Flight Readiness Report

MH Space Grant’s High-Powered Rocketry Competition

University of St. Thomas

UST Rocketry Team

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Table of Contents

Innovative Design Specifications

In order to set our design apart from others in the competition, we will be incorporating a design concept to be launched at the competition which involves turning a part of the booster's hull into a deployable air brake. This is to be accomplished by cutting three 3" long flaps that are deployed by a spring loaded hinge with a metal stop (looks like a small, slim, metal triangle) screwed on the outside of the rocket parallel to the rocket body as to avoid induced parasite drag before separation. On the opposite side of the flap from the spring loaded hinge, there will be three metal connectors coming together in the middle of the rocket. These connectors are attached to the rear of the flaps preventing them from deploying until a pin connected and holding all three connectors is removed. That pin is attached to the first stage of the rocket. When separation of the stages occurs, the pin will be pulled out of the locking position which will deploy the flaps. This design ensures that we will only force addition drag on the booster without inhibiting the performance of the dart.

Recovery System Design Specifications

Our recovery system consists of a standard electronic deployment using two Stratologgers to deploy two "TAC-1" parachutes sold by GiantLeapRocketry.com from both the first and second stage tethered to their respected stages by a part Kevlar part nylon rip cord.

<u>Second stage recovery</u>: (top half of rocket or the "dart")

At apogee (In our current built apogee is at 750 meters or 10 seconds after launch) a **Stratologger** triggers a pyrogenic pressure spike inside of a small contained space located just aft of nose cone. That pressure spike forces the nose cone from the hull of the dart taking with it one attachment point of the rip cord. The other end of the rip cord is attached to an anchor firmly planted in a bulkhead at the bottom of the dart via screws and epoxy. The parachute is attached 80cm down the cord length from that dart housed anchor. In the aforementioned contained space is the **parachute**, the **parachute shroud**, the **rip cord**, a **swivel mount** and an **anchor**. To mitigate several failure points of the recovery system, we did a few things.

<u>First stage recovery</u>: (bottom half of our rocket assisted by the engine)

At 8 seconds into flight we are having the StratologgerCF separate the two stages. This is done at a considerable speed so we have to allow the jettisoned stage slow down a little bit more before deploying the parachute. After the desired speed has been reached, deployment of the first stage will be exactly the same as the first stage with one acceptation. Instead of pushing the nose cone off we will be pushing a weak plastic cover off designed only to keep the parachute from deploying during the slow down period.

Equipment involved:

-**The Stratologger**: We are using a StratologgerCF sold by Perfectflite which is an on-board altimeter with a built in accelerometer that will be used to deploy the recovery system via 2 pyrogenic avenues for redundancy purposes.

-**The Rip Cord**: Firstly, we split the rip cord into two different materials. We needed our cord to be very resilient around the part that may come in contact with the edge of the dart as to mitigate a potential separation by cutting when the line becomes taut but we also needed it to be elastic to absorb some of the force produced when the line would become taut since we are essentially tethering a projectile (the nose cone) to a base (the anchor). We found that a combination of Kevlar around the section of potential cutting and an elastic nylon running the remaining length of the cord was optimal.

-**The Swivel mount**: We decided to use a swivel mount in our rocket build because we felt it necessary to eliminating a potential problem with the parachute deployment. There is a possibility of having the parachute spin so much that it arrests the parachute from being able to deploy. The introduction of the swivel mount reduces that possibility.

-**The Parachute Shroud/The Parachute**: We settled on the “TAC-1” design sold by

GiantLeapRocketry along with a Kevlar protector to go with it. This type of parachute design is incredibly light weight and almost guarantees a consistent deployment if used properly.

Here is a picture of a slightly smaller TAC-1 while deployed:

-**The anchor**: We simply put a normal steel hook rooted inside of a Spruce bulkhead and secured it by locking washers. This is a rudimentary yet effective way to ensure that our anchor will be able to absorb the force generated by the rip cord going taut. We found via testing on the ground and in the air that his was a successful way to mitigate worrying about another potential failure point on our recovery system. The bulkhead to which the anchor is attached is also supported by AeroPoxy adhesive as well as 2 screws.

Propulsion System Specifications

We are using a Cesaroni 475-I445-16A (54mm, 1 grain, Vmax) as our rocket motor which is required by the competition. We secured this motor in our first stage via a few different methods:

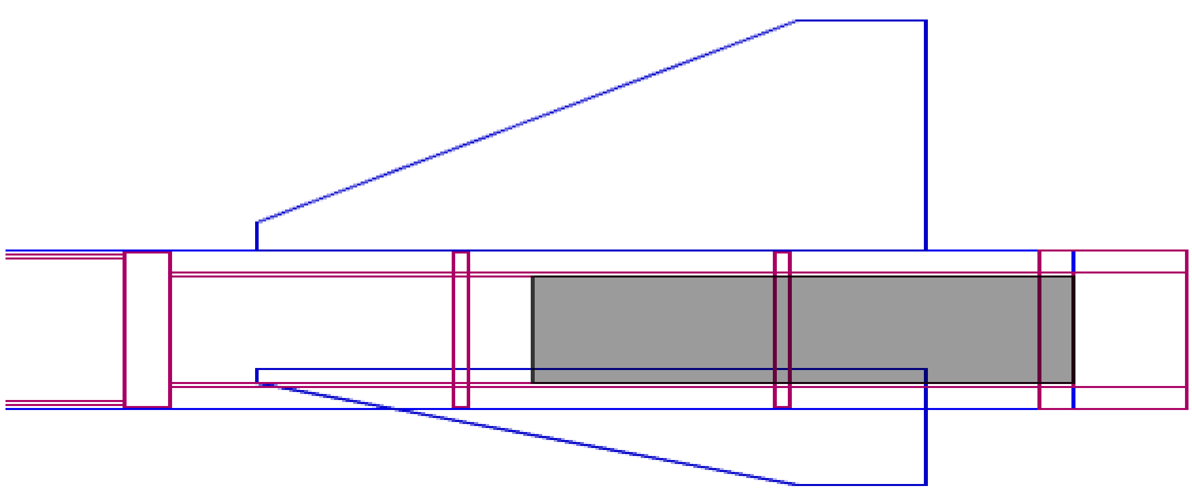
-Firstly, we have the "reloadable" secured in an aluminum heat shroud offered by Cesaroni. The reloadable is secured into this aluminum tube by a screwed in end cap which allows for the protrusion of the 1.5 grain charge exit port as well as the nozzle of engine.

-Secondly, the aluminum heat shroud is secured inside of the motor mount tube by the use of a retainer screwed into a tail cone. This allows easy interchanging of the motor "reloadable" if either failure were to occur or if another launch was necessary.

-Thirdly, the motor mount tube is secured into the hull by the application of 2 centering rings in addition to the tail cone. These centering rings are held in place by AeroPoxy adhesive as well as slits in the tail fins which protrude 2 cm into the rocket body coming flush with the motor mount tube. This allows for an added level of stability in the structure in case the epoxy was to fail.

Picture of the aft end of our two stage rocket

Forward | Aft



Avionics System Design Specifications

For our avionics bays we found that simple phenolic tubing way sufficient to housing the electrons of our Stratologgers, their power sources, and the JollyLogic altimeters. This choice though could lead to two potential problems, however, that we planned for accordingly.

> **-Firstly**: the separation charge could crush the phenolic tubing quite easily. We remedied this problem by adding reinforcing steel rods that run the entire length of the phenolic tubing. These screw into the two Spruce bulkheads the cover both sides of the Avionics bay.
>
> **-Secondly**: the separation charge might knock the bulkhead loose if we are using friction alone to keep it in place. To remedy this we added screws penetrating the hull of the rocked and securing into the bulkhead on the side that is going to receive the blast.

We also had to run wires through the bulkhead to allow the Stratologger to trigger the separation charge near the coupler. This was done by drilling very precise holes and running the wire through these ports in order to allow for separation without damaging the electrons. These ports were then sealed with electronic tape. We also had to add static ports (2 per avionics bay) in the hull of the rocket to allow ambient air pressure to equal the pressure inside of the avionics bay. Equal pressure is required to get an accurate readout from the JollyLogic as well as is required for the Stratologger to function.

Planned Construction Solutions & Techniques

We decided to use Aeropoxy adhesive to secure all centering rings, bulk heads, and to reinforce the fins. We then used screws to secure the avionics bay inside the hull of the rocket. Despite friction being a strong element to keep our avionics bay in place (we had to “load” the avionics bay into the hull with a broom handle like loading a cannon ball into a cannon, that is how tight it was) we decided to go the route of adding extra redundancy since small charges are being used to separate the stages as well as deploy the parachute.

We decided to cut out nooks in the bottom side of the fins (which protruded into the rocket via slits cut out of the hull) so they would “lock” into place with the centering rings, adding a level of stability to the rear end of the booster which was a potential high risk area.

A full plan was drafted of how to assemble the parts in certain orders. To do this however, we had to modify most of the parts we purchased and we had to do so safely. Below are a few examples of how we safely executed out construction plan.

We utilized The University of St. Thomas’ machine shop to safely modify all parts used in our rocket to tailor fit our design. As to be expected, parts ordered from a 3rd party were never exactly “perfect” and required some machining. We always made sure we wore safety goggles when modifying wood and always did so under observation of the shop’s knowledgeable machine operators. From this, we learned how to safely use drills, saws, and other machines that helped us build our rocket.

Once the parts were modify for our use, we followed our design plan which called for an order of parts to be assembled first. For instance, we had to insert and adhere all the centering rings before we put in our fins because these two parts locked into each other. A design idea that helps structural integrity.

I also made my team wear Nitrite gloves when handling the AeroPoxy adhesive used to secure our centering rings and fins. In addition, I made sure we worked in a well ventilated workspace when mixing the adhesive and apply it.

Budget – UST Rocket Team

Equipment	Name	Distributor	Price
(1) Transponder	AT-2B Transmitter	Communication Specialists, INC	$99.95
(2) Reciever	R-300A	Communication Specialists, INC	$349.95
(3) Engine	Cesaroni 475-I445-16A	The mortorman HPR	$170.49
(4) Altimeter	Jolly Logic AltimeterTwo (2)	Amazon	$139.90
(5) Hull (2)	(3inch-54mm G10 Fiberglass) 48"	Rocketry Warehouse	$349.60
(6) Printable checklist		Kinkos	$5.00
(7) Launch pad/guide rod			$5
(8) Engine Centering Rings (2)	3inch 54mm G10 centering ring	Rocketry Warehouse	$18.00
(9) Parachute (2)	36" parachute (PAR-STD-36)	Rocketry Warehouse	$135.80
(10) Fins (2 sets)			$193.60
(11) Tripoli Safety Inspection		Tripoli	$50.99
(12) Adhesive/bindings		Gaint Leap Rocketry	$9.70
(13) Rocket nose (3)	3inch:1 Ogive (FGNC-3-3-O)	Rocketry Warehouse	$90.00
(14) Tailcone Retainer(2)	3inch tailcone 54MM retainer	Rocketry Warehouse	$90.00
(15) Apogee explosive charges		Giant Leap Rocketry	$46.72
(16) Motor mount tubes (2)		Mad Cow Rocketry	$42.80
(17) Rip cords		Off We Go Rocketry	$6.99

(18) Electronics deployment altimeters x2	Gaint Leap Rocketry	$274.18
(19) Electronics (Stratologgers)	Gaint Leap Rocketry	$167.90
		Page 7
(20) Electronics (USB Data transfer wires) x2	Giant Leap Rocketry	$67.90
(21) "ffffg" type black powder	10 Ring - Houston	$21.99
(22) Registration Fee		$400
(23) *Total fund set aside for Hotel/Travel		$1,500.00
Rocket budget total		$4,709.47

Changes…

Our original budget estimated around $1500 per rocket which is a little under what we ended up spending. Most of the equipment however was purchased to further our ability to launch rockets in the future. Any additional costs of tracking equipment, future electronics, and books were well spent in our eyes.

Photos

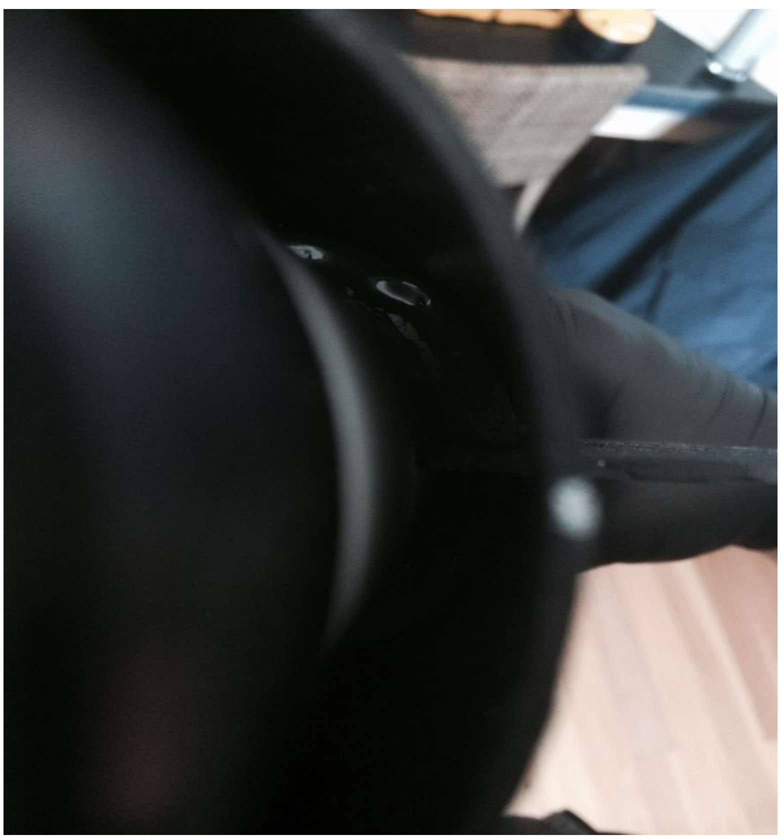
Dart before fins were installed.

Taking out the resin and the hardener for mixing using a barrel cleaning rod for application inside of the rocket hull.

Centering ring and motor mount tube adhesive (after drying)

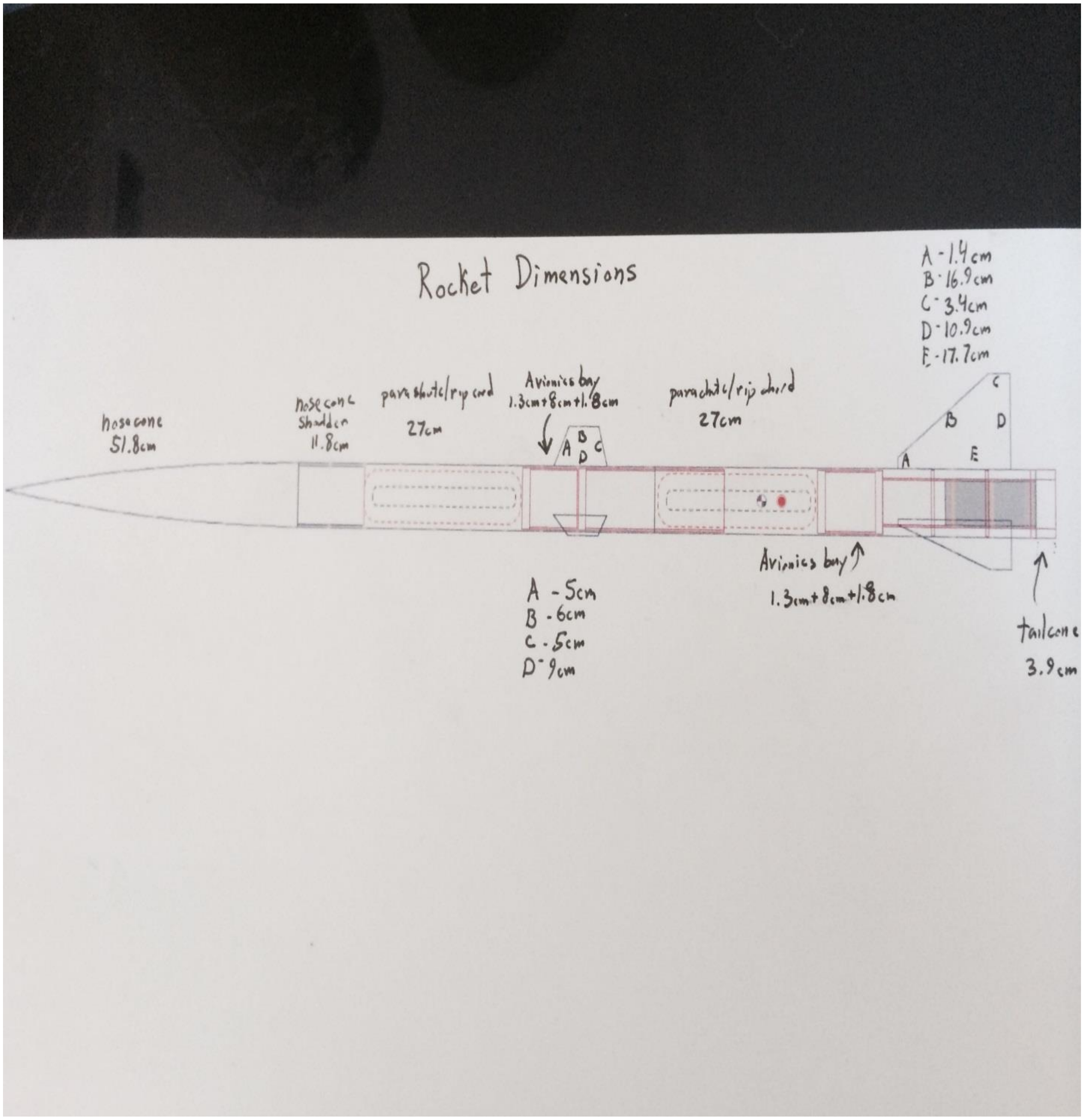
4 hours after application (Picture is of the fin where it meets the hull in the booster)

Motor mount with fins inserted (booster)



Picture of our second prototype rocket

More upclose version of our second roket named “Daedalus II”

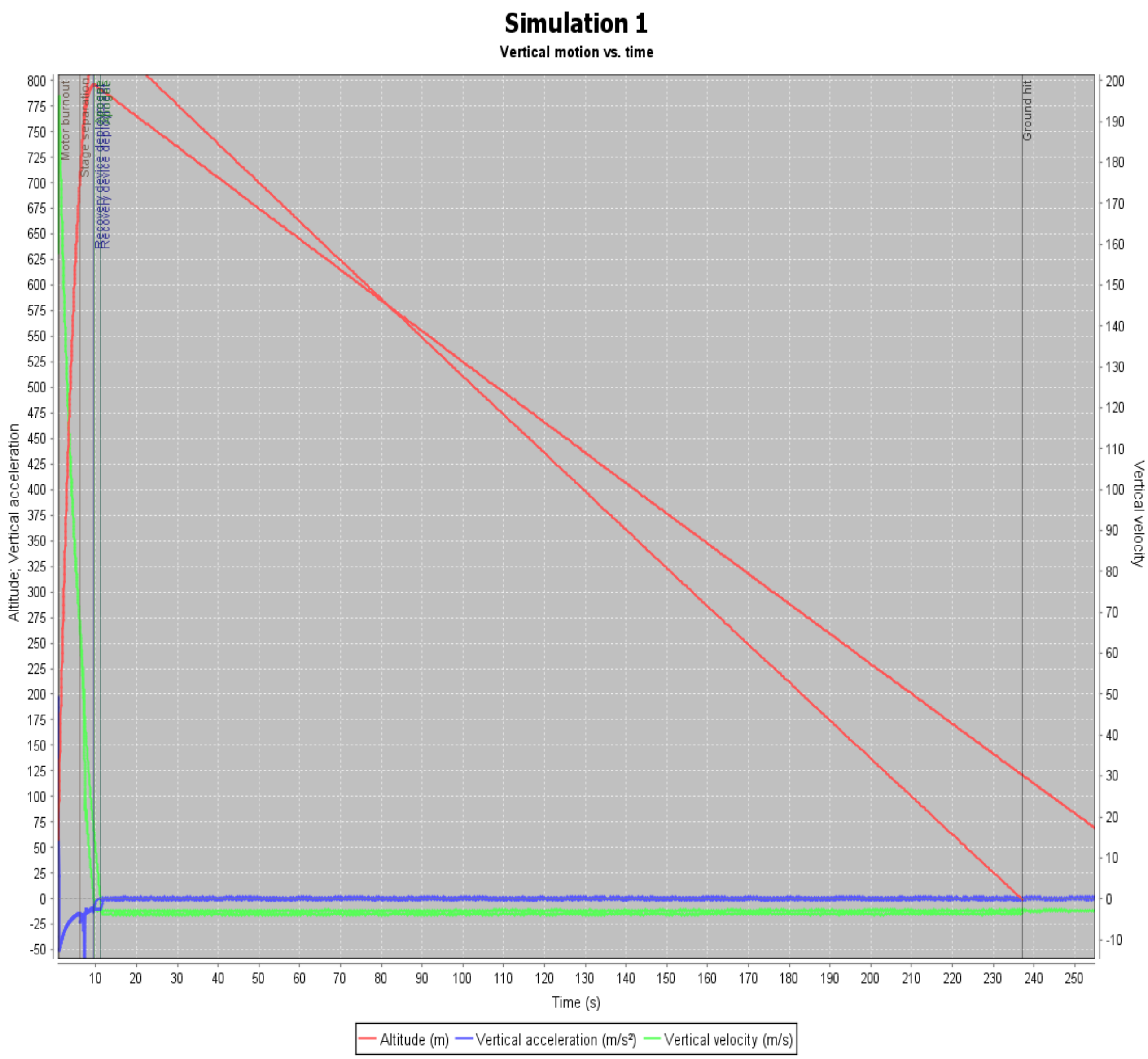


Planned Changes and Improvements

We plan on doing one more launch before the competition where we will test out the air brake idea mentioned on page 2 under “Innovative Design Specifications”. In addition to the air brake installation, we will be adding an additional three fins to the dart portion of the rocket to fix a stability issue we were brought aware of during our preliminary design report that we were going to fix with the addition of weights to balance the CG. The fins should solve the stability issue as well as stabilize the flight characteristics of the rocket.

Test Flight Report

Predicted results:



According the software we used to predict our rocket (openrocket) we were actually very close with our predicted altitude of 870m peak for the rocket with our value being slightly under it at 849m for the dart and 767m for the booster. This could have been due to varying weights in what the software used to calculate certain materials vs what their actual weight were. If not a weight issue, the error was probably due to the fact that our dart was slightly unstable at the time of launch. This has been corrected with the addition of the fins.

As with tests on the ground, the separation of stages caused by the 1.5 gram charges happened with no issue. In addition, the recovery system deployed with no signs of cutting by the edges of the coupler or the top section of the dart. This can probably be credited to the fact that we used a mixture of Kevlar and nylon for our shock cord.

The coast performance was a little different from our predicted results. Our predicted max velocity was 195 m/s (mach .57) compared to the Jollylogics, which put our velocities at 181 m/s and 179 m/s for the dart and booster respectively. Our peak acceleration was also a little lower than predicted values at 227 m/s^2 as opposed to the altimeters reading of 209 m/s^2. Differences in the readings were probably due to weight values being higher than predicted. As predicted, the booster stage of the rocket was slower due to more weight behind located in that section of the rocket. This explains the differences in apogees between the booster and the dart.

Discussion of Results

Since our test flight, we have reweighted most of our components and noticed that some of our equipment weighs more than we predicted with a 250g difference between our model and our actual rocket. We have noted this and will use the override function when predicting our final flight before the competition. It seems that our results yielded a similar trend. Almost everything was over estimated in the results (besides the rocket’s weight) and therefor our real world results were lower than expected. We will continue to try and shed more weight off the rocket to increase our max altitude we are able to reach.