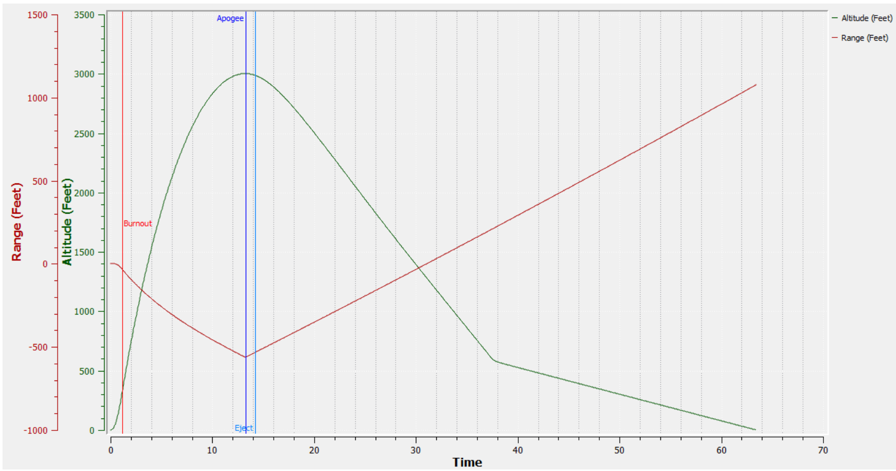


Figure 4:Altitude and Range with Deploy at 600 ft

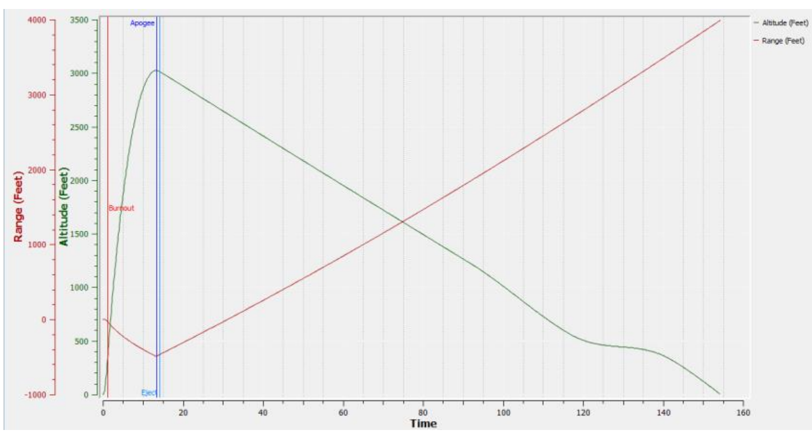


Figure 5:Deploy at Apogee

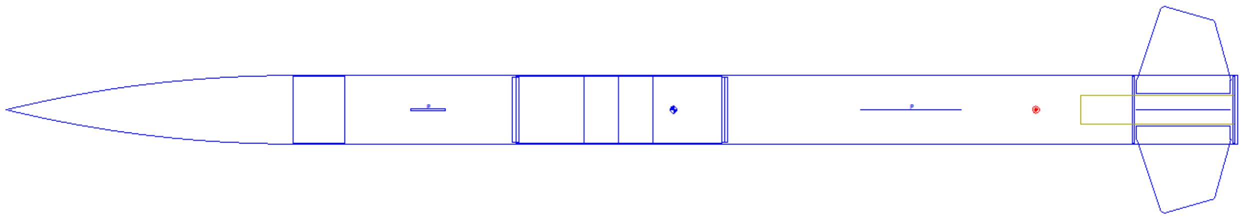


Figure 6:Drogue chute in upper body tube, main towards the aft

4. Construction Process

a. Fin Can

The Construction of the fin can was the first process in the building of the rocket. The fin can consist of two main bulkheads, which initially were too tight of a fit. The end of the fin can consisted of a bulkhead around a centimeter larger in diameter compared to the other bulkheads. From the picture below, the end of the fin can was the area where the two various sized bulkhead were epoxied to the end, with the larger size fitted at the end. Once this was done, the front bulkhead was temporarily placed on the front and the assembly was inserted into the rocket. The temporary fit was done in order to properly align the fins, which was the next step in building the fin can.

In order for the rocket to be aerodynamically stable, the fins had to be properly aligned on the rocket body, which was why the fin can needed to be temporarily inserted. Before the fins could be placed, they were sanded to a fillet like configuration in order to reduce unnecessary drag. The bottoms of the fins were taken into careful consideration to not be sanded for epoxy reasons. Using a template for the alignment, the fins were epoxied at the bottoms, and inserted into cut slits on the side of the body, which were then attached to the fin can and clamped. Once the epoxy hardened, the fin can was removed from the body with the newly epoxied fins attached.

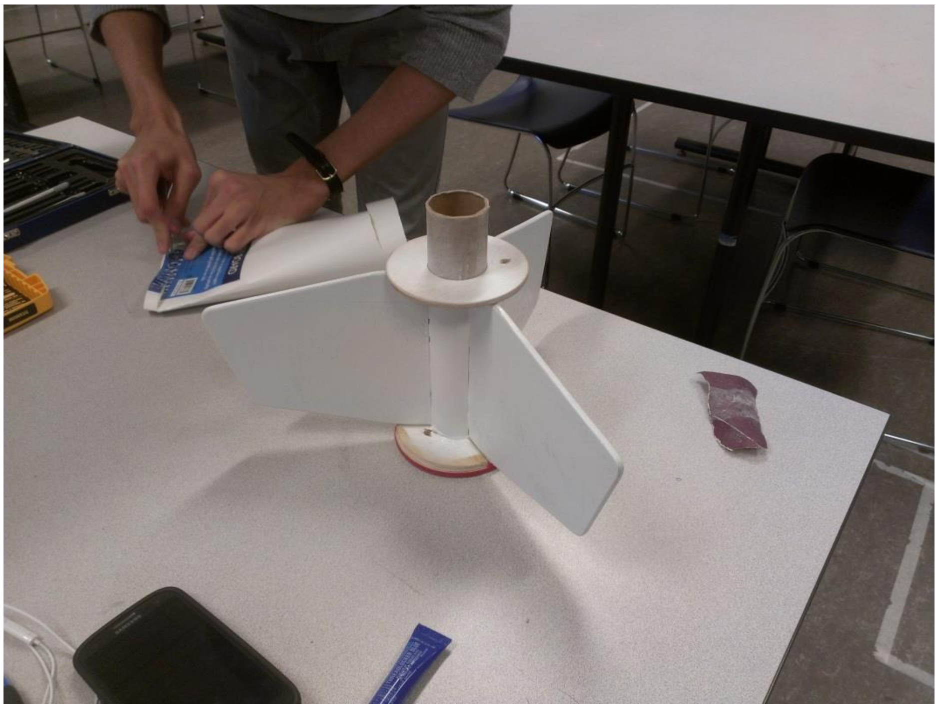


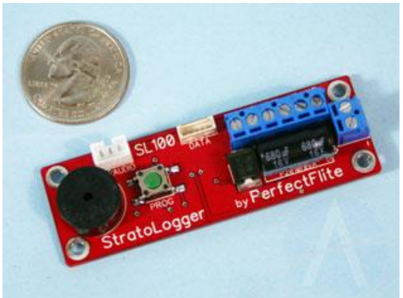
Figure 7:Construction of Fin Can assembly

The next step was to epoxy the top bulkhead to the fin can, which would be aligned to the tops of the fins. Once this was completed, a final round of internal epoxy was placed along the lines of each side of the fins. This was to increase structural durability of the fins during landing. The entire assembly was inserted a final time into the end of the rocket body, and a careful mixture of carbon fiber strands, epoxy, and hardener was applied in a fillet style around the fins for added durability as well as reducing induced drag on the rocket. The larger bulkhead was then placed so that it was flush with the end of the rocket. Finally, a considerable amount of epoxy was applied around the end to withstand the force of the backfire of the engine and the black powder charge.

Figure 8: Assembled Fin Can

b. Avionics

The altimeter in use is the PerfectFlite StratoLogger, a barometric sensor with an accuracy of +/- 0.1% which is more than enough for our needs. It has two event output ports, one for at apogee and the other for a desired altitude between 100-9999 feet. At apogee the drogue chute will deploy and the main chute will follow at an altitude of around 600 ft. This will allow minimal drift while keeping downward acceleration relatively low.



c. Rocket Body

The rocket body did not involve much implementation besides the placing of the avionics, weights, and nose. The directions given gave an ideal construction of the rocket body, which included the installation of the rail guides, and painting of the exterior of the rocket body.

5. Avionics Specifications and Layout

The avionics configuration was decided on a couple of factors. There had to be an easy access to the circuit board, as well as the battery and wiring that assist in completing the circuit. The layout of the avionics bay is shown below. The board that was used to supply support to the circuit board was a piece of balsa sanded down to the proper dimensions. The configuration shown displays a setup that doesn't allow too much slack with the wires.

A trade study was implemented to determine the best setup for the battery, switch and location for the competition altimeter. The final configuration is shown in the CADD model on the next page.

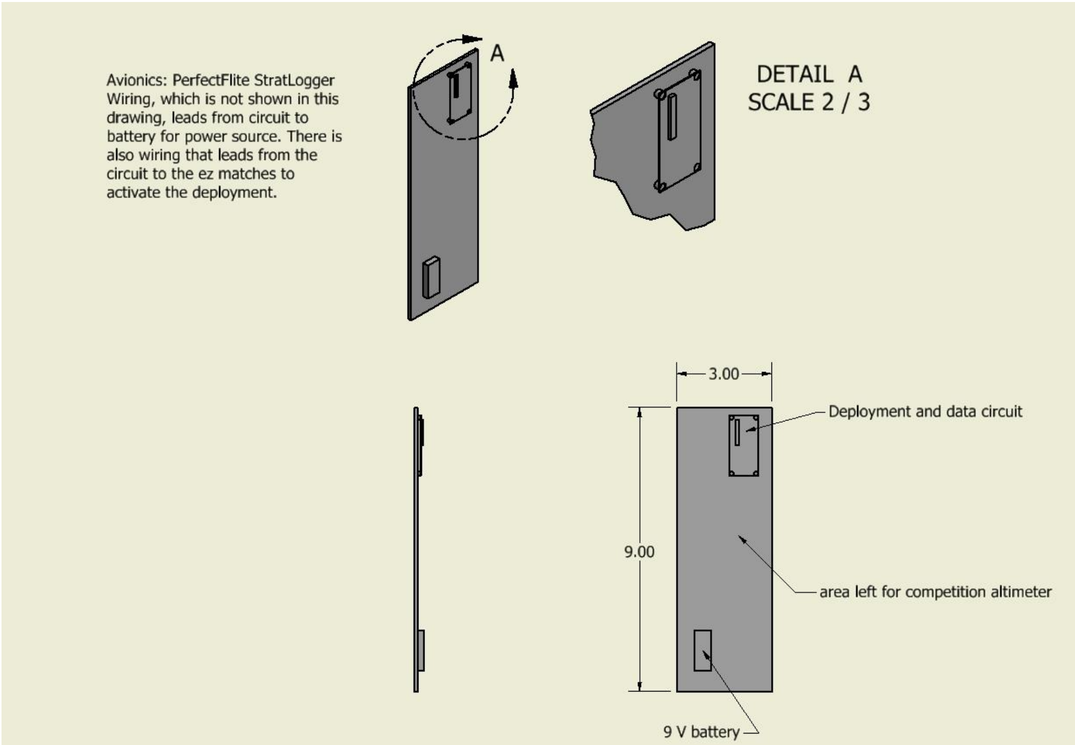


Figure 9: Model of avionics bay

6. Budget History

a. Overview

The objective of this project was to build a cost effective, optimal rocket to meet competition requirements. As stated in section 3 of this document, a budget analysis was done to assess the cost of materials, procurement, labor, and facility rental. Funding was made possible by the department of Aerospace Engineering at the University of Illinois; who supplied the program with funds in the amount of $1000. The sections below will outline the cost break down of the project and will explain the reasons of each purchase.

a. Materials

As can be seen in the table below, the majority of the cost was accumulated by the purchase of the rocket it, parachute, motor and case, and the altimeter. The miscellaneous costs comprise of numerous supplies for the build and finish of the rocket including wadding, shock cord and chute protectors, E-matches, spray paint, pellets, epoxy, and a weight scale among other supplies.

Material	Total Cost
SkyAngle Parachute 44"	$ 60.00
Excel Rocket Kit	$ 129.99
I540WT Motor	$ 50.66
5-Grain Motor case	$ 53.46
Altimeter	$ 85.55
Miscellaneous costs	$ 200.00
Total	$ 579.66

b. Procurement

The rocket kit was purchased from Binder Design, a prominent rocket kit supplier. Most other supplies were bought online at Performance Hobbies and Apogee Rockets or at the local Wal-Mart.

8. Educational Outreach

Educational outreach for Team Parasitic Swag focused on hands on experience for high school students. This was accomplished by presenting exhibits at the Engineering Open house at the University of Illinois from March 15th to the 17th. The exhibits were shown through the American Institute of Aeronautics and Astronautics, and included Rocket Races, a flight simulator, and a Jet cat engine.

Rocket Races

“Rocket races” was and continues to be a very popular event among the younger community. Instead of setting up a rocket system that goes up and the rocket going out of view, a decision was made to provide full view of the process by launching rockets along a horizontal cable. The audience would gather along the sides of the creek to witness launches of two classes every hour or so. After the launch and during the down time, students would ask various on the developments and physics of rocketry.

9. Concluding Statements

Overall, from the design to the construction of the rocket all the way to the test flight, the process for a successful launch was implemented tediously and on schedule. Team members carried out their job when jobs were handed to them, and completed their specific tasks in a timely manner. Along with the modifications to the design, the base rocket kit chosen should be an adequate candidate for the accuracy mark of 3000 feet. There was a fair share of late nights to finish the project in time, but there overall a schedule was well kept.

Once the initial test launch was completed, follow-up data allowed for slight tweaks in the configuration of the rocket. A final test launch along with another charge test would have been ideal, but the time scale for an extra test launch did not have time to make it into this report.