AIAA Orange County Section

Student Launch Initiative 2010-2011

Preliminary Design Review

Project M1
Quantification of the effects of acceleration on hard disk drive latency

Submitted by:
AIAA Orange County Section
NASA Student Launch Initiative Team
Orange County, CA

Submitted to:
Marshall Space Flight Center
Huntsville, Alabama

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Image From: XPRS.ORG

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Table of Contents

1. Summary

1.1. Team Summary

1.1.1. Team Name

The team name of the AIAA Orange County Student Launch Initiative is "M1."

1.1.2. Location

The team meets at :
20162 East Santiago Canyon Road
Orange, CA 92869

1.1.3. Team Official and Mentors

The team officials of this group are Jann Koepke and Robert Koepke. The team mentors are Michael Stoop, Brendan Clarke, Dr. James Martin, Jonathan Mack, Guy Heaton, Khoa Le, Michael Updegraff, and Doug Jacobs.

1.2. Launch Vehicle Summary

1.2.1. Size

The total length of the rocket will be 80 inches long, and the diameter of the rocket is four inches.

1.2.2. Motor Choice

The motor that the team chose is a K635 motor from Cesaroni, this will not accelerate our rocket over mach1, or even near that (0.58 mach). It will however get the rocket up to almost mile in height.

1.2.3. Recovery System

The recovery has a dual deployment system, this means the rocket has drogue 'chute and a main 'chute that will be fired at separate times. This is required by the projects specification and is needed for safety. The recovery electronics include MAWD Perfect Flight and a G-Wiz Partners HCX, along with three nine volt batteries, and associated wiring. This will be located in the electronics bay along with the payload. You will find more information on this subsystem in later portions of the Preliminary Design Review.

1.3. Payload Summary

The payload of our rocket will contain a small Linux computer, a laptop hard drive and supporting circuitry. The payload is powered by three 8.4 volt Lithium Ion battery packs. The linear tech DC 187/converter converts raw battery voltage to power the experiment. We will be measuring the acceleration experienced by the rocket using a G-Wiz Partners HCX flight computer. During the launch the hard drive will be subjected to forces and vibration. The hard drive will be operational during the flight. This will ultimately test the survivability of the hard drive as well as performance degradation during the flight. We will be testing hard drive latency in milliseconds. This will be recorded by a solid state thumb drive.

2. Changes Made since Proposal

Since the proposal, two team members have joined the team: Albert Zhu and Tina Zhu, both from Irvine High School in Irvine, California. The team now has representatives from five different high schools in Orange County, California.

2.1. Changes made to the vehicle criteria

The original Rocksim file used for the Proposal was also used for the PDR, but it was modified as well as much more detail added:

- The length has changed and is now 80 inches
- The payload bay has increased in length and is now 12 inches long to accommodate all of the scientific payload and the recovery electronics
- The payload bay now has two sleds back to back to hold all electronics
- The weight has changed and is now 299 ounces
- The fin shape and surface area has changed, together with the weight and location of that weight to bring the stability margin into range (2-2.5)
- The engine was originally specified as a Cesaroni K570 and is now a Cesaroni K635 to bring the simulated altitude under 5,280 with the other changes in the vehicle for stability margin

2.2. Changes made to the payload criteria

The payload presented in the proposal did not include much detail regarding the power supply. Most of the other details are unchanged

- The batteries used to power the payload are 3 LiIon 2200 mAH rechargeable batteries, connected in series
- The batteries are diode isolated to prevent high inter-battery current flow
- A DC-DC converter was added to provide additional regulated voltage to the payload

2.3. Changes made to the activity plan

We have added additional educational opportunities since the proposal.

- The AIAA is inviting a larger portion of their membership to a council meeting where the team is presenting their story
- Newspapers including the Orange County Register and the Foothills Sentry are interested in the team's story. In addition, the school newspaper at Sunny Hills High School
- One 4H Club has invited the team to present at their monthly meeting; we will try to leverage this to other clubs
- Discovery Science Center in Orange County caters to kids and is featuring space flight.

3. Vehicle Criteria

3.1. Selection, Design, and Verification of Launch Vehicle

3.1.1. The Mission

3.1.1.1. Mission Statement

We, the M1 team from the AIAA Orange County Section, will construct and launch a rocket that will reach a mile high while testing hard drive latency without exceeding mach. The rocket will include a dual deployment recovery and will remain reusable.

3.1.1.2. Requirements

Our team will design build and fly a rocket that has a dual deployment recovery system. It will reach an altitude of a mile at the highest point, or at apogee; during the launch data will be collected in the scientific payload. The data will be collected for the duration of the launch and reviewed after the vehicle has returned. It will remain reusable after the launch. The tracking system will work and enable the team to retrieve the rocket after each launch. The rocket will not exceed a mile, and will not land past 2,500 feet from the launch pad. The rocket will not accelerate faster than Mach1, and will not pose a safety threat to spectators or any other personnel.

3.1.1.3. Success Criteria

Our team's rocket will be designed and built by the team. It will be flown and reach a mile high. The recovery system will use dual deployment and will work successfully. For the payload systems data will be collected during the flight and will be recorded and reported on. The rocket will not exceed mach1, pose as a safety threat and won't travel outside of the 2,500 feet range from the launch pad. It will be a success if it meets this criteria, gathers useful data, and can be flown again without major repair.

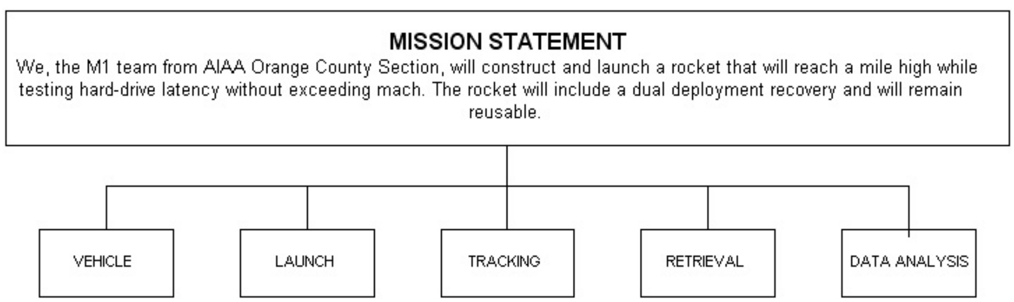
3.1.2. Major Milestone Schedule

- October 12, 210: Proposal Accepted
- October 16, 2010: Girl Scout Workshop
- October 21: Trial Web-Ex Conference
- October 24: SLI Meeting (Start Writing PDR)
- November 1: Website Presence Established
- November 6: Girl Scout Launch
- November 7: Overview of the PDR Requirements
- November 12-14: Work on PDR Together
- November 14: Subsections of PDR are Finished
- November 15-18: Proof Reading of the PDR
- November 19: PDR Submitted
- December 14: Web-Ex PDR Presentation 9AM
- December 15-16: Design Scale Model
- December 16: Order Parts
- December 17: Will Call
- December 18-23: Build Scale Model
- December 18-ongoing: Testing gunpowder, recovery and tracking

- January 17: Scale Model Launched
- January 24: CDR Due
- January 19-31: Finalize Full Scale Design
- February 1: Order Parts
- February 2: Will Call Parts
- February 2-8: Web-Ex CDR Presentation
- February 9-31: Build Full Sale Rocket
- March 12: Launch Full Scale Rocket
- March 21: FRR Due
- March 28-31 (TBD): Web-Ex FRR Presentations
- April 13: Travel to Huntsville
- April 14-15: Flight Hardware and Safety Checks
- April 15: Launch Day
- Ongoing: Fundraising

3.1.3. System Level Review

Several systems are required to accomplish our mission. These are shown in the diagram below (subsystems of those systems are covered in subsequent sections):



3.1.3.1. Vehicle

The vehicle is the rocket itself, it contains several sub systems: payload, recovery, and propulsion. All of these subsystems work together to create and form our project, without all of these working together our project would be incomplete and faulty. The payload was our team choice, we decide to test hard drive latency in milliseconds during acceleration to several “G”s and under vibration. This contributes pressure and different forces from what the hard drive would normally see. The recovery is one of the most important parts of rocket, if this is faulty the team could lose all electronics and data, the flight would be inconclusive, tragic, and poses a safety threat to the spectators. The payload and recovery will be located in the electronics bay. The propulsion is the rocket engine. The team decided to use a K635 motor from Cesaroni.

3.1.3.2. Launch System

When the team launches the rocket there’s a lot that contributes to it. To launch a rocket it requires: a launch rail, a launch controller with a safety interlock system, a weather station, wire/cable, two garden tractor batteries, alligator clips, a remote relay, and a fire extinguisher. The team’s rocket will use launch rail guides, thus we need a launch rail to launch. To actually launch the rocket you need a launch controller with a safety interlock system which needs a power supply which is the 12v garden tractor battery, wires/cables run out to the launch pad to a remote relay which attaches to a second 12 v battery. The launch controller closes the remote relay that provides power to the igniter. In this way, less power is lost in the long wire run from the controller to the pad. Just in case anything happens to our engine we will have a fire extinguisher on hand. Before we actually launch our rocket we need to check our weather station to make sure the wind speed is less than 20 miles an hour.

3.1.3.3. Tracking system

The tracking system allows the team to find their rocket after it is launched, keep in mind that the rocket could be up to 2,500 away from the pad. The electronics we will be using are: Big Red Bee Beeline GPS transmitter, Yaesu VX-6R Transceiver, Bionics Tiny Track 4, and Garmin E-Trex Vista. The Big Red Bee will be located in the nose cone of the rocket, this so that the radio waves will not interfere with the electronics in the electronics bay. The Big Red Bee will send radio waves to the Yaesu VX-6R Transceiver, the transceiver will be connected to the Bionic Tiny Track 4, which will take the audio from the Yaesu and convert them into a digital signal. The Garmin translates that into a location that will show both our location as well as that of the vehicle on the screen. The RF signal from the Big Red Bee can also be used with a Yagi antenna as a radio direction finder.

3.1.3.4. Retrieval

The retrieval of the rocket is the most simplistic of all the system. All we need is a group of ready people (people from our team) who are willing to walk to retrieve the rocket. Hopefully they are wearing comfortable shoes that day. With the retrieval, they have to be sure that they recover all parts just in case something malfunctioned.

3.1.3.5. Data analysis

Data Analysis is when the team collects their data from the flight. We would collect the data from both flight computers to see the curve of the flight, when the ejection charges were fired and to see what height they acquired. We would also look at the hard drive to make sure it is still usable, and we would see how the launch affected the latency in milliseconds was affected. For this process we would need the electronic device we were taking information from, a computer to download the information to, and a download cable so we could download the information.

3.1.3.6. System Performance and Characteristics

We expect all systems to work together so that our project is successful. All of our major systems include: vehicle, launch, tracking, retrieval, and data analysis. We expect the vehicle to work well with all of its subsystems. The vehicle contains the subsystems: recovery, payload, and propulsion. The recovery has to fire a total of four charges, two for the drogue and two for the main, not at the same time though. The recovery should return the rocket safely to the ground, within the 2,500 feet range. The payload will record data during the launch, and will be retrievable for a analysis and to draw a conclusion. The payload will record hard drive latency in milliseconds. This data will be referenced along with the G-Wiz Partners HCX. The propulsion will launch the rocket to a total of mile high without exceeding it. The motor that will be used is a K635 by Cesaroni. The launch subsystem will launch the rocket on a rail guide 200 feet away from the launch controller with a safety interlock system. The rocket will will reach a safe speed before leaving the launch pad. Tracking the rocket is essential because it enables us to record the data from the launch. The Big Red Bee, Yaesu VX-6R Transceiver, Bionics Tiny Track 4, and Garmin E-Trex Vista will work together to give us an accurate location. We will retrieve the rocket using the tracking system. We will have a group of team members use the tracking system to find the rocket and return it. After the rocket is returned the electronics will be plugged into a computer and the data will be uploaded. After that the team will for analyze the data to reach a conclusion regarding the effect of the flight.

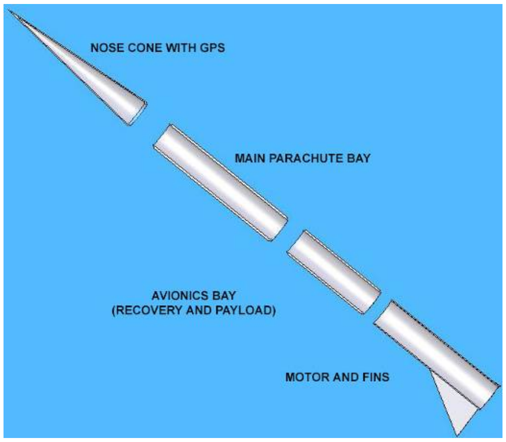
3.1.3.7. Evaluation and verification metrics

The vehicle can be watched and tested on the ground to verify that the system will work in flight. We can download data from the flight computers to verify that it worked completely. For the payload the Linux computer will be recording data throughout the launch. The launch can be controlled by the members, but they will be launching at a ROC launch. They will launch on a launch rail, and be within 2,500 of the launch pad. They will also not exceed mach1 and will not have a height higher than a mile. The tracking system will work and successfully guide the team to their rocket. The members will retrieve their rocket using the tracking device. The members will record the data from the launch, and write a conclusion statement using the results.

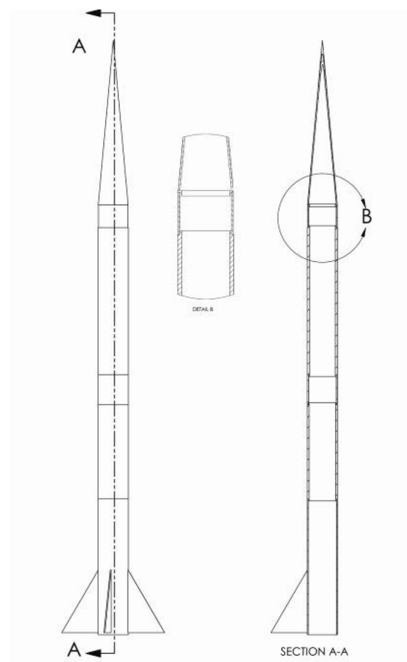
3.1.4. Subsystems required for this mission

3.1.4.1. Vehicle

3.1.4.1.1. Design Details



The Rocket was designed using Rocksim and is made up of 4 main parts. First there is the22.08 inch long conic nose cone with a 3 inch long shoulder. The GPS transmitter will be located within the nosecone. The nosecone will have three G10 bulkheads to secure it to nylon shock cord. Next is the 20 inch upper bay that will hold our Main 96 inch parachute and the shock cord it will be attached to. Next is the Payload bay. It is a 12 inch section that will house all of the recovery and payload electronics. It overlaps 4 inches into both the upper bay and the lower bay with a 4 inch long coupler around the middle. Last is the lower bay. This will house the motor mount, motor, drogue parachute, and the nylon shock cord that the drogue parachute will be attached to. All of the outer body tubes and the coupler around the middle of the payload bay will have a 4 inch outside diameter. The inside diameter of all body tubes and the outside diameter of the payload bay will be 3.9 inches. The outside diameter of the shoulder on the nosecone will be 3.875 inches. Lastly is the motor ending mount. It will have a 4 inch diameter and a 3.13 inch rear diameter with a length of 1.75 inches and accept the 54mm motor. There is also a screw type motor retention device to assure the motor stays with the vehicle. There will be three fins equally placed around the out side of the lower bay 12.875 inches from the front of the lower bay. The fins will have a root chord length of 7.75 inches, tip chord length of 6 inches, a sweep length of 5.582 inches, a sweep angle of 57°, a semi span of 4.125 inches, and they will be 0.1875 inches thick. All exposed pieces of the Rocket will be made out of G10 fiberglass. The recovery section including the electronics and parachutes are covered in detail in section 3.2.



Component	Material	Qty	Weight (grams)	Total Weight (grams)	Length (inches)	Width (inches)	Thickness (inches)
Vehicle							
Nosecone	Fiberglass	1	293	293	22	4	0.07
Coupler	G-10 Fiberglass	3	370	1110	12	4	0.06
Upper Body Tube	G-10 Fiberglass	1	500	500	20	4	0.06
Middle Body Tube	G-10 Fiberglass	1	100	100	4	4	0.06
Avionics Bay							
Coupler	G-10 Fiberglass	1	370	370	12	4	0.06
Bulkhead	G-10 Fiberglass	2	33	66	n/a	4	0.06
Bulkhead Shaved	G-10 Fiberglass	2	32	64	n/a	3.8	0.06
Lower Body Tube	G-10 Fiberglass	1	763	763	31	4	0.06

Fins	G-10 Fiberglass	3	138	414	12	5	0.06
Launch Rail Lugs	Aluminum	1	4	4	1.526	0.75	0.29
Tailcone assembly	Balsa, G10 Fiberglass	1	75	75	6	4	n/a
Motor Retention	Aluminum	1	42	42	1	2.6	0.09
Propulsion							
5 Grain Motor Casing	Aluminum	1	484	484	18.83	2.125	n/a
Cesaroni K635 Motor	APCP, Plastic	1	1990	1990	18	2	n/A

The final rocket design is modeled after the Black Brant sounding rockets and has the following characteristics:

- Length: 80.54 inches
- Diameter: 4.02 inches
- Span: 12.27 inches
- Mass: 299 ounces
- Center of Gravity: 49.85 inches behind the nose tip
- Center of Pressure: 58.97 inches behind the nose tip
- Stability Margin: 2.29

To select a motor we needed to have all of the details of components for the rocket (major vehicle components are in the table above, for complete list see appendix D). The total final weight from our table was 299 ounces, or 18.7 pounds (this varied as we loaded different motors). This corresponded closely with the weight of the individual components entered into Rocksim using their data base. We selected several different motors made by Cesaroni, since Cesaroni motors have a reputation for being consistent and reliable. Our target altitude was just under 1 mile. From the simulations, the K635 redline motor carried our design to 5,255 feet – just short of the needed 5,280 feet (better to err on the low side of 1 mile) with a burn time of 3.13 seconds. Specifications of this motor as well as the thrust curve are in Appendix E.

Motor	Wind (MPH)	Total Impulse	Rocket Mass (Ounces)	Maximum Altitude (feet)	Max Velocity (ft/s)	Max Accel (ft/s2)
K530	0	1414	295	3281.73	482.43	582.17
K630	0	1681	286	4399.61	592.27	582.13
K635	0	1973	299	5255.41	657.76	582.18
K750	0	2362	309	6455.77	772.76	582.33
K590	0	2415	307	6767.42	724.74	652.22

If the design should need to change requiring more or less thrust, engines are available (e.g. the K530, K630, K750, or K590) as shown in the table below. This motor selection also keeps the vehicle from exceeding mach1, another requirement.

3.1.4.1.2. Performance characteristics and metrics

Our estimates are shown in the tables on the next page for maximum altitude, maximum velocity, maximum acceleration, time to apogee, velocity at deployment, and altitude at deployment. These estimates were done through calculations in Rocksim. We have different calculations for 0, 5, 10, 15, 16, 17, 18, and 19 MPH wind speeds since we do not know what the conditions will be during the actual launch. Once we launch our rocket, we will compare the data recorded on the HCX to our initial predictions and flight simulations.

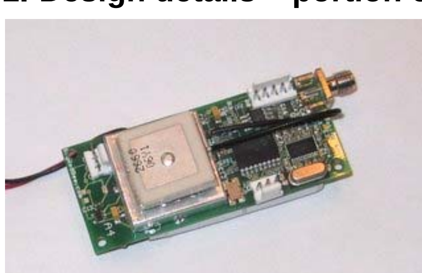
CESARONI K635 REDLINE MOTOR

Wind (MPH)	Altitude (feet)	Max Vel (ft/s)	Max Acc (ft/s2)	Time to apogee (seconds)	Velocity at Deployment (ft/s)	Total Flight Time (seconds)
0	5255	658	582	18	0.02	109
5	5242	658	582	18	22	109
10	5198	657	582	18	46	108
15	5123	657	594	18	69	109
16	5103	657	582	18	74	106
17	5083	656	571	18	79	105
18	5062	656	574	18	83	105
19	5039	656	582	18	88	106

These simulations show the vehicle on a K635 motor at wind speeds from none to the maximum of 19MPH. The stability margin of 2.29 assured a stable in all of these wind conditions. As the wind speed increases, the rocket weathercocks. Flights use a 24 inch drogue parachute with a 96 inch main parachute. Details behind the selection of these parachute sizes are in the recovery section later in this document.

3.1.4.2. GPS Tracking System

3.1.4.2.1. Design details – portion carried in vehicle



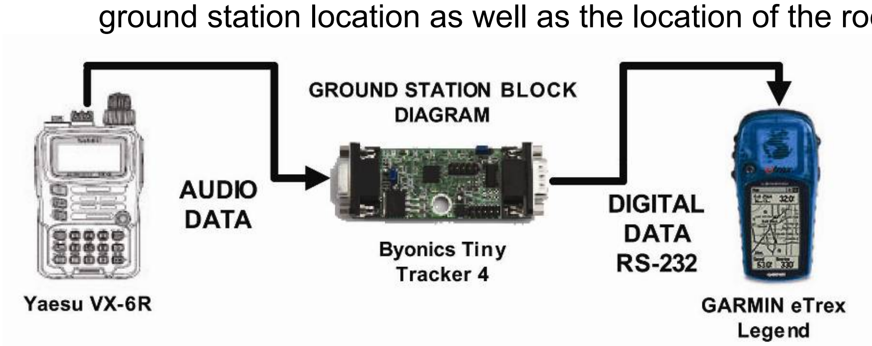
The GPS and Downlink Transmitter will be a Beeline GPS from Big Red Bee measuring 2 7/8" x 1 1/4", the antenna is 6.25" long. This device is an integrated GPS receiver and 70cm amateur transmitter (two mentors to the team have an amateur radio license) with a micro controller translating the position received from the GPS receiver into AX.25 APRS (Automatic Packet Reporting System) information packets containing the latitude, longitude, and altitude of the rocket. This information is then transmitted as audio information via an integrated FM transmitter on any frequency of our selection in the 70 cm amateur radio band (420 – 450 MHz). The device is powered from a single cell 750mAH lithium battery (approximately 4.2 volts) which provides power for up to 10 hours. The device will also store 10 minutes of location data after launch is detected.

3.1.4.2.2. Performance characteristics and metrics

We expect our GPS tracking device to work accurately, and give us the correct locations. We know the area that we are launching at, so we can tell whether or not our GPS system is working correctly. Our testing will validate our GPS system as well. According to the BeeLine transmitter specification, the range for the transmitter is 50 miles while in the air. But that can be cut down to much less than 1 mile when the vehicle is back on the ground. Unless the vehicle returns very close to the launch pad, we expect the last valid GPS signal to be several hundred feet in the air. Back on the ground we might be able to use the signal for radio direction finding if it cannot be decoded. Range, both for a valid GPS signal and direction finding will be validated before any launch.

3.1.4.2.3. Design details – ground station

The tracking station on the ground will enable the data received via the RF downlink to be interpreted by the team on the ground. It consists of three parts: (1) A Yaesu RX-6R handheld transceiver capable of receiving most frequencies from .5 to nearly 1000 MHz. It will be used on the selected frequency in the 70 cm amateur radio band. The audio output from this device is connected to a (2) Byonics Tiny Track 4. This device is an interface that translates the encoded audio signals from the receiver into RS-232 data that can be sent to a GPS device that understands NMEA (National Marine Electronics Association). This output is then sent to (3) a Garmin eTrex Legend handheld GPS receiver that can show our current ground station location as well as the location of the rocket.



3.1.5. Verification plan and its status

3.1.5.1. GPS Subsystem

- Validate that the GPS transmitter is actually transmitting on 433.920 MHz which is the preset frequency. We should hear tones on the Yaesu VX-6R. Status: Not started – we do not have the GPS transmitter.
- Validate the ground station is encoding GPS signals by listening on 144.390 MHz, a frequency used in the Los Angeles area for APRS to see data on the Garmin. Status: We hear the APRS signals but they are not yet decoded.
- Validate the GPS transmitter and ground station can work together by setting up the transmitter and receiver and validating to a known location. Status: Not started
- Range Testing (ground): Repeat the test above in the desert with the GPS transmitter in a nose cone on the ground. Increase the distance between transmitter and receiver, noting the distance when the decoding stops and when the signal is so weak it cannot be used for direction finding. We would like to see 2500 ft. Status: Not started
- Range Testing (elevated): Repeat the test above with the nose cone and GPS transmitter on the top of an 8 foot step ladder. We need to see at least one mile. Status: Not started

3.1.5.2. Recovery Subsystem

- Validate the team's understanding of the MAWD and HCX flight computers and how they are programmed by an application running on the PC. During this test we will also make cards indicating the meaning of the beep sequences from each flight computer for use during actual launches – some sequences indicate errors and would stop the launch until fixed. Status: We programmed an Entacore AIM flight computer since it was available – it should be similar to the MAWD and HCX. This step will be repeated on the MAWD and HCX.
- Bench test the MAWD and HCX flight computers by connecting the batteries and running the flight simulation supplied by the manufacturer. The e-matches are replaced by LEDs (with a 100 ohm series resistor) and each flight computer connected to the PC running the manufacturer's configuration program. A simulation is then run validating that the LEDs light at the appropriate times when the ejection charges should have fired. Status: Run on the Entacore AIM USB flight computer. Not started on the MAWD or HCX.
- Bench test simulating altitude with a vacuum chamber. Each flight computer is programmed using the manufacturer's configuration program. The batteries and LEDs are connected and the entire assembly is placed in a sealed chamber. Pressure is then lowered by sucking on an attached tube to

simulate launch and altitude. Pressure is next returned to ambient – this process simulates a flight (using the barometric altimeter) and the LEDs should light when the ejection charges would fire. We have access to a Druck DPI 605 Pressure Calibrator to use instead of sucking on the tube. Status: Not started.

- Field testing: The flight computer will be set up in a rocket body and payload section to simulate the actual vehicle and payload. E-matches with black powder will be used rather than LEDs. Each flight computer will be connected via USB to the PC and a simulation run. This will validate full simulated functionality of the flight computer, level of black powder required, ability to shear the nylon pins, and the ejection of the parachute. This test will be repeated as necessary to adjust the amount of black powder required to assure full parachute deployment without damage to the rocket. And it will validate the payload section is fully sealed and protected from the black powder ejection charge. Status: Not started.

3.1.5.3. Scientific Payload Subsystem

- Bench test of payload subsystem electronics. All electronics will be connected to a bench power supply and the hard drive exercised to measure latency times. Results are sent on the Ethernet port. Status: completed
- Bench test of the payload subsystem in the avionics bay with battery power source, recording to the flash thumb drive. Then that data will be downloaded and analyzed. This will assure functionality of the experiment and the ability to capture data after the experiment has flown. Status: not started.
- Field test of the payload subsystem. Similar to above, but the payload will be powered and collecting data while being swung overhead on a rope to simulate “G” forces. Data will be downloaded from the flash thumb drive and HCX to determine functionality. If needed, the test will be repeated with a different hard drive to assure reasonable data can be collected. Status: not started.

3.1.5.4. Scale model vehicle and partial subsystems

- A scale model of the full sized vehicle presented in this document will be designed and simulated on Rocksim (based upon this document and NASA feedback). This vehicle will use a 2.6” body tube and an identical design and layout. Due to the size constraints, it will be flown with a single electronic deployment system and no payload. Status: Vehicle identified as 2.6” Black Brant kit from Mad Cow rocketry with the addition of an avionics section.
- The scale vehicle will then be built and flown. It should fly to the altitude predicted by the Rocksim simulations with the main

deployed at apogee and the drogue at 900 feet. This will be verified by downloading flight data and comparing against what is expected from the simulations. Catastrophic failure will require repairing or rebuilding the vehicle until the flight is successful. Status: not started.

3.1.5.5. Full scale vehicle and full subsystems

- The full sized vehicle as presented in this document (with modifications as directed through NASA feedback) will be built and flown. This vehicle will have a full avionics bay with redundant dual deployment and the payload. Flight will be on the design Cesaroni K635 motor. We will launch at a regular, scheduled ROC launch at Lucerne Dry Lake in the Mojave Desert to take advantage of their FAA waiver. If for some reason scheduling does not permit launching at an ROC launch, we have our own launch equipment and will obtain an FAA waiver to launch at the same location using our own launch equipment.

3.1.6. Risks

The risks can be found in appendix C. This covers risks such as what could go wrong with the rocket as well as personnel risks top the team and spectators.

3.1.7. Planning of manufacturing, verification, integration, and operations including component testing, functional testing, static testing

Once the design has been approved by NASA we can begin manufacturing. In preparation, we have already purchased some body tube and coupler sections and made the avionics bay sleds. We have most of the electronics payload components and have recently purchased the flight computers. Sources have been identified for most components:

Component	Vendor/Manufacturer	URL
Scale Sized Vehicle	Modified 2.6" fiberglass Black Brant kit from Mad Cow with added avionics bay	http://www.madcowrocketry.com
Full Sized Vehicle	Modified 4" fiberglass Black Brant kit from Mad Cow rocketry with additional components from Mad Cow	http://www.madcowrocketry.com
Additional vehicle components	Payload bay coupler, longer body tube couplers, motors, e-matches, black powder from What's Up Hobbies (vendor at ROC launches)	http://whatsuphobby.com
Recovery Electronics	MAWD flight computer directly from PerfectFlite	http://www.perfectflite.com
Recovery Electronics	HCX flight computer and other miscellaneous parts	http://www.apogeerockets.com
GPS transmitter	Beeline GPS transmitter and download cable direct from manufacturer	http://www.bigredbee.com
APRS TNC	Byonics Tiny Trak 4 direct from manufacturer	http://www.byonics.com
GPS receiver	Garmin – older unit purchased from ebay	http://www.ebay.com
400 MHz receiver	Yaesu VX-6R and cabling, antennas, connectors purchased from Ham Radio Outlet	http://www.hamradio.com

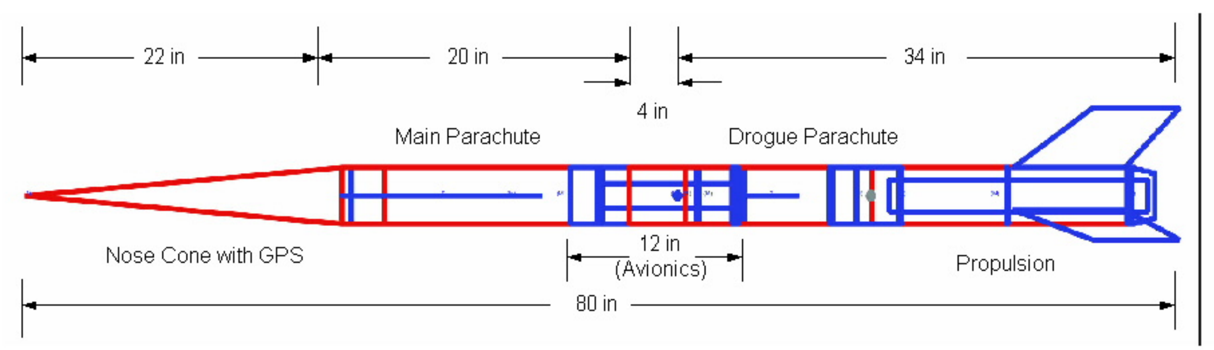
Yagi for Radio Direction Finding	430 MHz (70cm ham band) directional antenna purchased from Adept Electronics	http://www.adeptrocketry.com
Parachutes	Parachutes, launch lugs, miscellaneous parts, launch rail from vendor Giant Leap Rocketry	http://www.giantleaprocketry.com
Parachutes	Heavier parachutes- both main and drogue from Rocketman Enterprises	http://www.the-rocketman.com
Misc electronics	Local retailer Fry's Electronics	http://www.frys.com
West System Adhesive	West Systems Epoxy is available from the local West Marine store	http://www.westmarine.com
Fin Jig to assure alignment	Machinist serving the rocketry community with various standard product fin jigs is BMI Machining	http://www.bmibay.net
Launch Pad Controller	We are using the 6 pad controller from Pratt Hobbies	http://www.pratthobbies.com
"Remove before flight" flags	Flags and some electronics including the key switches are available from Aerocon Systems	http://aeroconsystems.com

Most of the construction will be done at the home of one of the mentors. All components will be assembled using West System Epoxy. Fin alignment will be assured using the BMI Fin Jig. Verification and testing will be done at the home of one of the mentors as well as at the launch site at Lucerne Dry Lake in the Mojave Desert in Southern California. John Coker (who also brings us thrustcurve.org) did a strength study of various epoxies which showed West Systems and Aeropoxy as far superior to hobby store epoxy (<http://www.jcrocket.com/adhesives.shtml>). We have chosen West Systems since it is easier to obtain than Aeropoxy. The details behind this testing and validation is in section 3.1.5 on design verification.

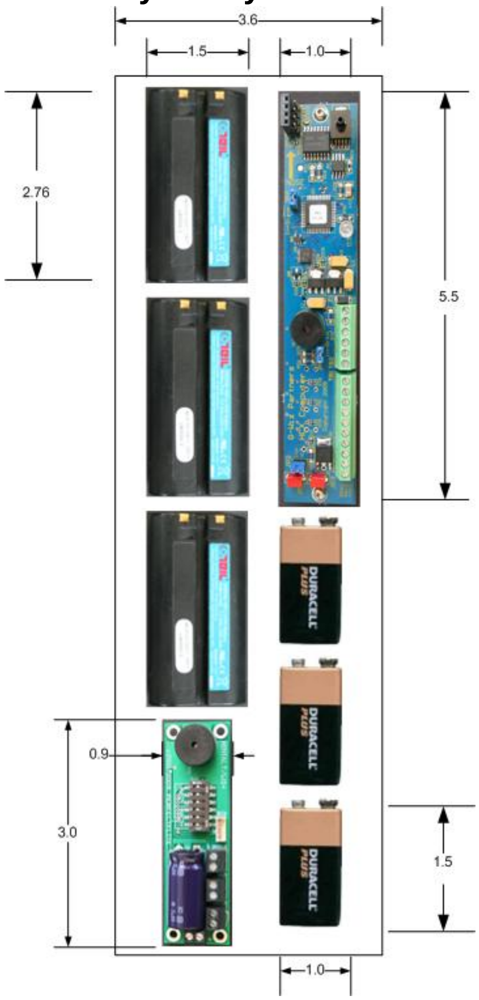
3.1.8. Confidence and maturity of the design

Several members of the team have been using Rocksim for years and when the flight simulations were successful on Rocksim with a reasonable stability margin the flights have always been successful and safe. One team mentor designs and sells rockets as a business and is our guide for design and assembly.

3.1.9. Dimensional drawing of the entire assembly

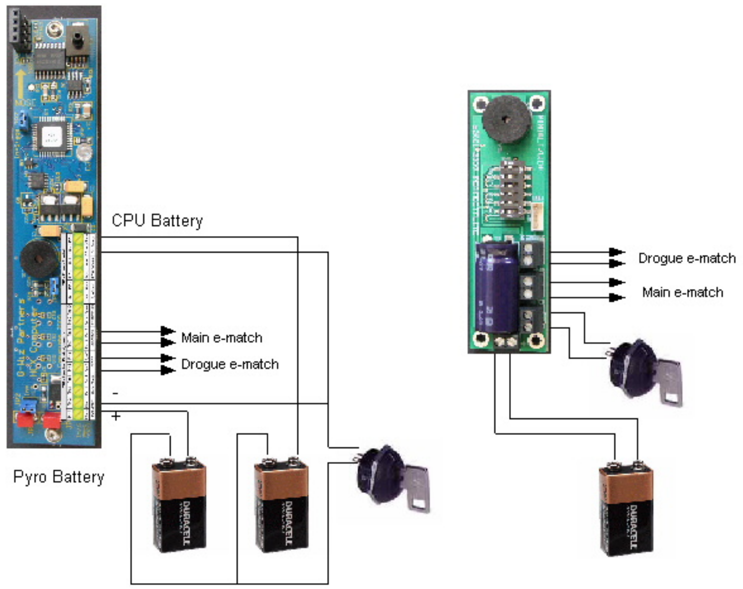


3.2. Recovery Subsystem



The recovery system will be in the electronics bay along with our payload. We do not have to fear that they will interfere with one another because they do not transmit radio waves or any other frequencies. We plan on using one side of the 3 1/2 inch by 11 7/8 inch sled. Both our flight computers will be placed vertically as indicated by the arrow that is on them. The flight computers will be on the top right and the bottom left and they will be half inch in and down from the edges on the sled. This is to allow room for mounting and to create a better fit inside the body tube. We will have a total of three batteries. The MAWD perfect flight requires one battery and the G-wiz Partners HCX allow us to use one or two batteries. We chose to use two to isolate the CPU battery from the e-match battery in case the voltage dips too low when the e-match fires – a total of three batteries placed in a line below the HCX flight computer. There will be a zip tie holding it in place, this runs over the battery. The picture is how we plan on having our recovery electronics. The other three batteries are electrically isolated from the recovery electronics and are used to power the scientific payload. Outside the bulkheads that contain the electronics bay will be two terminal blocks on both ends creating a total of four terminal blocks, there will be wires inside our electronics bay that are hooked up to our flight computers that will hook up to these terminal blocks, for each flight computer there is a terminal block for the drogue ‘chute and the main ‘chute. The electric match(es) will hook up to these terminal blocks, when the time is right our flight computers will send an electrical charge through the wires which will then ignite the progen at the end of the electrical match which will ignite the black powder. The black powder will be contained inside then end of a finger of a glove, the electrical match will be placed in the center of the black powder. Around the opening, it will be taped securely, and then taped to the bulk head. Before it is taped we will make sure that the electrical match is touching the black powder and there is no air surrounding it. The MAWD flight computer draws 8 ma and the 9V Duracell battery has a capacity of 450maH so even drawing the battery down to 50% gives us a battery life of 225maH/8ma or 28 hours. The HCX flight computer draws 65ma and again assuming 50% usable battery capacity gives us 225maH/65 or 3.46 hours. The e-match draws a lot of current but for a short period of time and should not affect the overall capacity of the MAWD battery. Our target is 3 hours (1 hour dwell time on the pad plus 1 hour flight/recovery and 1 hour margin)

3.2.1. Recovery Electronics



In the recovery system we have two flight computers, MAWD Perfect Flight and G-Wiz Partners HCX. The MAWD perfect flight altitude is based on barometric pressure while the G-Wiz Partners HCX is based on barometric pressure and an accelerometer. Our team is using two different types of altimeters so that if one malfunctions, or has a design flaw, the other one shouldn't. We hope by using this system we won't have to worry about a faulty recovery system. The two systems are electrically isolated and each has a interlock switch which will allow the recovery electronics to be off until the vehicle is on the launch pad ready for launch.

3.2.2. Black powder ejection charges

The black powder charge is essential for a successful recovery system. The top section of our rocket which contains the main parachute will need 1.27 grams of 4444F gunpowder. We got this calculation by using and online calculator at the following site <http://www.rocketreviews.com/tool_black_powder.shtml>. First we needed to find out how tall the cavity was, once measured we found out that the top section of our rocket is 18 inches long, and we are using a 4 inch body tube, which is the second measurement we need. Then our team calculated how many psi we need. We need 105 pounds of pressure to break three shear pins (35 pounds each), and then we figured out the surface area of the bulk head, which turned out to be 12.5 square inches. We then divide the pounds of pressure we needed by the surface area of the bulkhead (105lbs/12.5inches squared), this calculation gave us 8.4 pounds per square inch. We figured we need 11 PSI this number includes margin. We then plugged this calculation into the online calculator and got 1.27 grams of 4444F gun powder for the top section. For the bottom body tube, or the body tube section that holds our drogue 'chute, we did the same exact thing. The cavity is 14 inches tall, and 4 inches wide, we did not need to calculate the psi again, it would be the same. We used the online calculator and got 0.99 grams of 4444F black powder.

3.2.3. Drogue parachute

We got the diameter of the drogue parachute, made of nylon, with the use of the site, <http://www.aeroconsystems.com/tips/descent_rate.htm >, which calculated the descent rate by comparing both the mass of the rocket and the diameter of the parachute. The drogue parachute is required to keep the rocket from exceeding 100 feet per second until the main parachute deploys. The drogue diameter, we came to conclude with, is 24 inches long and it descends at a rate of 80.50 feet per second. This parachute will lower the rocket down to an altitude of 900 feet from the apogee at which it is deployed in about 54.41 seconds. It will collapse once the main parachute is deployed. The drogue parachute will be deployed by the electronics at apogee.

3.2.4. Main parachute

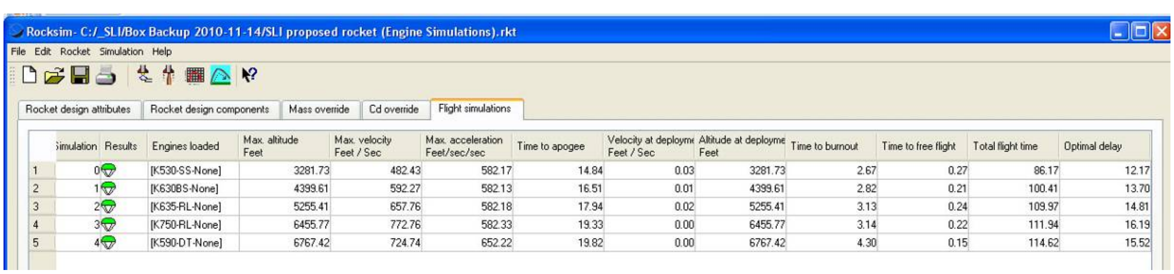
We got the diameter of the main parachute, made of nylon, with the use of the site, <http://www.aeroconsystems.com/tips/descent_rate.htm>, which calculated the descent rate by comparing both the mass of the rocket and the diameter of the parachute. The main parachute is required to keep the rocket from exceeding 22 ft/s until it lands. This parachute is 96 inches long in diameter and it descends at a rate of 20.1 ft/s. The parachute will lower the rocket down to the ground from an altitude of 900 feet within 44.73 seconds. The main parachute will be deployed when the vehicle returns to an altitude of 900 feet on the drogue.

3.3. Mission Performance Predictions

The rocket will fly to a mile high, landing within 2,500 feet of the launch pad. The altimeters will eject the drogue ‘chute at apogee, and the main ‘chute at 900 feet. The payload will collect data throughout the flight, and then be collected to formulate a written conclusion. Our GPS system will give the team the accurate location in which the rocket is.

3.3.1. Flight simulations and altitude predictions

We ran over 100 flight simulations with various vehicle configurations, wind, and motors to determine the optimum vehicle, motor, and parachutes to achieve our mission. Summaries of these simulations are shown in vehicle section under 3.1.4; the resulting vehicle design is shown in that section as well. Our final engine simulation run is shown below at zero wind:



	Simulation	Results	Engines loaded	Max. altitude Feet	Max. velocity Feet / Sec	Max. acceleration Feet/sec/sec	Time to apogee	Velocity at deployme Feet / Sec	Altitude at deployme Feet	Time to burnout	Time to free flight	Total flight time	Optimal delay
1	0		[K530-SS-None]	3281.73	482.43	582.17	14.84	0.03	3281.73	2.67	0.27	86.17	12.17
2	1		[K630BS-None]	4399.61	592.27	582.13	16.51	0.01	4399.61	2.82	0.21	100.41	13.70
3	2		[K635-RL-None]	5255.41	657.76	582.18	17.94	0.02	5255.41	3.13	0.24	109.97	14.81
4	3		[K750-RL-None]	6455.77	772.76	582.33	19.33	0.00	6455.77	3.14	0.22	111.94	16.19
5	4		[K590-DT-None]	6767.42	724.74	652.22	19.82	0.00	6767.42	4.30	0.15	114.62	15.52

We also simulated all engines at wind speeds of 0, 5, 10, 15, 16, 17, 18, and 19 miles per hour. Below is a screen capture of the graphic flight simulation from Rocksim. This simulation used the Cesaroni K635 motor with a 24 inch drogue parachute deployed at apogee and a 96 inch main parachute deployed at 900 feet. Additional data from Rocksim is in appendices G and H.

3.3.2. Performance in wind and simulated landing area

Our target was to design the rocket to have a stability margin of between 2 and 2.5 (margin is the number of body tube diameters the Center of Gravity is ahead of the Center of Pressure). The absolute minimum margin is 1.0, but this low number might be unstable in higher wind conditions. As the margin increases, the rocket will increasingly weathercock, or turn into the wind. Excessive weather cocking means the vehicle will not reach its designed altitude, since a portion of the propellant is used to push the vehicle sideways into the wind rather than straight up. The specifications indicate that we need to recover the vehicle within 2500 feet of the launch pad. If there is zero wind, this should not be a problem. But as the wind increases, the vehicle under its parachutes will be blown sideways. If we assume that the vehicle goes straight up, then the rocket will travel away from the pad by the product of the wind speed and descent rate on the drogue 'chute plus the product of the wind speed and descent rate on the main parachute. If the vehicle weathercocks into the wind, and the vehicle is blown down wind, then the distance from the pad is less than the table below:

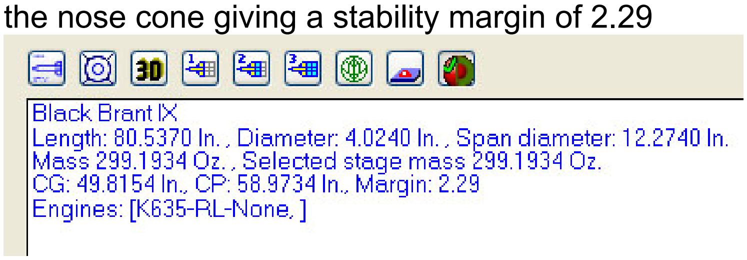
Wind (MPH)	Wind (ft/s)	Drogue Range (feet)	Main Range (feet)	Total Range (feet)
0	0.00	0.00	0.00	0.00
5	7.33	403.26	331.47	734.73
10	14.67	806.52	662.93	1469.46
15	22.00	1209.78	994.40	2204.19
16	23.47	1290.43	1060.70	2351.13
17	24.93	1371.09	1126.99	2498.08
18	26.40	1451.74	1193.28	2645.02
19	27.87	1532.39	1259.58	2791.97

If the vehicle does not weathercock at all, we can easily meet the design objective of landing within 2500 feet of the pad in 10 mile per hour wind. We still meet that criteria in 17 mile per hour wind giving us a wind margin of 7MPH. Weather cocking will further reduce that distance. This table was generated using the following parameters from the vehicle and recovery design (descent rates were calculated using a 299 ounce rocket and an on-line calculator at <http://www.aeroconsystems.com/tips/descent_rate.htm> :

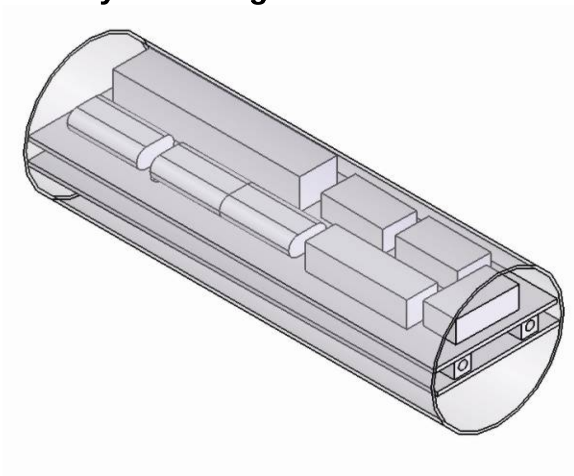
- Main parachute of 96 inches
- Drogue parachute of 24 inches
- Altitude of 5,280 feet in all cases
- Drogue deployment at apogee (5280 feet) and falls 4380 feet to main deployment at 900 feet
- Drogue descent rate of 79.65 fps (specification is 50 – 100 fps)
- Main deployment at 900 feet
- Main descent rate of 19.91 fps (specification is 17 – 22 fps)

3.3.3. Simulated Center of Pressure, Center of Gravity

Rocksim calculated the center of gravity at 49.8 inches back from the tip of the nose cone and the center of pressure at 58.9 inches back from the tip of the nose cone giving a stability margin of 2.29

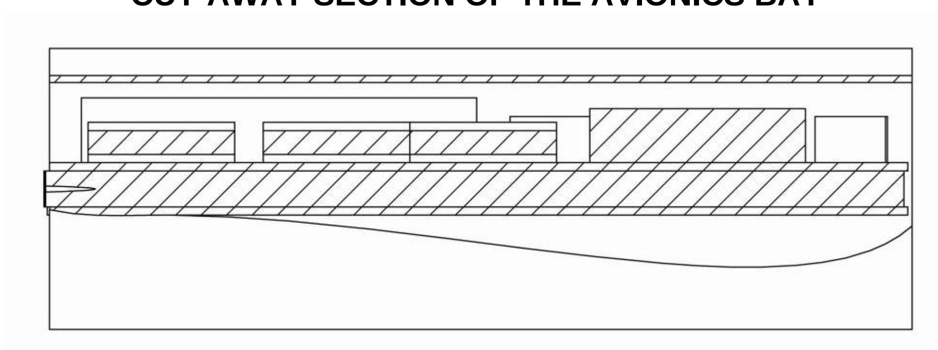


3.4. Payload Integration



The payload bay is housed in a 12" section of coupler. Inside are two sleds mounted on opposite sides of a custom aluminum rail guide pair. The recovery electronics and batteries are mounted on one sled along with the electrically isolated batteries for the scientific payload. The scientific payload is mounted on the other sled. The 3D rendering of the payload bay was done in SolidWorks and shows a slightly earlier version than the final (the 3D rendering showed some interference with the height of some of the components and required re-arranging). Each sled is attached to the aluminum rail guides with screws so it can be easily removed to gain access to the back of the sled. Once the total size, material, and weight of the entire avionics bay (scientific payload and recovery electronics) was determined, the rocket design could be completed. To assure that the payload section does not weaken the rocket, yet can be removed for servicing and data retrieval, four inches of the coupler is inserted into the vehicle body tube on either side of the bay. The remaining four inches in length is in the center and has a regular body tube section cemented in place. The one body tube insertion length is consistent with best practices for using couplers to join sections of body tube with or without a payload.

CUT-AWAY SECTION OF THE AVIONICS BAY



3.5. Launch Operation Procedures

The team will launch their rocket at a ROC launch (Rocketry Organization of California (<http://www.rocstock.org>). The ROC launch provides all equipment if the team did not launch there they would need: FAA waver, launch rail, 200+ feet of wire/cable, launch controller with a safety interlock, fire extinguisher, 2 mini tractor batteries, alligator clips, relay, and a no smoking sign.

3.5.1. Outline of the final assembly procedure

Two sections of the rocket will need to be pre-assembled before the final assembly of the vehicle can begin. These include the nose cone with GPS, the Avionics bay (recovery and scientific payload). Our flight checklist has been started and appears in appendix F.

3.5.1.1. Nose Cone with GPS

The nose cone has a cavity in foam for the GPS. The bulkhead at the back of the nose cone has a "U" bolt and a removable cover. The cover can be removed and the GPS with a freshly charged battery inserted, then the cover replaced.

3.5.1.2. Avionics Bay

HAZARDOUS MATERIAL – SEE MSDS

The assembly with the two sleds should be removed from the avionics bay. One sled contains electronics and batteries. Make certain that the key switches are in the OFF position before proceeding. The secondary rechargeable batteries should be recharged and primary single-use batteries replaced. Older single use batteries need to be disposed of properly. Verify that the scientific experiment is powered ON. The sleds can now be placed into the avionics bay – attaching any cabling assemblies. Weigh the proper amount of black powder and place in the end of a rubber glove with an electric match. Seal the end of the rubber glove with a tie wrap. Once again verify that the safety arming switch is in the OFF position. Secure this ejection charge to the bulkhead of the payload assembly and attach to the terminal block. This needs to be repeated for the two Drogue ejection charges (smaller charges) as well as the two main ejection charges. The scientific payload is now drawing power from the batteries so the balance of the assembly and flight preparation must proceed without pause. The final design should include an external switch to turn the power to the scientific payload on and off to conserve power.

3.5.1.3. Vehicle and recovery

- Attach the nose cone to the forward body tube with the steel screws
- Assure that one end of one nylon shock cord is attached to the "U" bolt on the nose cone and the other end is attached to the avionics bay. About 2/3 of the way up this shock cord (towards the nose cone) should be the Main parachute and Nomex shield.
- Assure that one end of the second Nylon shock cord is attached to the "U" bolt on the avionics bay and the other end is attached to the "U" bolt on the centering ring. About 2/3 of the way up this shock cord (towards the avionics bay) should be the Drogue parachute and Nomex shield.
- Assure the shroud lines of the main parachute are not tangled and are attached to the swivel. Fold and roll the parachute, then

roll the shroud lines around the parachute. Put the Nomex shield around the parachute and pack in the forward body tube.

- Secure the forward body tube with the end of the Avionics bay labeled MAIN with three nylon screws.
- Repeat the procedure above with the drogue parachute and the rear body tube with fins and attach to the end of the Avionics bay labeled DROGUE with three Nylon screws

3.5.1.4. Propulsion

HAZARDOUS OPERATION – SEE SAFTEY PLAN

Open the package with the Cesaroni motor. Locate the delay section and drill it out to the desired delay using the Cesaroni drill (for the current vehicle design the optimal delay identified by Rocksim was 15 seconds). Secure the delay to the top of the propulsion grains, lightly grease this assembly and insert into the casing. Screw on the rear closure. This assembly (without igniter) can be placed into the rocket and the motor retention cap screwed over the end of the motor. Twist the bare wire leads of the igniter together and securely wrap around the body of the vehicle or tape in place.

3.5.1.5. Final Launch Preparation

Once on the launch pad (rail), the electronics can be armed by turning the two key switches to the ON position listening for the audible validation from the recovery electronics that they are ready for flight. The two keys with the “Remove Before Launch” flags can then be removed. The igniter is then installed in the motor, the wires untwisted and attached to the launch system. The vehicle and payload are now ready to launch.

3.5.2. Launch Procedure

At the ROC launch the members will first check into the launch. Then they will set up their area and begin prepping the rocket. First they will assemble the payload, setting the flight computers to the right settings and set up their payload. Then they will finish assembling their rocket. They will insert the engine leaving the igniter out for safety purposes. Then they will fill out information card and wait to have their rocket checked, they will also have prove that their rocket is stable. After they are checked they then will give their information card to the announcer, He will then place them on a launch rail pad 200+ feet away. Once it is safe to do so, they will place their rocket on the launch pad , arm the recovery electronics, they will put their igniter in and arm electronics. They will then check for continuity and return to the spectator area. Once it is safe the announcer will launch the rocket. The team will then retrieve the rocket once it is safe to do so and collect all data.

3.6. Safety and environment (Vehicle)

3.6.1. Safety Officer

The safety officer for our team is Sjoen, she is also the manager of our team.

3.6.2. Failure modes of the vehicle, payload, and launch operations

The failure modes of the rocket can be found in appendix A. That appendix has a table that includes everything that could go wrong with our rocket.

3.6.3. Personnel hazards

Personnel hazards can be through materials and or processes. For materials there is Material Safety Data Sheet (MSDS), these can be found on our team website along with manuals. Our team will comply with all NAR and TRA rules and regulations. We will use all safety data instructions with our materials. All mitigations can be found in Appendix C.

3.6.4. Environmental concerns

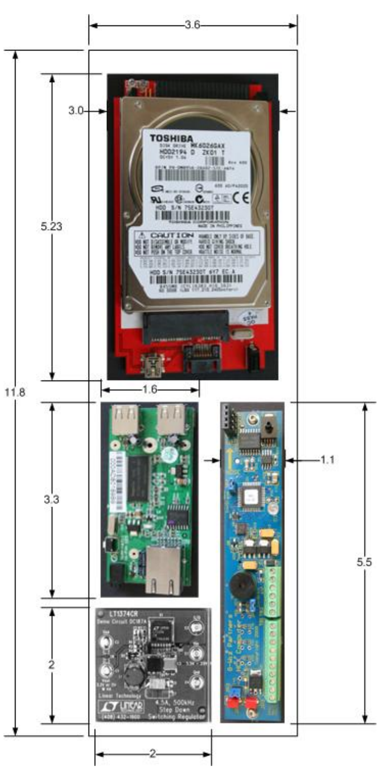
Any environmental concerns that our team has is in the table that is in Appendix B.

4. Payload Criteria

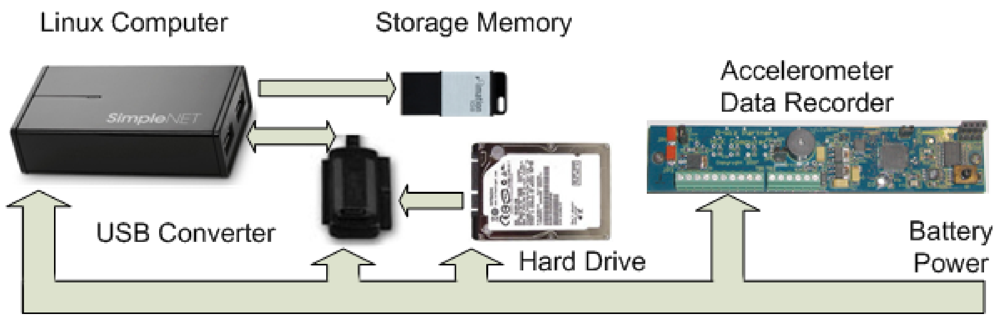
4.1. Selection, Design, and Verification of Payload Experiment

The scientific payload is designed to measure the effects of high “g” forces and vibration on an electromechanical device – a common laptop hard drive – by measuring disc latency time. We see that laptops are in use on the Space Shuttle and International Space Station – they had to have gotten there riding on a rocket. Although the “amateur” rocket in this mission exerts forces that are substantially different than those experienced in the government space program, this will still validate that if a lot of data needs to be stored during an “amateur” launch, an electro-mechanical hard drive can (or cannot) be used. Solid state hard drives will undoubtedly replace the less robust electro-mechanical hard drives of today, but the price difference still makes the older drives attractive.

4.1.1. Review of the design at the system level

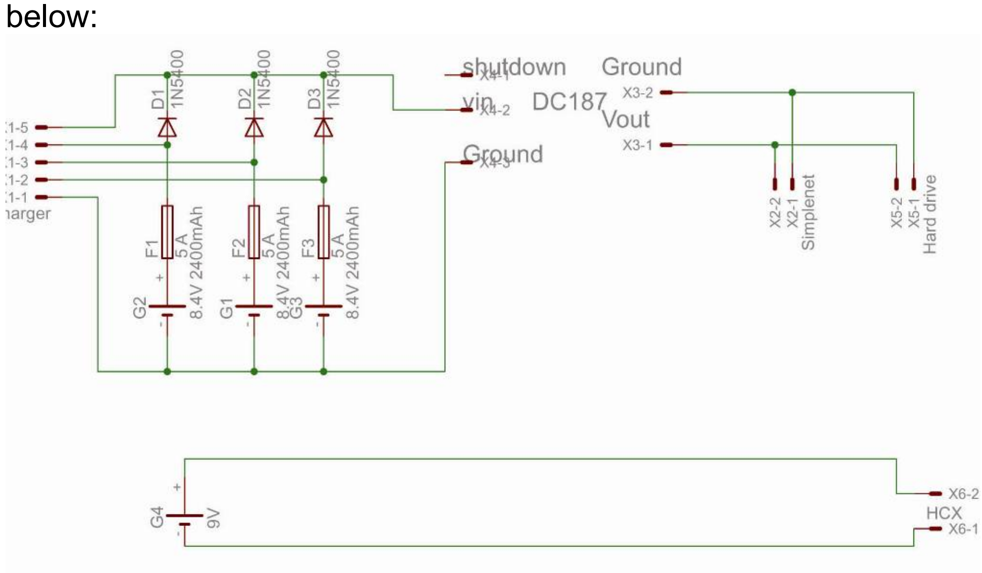


The team’s original concept was to launch an Apple iPod to see if it, especially the hard drive, could withstand the effects of an Amateur rocket launch without failing. While this sounded fun, the results were rather binary (yes it survived, or no it did not) and really did not lend itself to the scientific method. As the team talked over the options, the concept of measuring the latency time on a hard drive emerged, and the Apple iPod remained to measure the acceleration. Further examination of the iPod specifications indicated the iPod accelerometer was meant more for precision and small forces, so the iPod was dropped in favor or using the original HCX recovery computer. But this linked the recovery system to the scientific payload which is not allowed. So now the experiment includes its own HCX flight computer just to measure the acceleration. The HCX has a memory card assuring plenty of space for data storage. The hard drive is a 3.5” hard drive is a Toshiba (specifications show the hard drive can withstand 200g's while operating – but for a very short period of time). A program running on a small Linux computer will exercise the hard drive and measure the latency time, storing it on a common USB thumb flash drive. This is all powered by 3 diode isolated 8.4V 2200mAH LiIon batteries in parallel, giving a total of 6.6AH. A power converter furnishes the 5VDC required for some of the electronics. The hard drive draws approximately 0.5A at 5VDC and the Linux computer is estimated at 300ma and the HCX at 65 ma giving a total current drain of 865ma. Using 50% of the 6.6AH batteries fives 3.3AH. The power supply is 80% efficient, so 2.65AH is available to power the electronics. This gives 2.65AH at .865A or approximately 3 hours – our target on time. A functional block diagram is below:



4.1.2. Subsystems required

The Linux computer runs the program or script and the laptop hard drive records the data. Also, the supporting circuitry connects all the payload sections together. Furthermore, the 8.4 volt Lithium Ion battery packs contain the power to run all of the payload sections for three hours. In addition, the Linear Tech DC 187 converts raw battery voltage to power the experiment. A red LED visible outside of the rocket will show that the payload is powered. A schematic of the power system for the payload is below:



4.1.3. Performance

4.1.3.1. Characteristics

In our system, the small Linux computer runs our program, then the supporting circuitry that connect every sections of the payload carries the data to the hard drive and let the hard drive records the data. Also, all of the sections are power by the three 8.4 volt Lithium Ion battery packs and the Linear Tech DC 187. The 8.4 volt Lithium Ion battery packs provides the powers for all of the sections to run and the Linear Tech DC 187 converts those raw battery voltage to power the experiment.

4.1.3.2. Evaluation and verification metrics

We demonstrate that the disc latency increased after we constantly tap the hard drive. The latency went from the low 4's to the high 4's. This demonstrates that we are capturing data and the hard drive is affected by vibration.

4.1.4. Verification plan and status

We measure the hard drive latency by taping the hard drive constantly. The results showed that disc latency does increase. It went up to the high 4's. This demonstrates that our experiment is accurate.

4.1.5. Preliminary Integration Plan

Our payload experiment fits into the rocket because during the launch, the hard drive will be subjected to forces and vibrations, which will cause the hard drive to not function properly.

4.1.6. Precision and reliability

We will be testing the hard drive latency in milliseconds. This will allow us to lower our experimental error and increase our experiment's reliability. Also, the experiment will be recorded by a solid state drive.

4.2. Concept Features and Definition

4.2.1. Creativity and originality

We chose to do this experiment because we wanted to test what would happen to a hard drive when launched up into the sky. We watched a video on yelling at a database which causes vibrations on a data processor (<http://www.youtube.com/watch?v=tDacjrSCeq4>) . It was discovered that the vibrations cause disc latency. Latency is the time required to locate the first bit or character in a storage location, expressed as access time minus word time. So, with the vibration of the launch, we would measure the time it takes for the a bit or character to be stored in a location.

4.2.2. Significance

This is an important experiment because it will show us the effects of a shaken hard drive. When the hard drive is launched, the hard drive itself will be affected, and this will explain why any hard drive may actually work slower due to the slightest of vibrations.

4.2.3. Level of challenge

This experiment involves many disciplines including electrical engineering, software engineering and programming, mechanical engineering, computers and an understanding of the way electromechanical hard disk drives work. The team needs to mount the electronics securely in a limited space and design a battery power supply that will power everything for 3 hours while minimizing weight. They need to generate multiple voltages from the single battery voltage available. The payload team needs to write a program and/or script that will exercise and measure hard drive accesses and record them to a flash drive memory device. And they need to devise a way of retrieving that information and matching it against the acceleration data from a separate piece of hardware, then analyzing the data.

4.3. Science Value

4.3.1. Payload objectives and success criteria

The objective of our experiment is to show that disc latency truly does increase by measuring that increase when the rocket is subjected to high “G” forces and vibration during flight. Since they payload is made up of a series of parts to a computer, we would have to make sure that each and every piece is put up securely. The parts should not be touching the sides of our coupler because that would cause extra vibration which we are not testing for. After we retrieve the rocket, we will access the hard drive and see how the disc latency would vary during the flight.

4.3.2. Experimental logic, approach, and method of investigation

In order for this experiment to work, we require that the set up of the payload is set up in a way that allows for a secure way stay upon its platform. We would put the batteries on the side of the recovery because the items within the payload take up much more space than the recovery mechanics. The batteries, three 8.4 volt Lithium Ion battery packs, will power the Linux computer, laptop hard drive, supporting circuitry, and the G-Wiz HCX. The Linux computer, laptop hard drive, and supporting circuitry consist of one system while the G-Wiz HCX will stand alone to measure the vertical distance it travels. The power will be converted through a Linear Tech DC 187. So when in lift off, all of the subsystems will be active and will record data through the whole flight. After the flight is over, we will connect these separate electronic systems to a laptop and view the information. If our predictions are true, we will discover that the disc latency will have increased causing the Linux computer to work harder during lift off.

4.3.3. Test and measurement and controls

We, with the help of the video of shouting at the data center, hypothesize that vibrations will cause the disc latency to go up. To experiment this out of the rocket, we will tap and shake the hard drive while it is running and access the computer to read the disc latency. When in the rocket, we will record the readings of the disc latency as it goes up and down to see the effects of a shaken hard drive.

4.3.4. Relevance of expected data and accuracy/error analysis

When we tested the disc latency outside of the rocket, we measured the disc latency, but after tapping the hard drive, the disc latency went up. We expect more vibration and forces to be present when the rocket launches up so we may see readings go up substantially. Our data should be fairly accurate because we are directly accessing the hard drive; so the data will be expressed to the hundredths place.

4.3.5. Experimental process procedures

To gather the information, we are going to link the Linux computer along with the hard drive and circuit connector to another computer and transfer the information the computer.

4.4. Safety and Environment (Payload)

4.4.1. Team Safety Officer

The safety monitor is Sjoen, she will watch out for all safety hazards.

4.4.2. Failure modes

You can find the failure modes in appendix A.

4.4.3. Personnel hazards

Personnel hazards can be through materials and or processes. For materials there is Material Safety Data Sheet (MSDS), these can be found on our team website along with manuals. Our team will comply with all NAR and TRA rules and regulations. We will use all safety data instructions with our materials. All mitigations can be found in Appendix C.

4.4.4. Environmental

The environmental hazard can be found in Appendix B

5. Activity plan

5.1. Budget

Our budget is in Appendix I. To pay for this, we are going to target fundraising the many aerospace industries in Southern California. These include Boeing, Raytheon, Northrop Grumman, and Lockheed Martin. Even though JPL is close-by, they cannot help since all of their funds are allocated. We are planning to have a writing letter campaign asking for donations. The AIAA Orange County section is also helping us with a grant from Boeing, since they have inside contacts. When we write the articles for the newspapers we will ask for donation as well if we are allowed. We are planning a garage sale in January and a car wash in February.

5.2. Timeline

The complete timeline is in Appendix J.

5.3. Educational engagement

Educational outreach has already begun. After we announced our need to do some educational outreach to some ROC members, we were contacted by Richard Dierking of the Temecula Rocketry Group. He asked if we would like to do a workshop for the Girl Scouts of Long Beach, California.

5.3.1. Girl Scouts

On October 16th at 8 am we arrived at the Girl Scout clubhouse. The group setup tables and chair for about 35 scouts, put out the supplies and laid a rocketry kit at each position. At 9:00 the scouts began to arrive. We introduced ourselves and began the build. We kept everyone on the same step to make it easy on us and when that step was done we moved on. All the rocket kits were built in about two hours.

On November 6th at the Santa Fe Dam Recreational Area in the city Of Irwindale, California all the girl scouts who participated in the rocketry workshops across two counties came to launch to launch their rockets. We helped prepare their rockets for launch by showing them how to place “dog barf" (heat insulation) in the rocket body tube to protect the parachute, then taught them how to fold their parachutes so it would deploy properly. We then showed them how to place the engine in the motor tube and insert the igniters. Then they went to the inspection table to check in. There were about 40 Girl Scouts that came to the launch and they looked like they were having a good time since they launched their rockets over and over.

5.3.2. AIAA Professional Society

The AIAA Orange County section has asked us to come to their Board meeting on January 11th to give a presentation on our project and have invited the AIAA membership for Orange County. We will present our project in a PowerPoint including our budget. We have also been asked to give a paper at the ASAT (Aerospace Systems And Technology) Conference in May

5.3.3. Newspaper Articles

Our local newspaper "The Register" is planning on doing a feature story on our group. They want to attend some of our meetings and go to one of our launches. We have also been asked to write an article for our neighborhood newspaper , "The Foothills Sentry" - after the PDR is done.

5.3.4. 4H

The Fountain Valley Cloverdales 4 H club has invited us to come to their General Meeting and give a presentation and a workshop in January or February. We hope to leverage this opportunity to reach more 4H youth.

5.3.5. Discovery Science Center

We are waiting to hear back from Discovery Science Center in Orange County California to see if we can schedule an outreach event at their center in January. The center is focusing on space and caters primarily to youth.

6. Conclusion

The AIAA Orange County section SLI team is very excited to be a part of the Student Launch Initiative program. We hope that we continue on and are able to travel to Huntsville for the final Launch. We believe that our payload will work properly and we will receive meaningful results. We believe our rocket will travel to the 1 mile altitude and will not go outside of the allowed 2,500 foot range. This project provides a valuable insight into a real engineering project and will help improve out team's writing skills (technical and otherwise).

Appendix A

This is a table of what might or could go wrong with our project with solutions and safety precautions.

What could go wrong	How we will fix it
The Rocket misfires	-We will use E-Matches for our Cesaroni engines, they are the provided igniters -We will double check the igniter before putting on the cap on of the Cesaroni Engine -We will we check for contiguity before returning to the spectator area
The rocket struggles off the launch pad	-We will use a large enough engine that has enough impulse for the rocket(K635) -We will make sure the engine we use manufacture recommendation of weight is applied to our rocket
The engine “chuffs”	-We will use a single use Engine for our rocket, That will be a Cesaroni engine, manufacture made
The engine explodes	-We will use a single use engine for our rocket, That will be a Cesaroni engine, manufacture made
The Drogue parachute does not deploy	-We will double check our recovery system before launch, once while assembling it and once before it is placed on the launch pad -Before leaving the launch pad we will check that our Electronics bay is armed and ready to go -We will test how long a battery will last in the recovery system, in case there is a delay because of weather conditions or other such things that would prevent launching -We will use a electronics bay and tape in our batteries before launch -We will check that there is no air between the gun powder and the E-match -We will check that all electronics are wired properly and will do what they are programmed to do in flight
The Drogue parachute deploys at the wrong altitude	-We will double check our recovery system before launch, once while assembling and once before it is placed on the launch pad -We will test how long a battery will last in the recovery system, in case there is a

	delay because of weather conditions or other such things that would prevent launching -We will program our electronics and test them to make sure they work properly -We will check that there is no air between the gun powder and the E-match
The Main parachute does not deploy	-We will double check our recovery system before launch, once while assembling it and once before it is placed on the launch pad -Before leaving the launch pad we will check that our Electronics bay is armed and ready to go -We will test how long a battery will last in the recovery system, in case there is a delay because of weather conditions or other such things that would prevent launching -We will use a electronics bay and tape in our batteries before launch -We will check that there is no air between the gun powder and the E-match -We will check that all electronics are wired properly and will do what they are programmed to do in flight
The Main parachute deploys at the wrong altitude	-We will double check our recovery system before launch, once while assembling and once before it is placed on the launch pad -We will test how long a battery will last in the recovery system, in case there is a delay because of weather conditions or other such things that would prevent launching -We will program our electronics and test them to make sure they work properly -We will check that there is no air between the gun powder and the E-match
The Rocket weather cocks	-Our rocket will be stable, not over stable -We won't have over sized fins -We might include a tail cone to reduce drag
The rocket folds upon itself	-We will use a engine that won't accelerate to that speed -We will use fiber glass material to construct our rocket

The altimeter(s) gets damaged	-we will use an electronics bay to hold all electronics -we will have rails with nuts to hold the sled in place so it will not shake and slide during launch -We will secure our electronics onto the sled securely so they will not come apart from it
The battery(s) of our electronics bay fall out	-We will tape in battery(s) so they will not fall out
The battery(s) 'die' during launch	-we will use fresh batteries for each launch, testing them to make sure there isn't any fault in their power (very low electricity output) -We will test how long a battery will last in the recovery system, in case there is a delay because of weather conditions or other such things that would prevent launching
The electric match doesn't ignite the black powder	-We will fresh e-Matches when launching our rocket, that made from a recommendable manufacturer -We will check that there is pyrogen at the end of the e-match and enough of it to be able to ignite the black powder
The altimeter isn't set to fire the drogue 'chute	- We will double check to make sure that the electronics bay is set up correctly and everything is programmed to do everything that it is supposed to
The altimeter isn't set to fire the drogue 'chute at correct height	-We will double check the programming of our altimeters is correct
The altimeter isn't set to fire the main 'chute	- We will double check to make sure that the electronics bay is set up correctly and everything is programmed to do everything that it is supposed to
The altimeter isn't set to fire the main 'chute at the correct height	-We will double check the programming of our altimeters is correct
Tracking device isn't accurate	-We will test our tracking device before using it in our vehicle -We will make sure that our tracking device is accurate so we may retrieve the rocket
Tracking device doesn't transmit radio waves	-We will check that our tracking device is set up properly and is functioning correctly before loading it into the electronics bay -We will make sure that the batteries are

	new and fresh to make sure that our tracking device can transmit radio waves
Tracking device is damaged in launch	- We will use an electronics bay to hold all electronics -we will have rails with nuts to hold the sled in place so it will not shake and slide during launch -We will secure our electronics onto the sled securely so they will not come apart from it

Appendix B

This is a table showing environment hazards and waste material and how we fix there apposed threat or how we dispose of the properly

There is grass surrounding the launch pad	-The site we will be launching at Lucerne Dry Lake, there is no surrounding grass.
The rocket's launch pad is angled or faced so that it will be launched at targets, clouds, near airplanes, or on trajectories that take it directly over the heads of spectators or beyond boundaries of the launch site.	-The site we will be lunching at is at Lucerne dry lake. The launch is regulated by ROC, there is a area for spectators, they wait for airplanes to pass and the rockets do not launch into clouds.
The rockets launch pad is near trees, power lines, buildings and persons not involved in the launch	-the launch site we will be launching at is at Lucerne dry lake, there are no trees, power lines, or buildings. There are miles and miles of open space so there will be no problem with people who are not involved with the launch presenting a hazard.
The launcher isn't 1500 feet away from an inhabited building or from any public highway on which traffic flow exceed ten vehicles per hour, not including traffic flow related to the launch	-The launch site we will be launching at id Lucerne Dry Lake, we will be roughly five miles out from the road.
Person(s) are closer to the launch pad of a high power rocket than the person actually launching the rocket	-The launch site we will be launching at is at Lucerne Dry Lake at a ROC Launch. There is a designated spectator area.
The recovery system fails, the rocket free falls	-The rocket will have a dual recovery system, to prevent a failed recovery -The Batteries will be tested and known to work after sitting on the launch pad for an hour plus the launch and recovery.
Person(s) recovering the rocket attempt to recover it in a hazardous area	-The launch site we will be launching at does not contain hazardous areas like tall trees or power lines
The Rocket might be unstable	-The rocket will be constructed using *Rocksim, documentation proving it is stable will be on hand if asked to prove the rockets stability
The payload in the high power rocket could be flammable, explosive, or cause harm.	-The rocket's electronics bay does not contain explosive material/ substances. The use of black powder is limited to how pressure is necessary to deploy the drogue 'chute or the main 'chute
Disposal:	
Batteries	-The team will dispose of this material at **Anaheim Disposal, Inc.**

	Customer Service (714) 238-2444 1131 North Blue Gum Street Anaheim CA 92806 or at Datamax-O'neil 8 Mason, Irvine, CA 92618-2705 (949)206-6810
Electrical Matches	-The team will dispose of this material at **Anaheim Disposal, Inc.** Customer Service (714) 238-2444 1131 North Blue Gum Street Anaheim CA 92806 or at Datamax-O'neil 8 Mason, Irvine, CA 92618-2705 (949)206-6810
Dead or Damaged Electronics	-The team will dispose of this material at **Anaheim Disposal, Inc.** Customer Service (714) 238-2444 1131 North Blue Gum Street Anaheim CA 92806 or at Datamax-O'neil 8 Mason, Irvine, CA 92618-2705 (949)206-6810
Fiberglass	-The team will dispose of this material at Higgins Environmental 311 Yorktown Huntington Beach, CA 92648 (714) 747-9850
Paint Materials	-The team will dispose of this material at Higgins Environmental 311 Yorktown Huntington Beach, CA 92648 (714) 747-9850
Spent Engines	-The team will dispose of this material at Higgins Environmental 311 Yorktown Huntington Beach, CA 92648 (714) 747-9850
Epoxy	-The team will dispose of this material at Higgins Environmental 311 Yorktown Huntington Beach, CA 92648 (714) 747-9850

Appendix C

The Appendix C contains a table displaying the risks and the probability of them occurring and how much damage it could impose, the lower the number the lower the risk. The table should be read left to right to left, the left showing a consequence that is less severe. Inside the graph is how we can avoid the risk under the graph are the risks

.1 rocket misfires
2 The rocket folds upon itself
3 rocket struggles off the launch pad
4 The engine "chuffs"
5 The Rocket weather cocks
6 Payload isn't set up
7 The Payloads HCX isn't accurate
8 The *Linn Ex Computer isn't programmed correctly
9 The rocket landing in a dangerous area
10 The rocket landing in mud
11 The rockets fin breaking
12 The engine explodes
13 The Drogue 'chute fires at the wrong altitude
14 The battery(s) 'die' during launch
15 The Drogue 'chute misfires
16 The altimeter isn't set to fire the drogue 'chute
17 The altimeter isn't set to fire the drogue 'chute at correct height
18 The Main 'chute fires at the wrong altitude
19 The Main 'chute misfires
20 Tracking device isn't accurate
21 Tracking device doesn't transmit radio waves
22 Tracking device is damaged in launch
23 sheer pines aren't put in place
24 The car running over the rocket
25 The altimeter isn't set to fire the main 'chute at the correct height
26 The electric match doesn't ignite the black powder
27 The black powder blows the rocket apart
28 The altimeter isn't set to fire the main 'chute
29 No recovery system
30 The battery(s) of our electronics bay fall1 out

5 the design is not over stable	10 Make sure launch site is dry	15 double check programming on the altimeter is correct	20 Make sure tracking device works	25 double check programming on the altimeter is correct	30 Tape batteries and double check connection
4 make sure igniter is all the way in the engine	9 Launch site is clear of all hazardous materials	14 use fresh batteries	19 double check programming on the altimeter is correct	24 hope for the best	29 Double-check our rocket is set up correctly
3 use the correct size launch rod	8 double check programming before launch	13 double check programming on the altimeter is correct	18 double check programming on the altimeter is correct	23 double check the rocket before placing on the launch pad	28 double check programming on the altimeter is correct
2 body tube and nose cone are fiberglass	7 Make sure device isn't damaged	12 make sure there is no defects in engine	17 double check programming on the altimeter is correct	22 Make sure Tracking device is secure	27 make sure black powder amount is correct
1 check continuity	6 double check the payload is set up	11 Use in wall fins	16 double check programming on the altimeter is correct	21 double check tracking device is on	26 make sure there electric match is touching the black powder

Appendix C 'Continued'

This is a table of risks that don't deal directly with the rocket and subsystems. This would include budgeting, parts, school holidays and team members themselves. The table should be read left to right to left, the left showing a consequence that is less severe. Inside the graph is how we can avoid the risk under the graph are the risks

1 Parts are delivery damaged
2 Parts delivery is delayed
3 Large amounts of people leaving for the holidays
4 Having a lack of mentors
5 Wrong part is delivered
6 Not fulfilling our public outreach
7Not being recognized publicly by media response
8 Team members not being familiar with the project
9 Vehicle getting damaged
10 Members not completing written sections
11Vehicle receives damage traveling to launch site
12 school holidays not coinciding
13 Miscommunication between members
14 Not raising enough money to cover the costs
15 Electronics damaged during tests
16 Not raising enough money to cover travel fees
17 Not all members are readily availed to travel to Huntsville
18 Written Document not being completed on time
19 Suppliers not having our items in stock
20 Not following the schedule

4 Our team has a large group of mentors that are skilled in rocketry	8 our team will give presentations on their sections. We will also review vital information	12 A large sum of our team have the same holiday schedule	16 Our team plans on holding many fundraising events	20 The team will be constantly reminded of the schedule
3 Most people are not leaving or if they are it is for a short period of time	7 Local media already has interest in our team	11 The vehicle will travel safely inside the car.	15 Our team will be precautious during testing	19 The team will have a backup supplier
2 Bob will pick up parts	6 our team is ready and willing to help the community	10 The team will have many meetings to finished written sections	14 Our team plans on holding many fundraising events	18 The team will push themselves to finish the written document
1 Bob will pick up parts	5 Bob will pick up parts	9 Vehicle will be stored safely	13 Our team will have frequent meetings throughout the project	17 Members who don't have a break during the time to travel to Huntsville are willing to miss school for this educational program

Appendix D

This appendix shows all materials, weights and sizes of parts that we will use on our rocket. This included everything from body tubes to electronics.

Component	Material	Qty	Weight (grams)	Total Weight (grams)	Length (inches)	Width (inches)	Thickness (inches)	Comments
Vehicle								
Nosecone	Fiberglass	1	293	293	22	4	0.07	Fiberglass with gel coat
Foam		1	60	60	22	4	n/a	Foam Fill around removable GPS
GPS Transmitter	PCB, Copper Wire	1	57	57	3	1.25	0.75	6.5" antenna
Battery	LiIon	1	51	51	1.75	1.25	0.25	Power for GPS
Bulkhead	G-10 Fiberglass	3	33	99	n/a	4	0.09	Total 0.27 thick 99g weight
Bulkhead Cover	G-10 Fiberglass	1	8	8	n/a	1.75	0.09	Cover for GPS access
Retaining Nuts	Steel	2	1	2	n/a	#6	n/a	Retention for cover (2g total)
Retaining Screws	Steel	2	1	2	0.5	#6	n/a	Retention for cover (2g total)
"U" Bolt assembly	Steel	1	37	37	2	2.1	0.2	Attachment for shock cord
Upper Body Tube	G-10 Fiberglass	1	500	500	20	4	0.06	Home for main parachute
Main Parachute	Ripstop Nylon	1	627	627	n/a	84	n/a	
Swivel	Steel	1	75	75	3	0.5	n/a	1500 lb test
Shock Cord	Nylon	1	135	135	180		9/16	15 ft flat nylon strap 2000lb test
Kevlar Sleeve	Kevlar	1	25	25	36	1	.015	Protect Shock Cord during eject
Nomex Shield	Nomex	1	53	53	n/a	18	.015	Protect Parachute during eject
Quick Link	Steel	2	33	66	2	1	0125	
Screws	Steel	4	1	4	0.5	#6	n/a	Retention for nose cone
Launch Rail Lugs	Aluminum	1	4	4	1.526	0.75	0.29	
Middle Body Tube	G-10 Fiberglass	1	100	100	4	4	0.06	Over the payload bay
Avionics Bay								
Coupler	G-10 Fiberglass	1	370	370	12	4	0.06	

Bulkhead	G-10 Fiberglass	2	33	66	n/a	4	0.06	0.12 total thickness
Bulkhead Shaved	G-10 Fiberglass	2	32	64	n/a	3.8	0.06	
Threaded Rod	Steel	2	66	66	13	n/a	0.25	Holds A-Bay together
0.25" tube	Cardboard	2	4	8	10	0.25	n/a	On sled - slides over rod
Captive Nuts	Steel/Nylon	2	2	4	n/a	0.25	n/a	One end of threaded rod
Nuts	Steel	6	3	18	n/a	n/a	n/a	On threaded rod inside of Avionics Bay
Wing Nuts	Steel	2	5	10	n/a	n/a	n/a	Removable end of threaded rod
Small Washer	Steel	4	2	8	n/a	0.62	0.08	Outside - between nut and bulkhead
"U" Bolt Assembly	Steel	2	37	74	2	2.1	0.2	Attachment for shock cord
Electronics Sled	Plywood	2	57	114	11.75	3.625	0.25	Attachment for electronics
Terminal Block (2 wires)	Nylon/Steel	4	4	16	0.67	0.58	0.55	Electrical Contact for e-matches
Rubber Glove Finger End	Nitrile	4	0.5	2	1.8	1	n/a	Containment for black powder
Small zip ties	Nylon	4	0.5	2	4.125	0.1	0.045	Seal glove-black powder-ematch
Black Powder	Gun Powder	2	1.25	2.5	n/a	n/a	n/a	Main Parachute Ejection Charge
Black Powder	Gun Powder	2	1	2	n/a	n/a	n/a	Drogue Parachute Ejection Charge
Electric Match	Copper/Pyrogen	4	6	24	6	n/a	n/a	J-Tek
Recovery Electronics								
MAWD Computer	PCB	1	17	17	3	0.9	0.75	Barometric altitude flight computer
Attachment hardware	Steel	1	6	6	n/a	n/a	n/a	Standoffs, nuts, screws
HCX Computer	PCB	1	44	44	5.5	1.125	0.75	Accelerometer altitude flight computer
Attachment hardware	Steel	1	6	6	n/a	n/a	n/a	Standoffs, nuts, screws
9V Batteries	Alkaline-Zinc Manganese Dioxide	3	46	138	2	1	0.65	1 for MAWD and 2 for HCX
Battery connector	Steel, Plastic, Copper	3	3	9	n/a	n/a	n/a	for 3 9VDC batteries
Wiring	Copper	1	20	20	n/a	n/a	n/a	Multiple lengths of copper wire
Safety Interlock Switch		2	27	34	0.75	0.875	n/a	Externally accessible to arm recovery
Tie Wraps	Nylon	12	2	24	14	0.17	0.05	To secure batteries to sled
Scientific Payload								
Linux Computer	PCB	1	44	44	3.4	1.6	0.77	Reads & Writes & Measures to hard drive
3.5" Hard Drive	PCB, metal	1	130	130	5.25	3	0.44	Hard drive and interface assembly

USB Interface for Hard Drive	PCB	1						
USB Flash Drive	PCB, metal, plastic	1	8	8	2.75	0.64	0.37	Thumb drive for PC
HCX Computer	PCB	1	44	44	5.5	1.125	0.75	Acceleration measurement
Mounting hardware	Steel		24	24	n/a	n/a	n/a	Mounting for all hardware above
Power Converter to 5VDC	PCB	1	17	17	2	2	0.25	Convert battery to 5VDC
8.4 V LiIon Batteries	LiIon	3	101	303	2.75	1.5	0.8	Diode Isolated in parallel
Lower Body Tube	G-10 Fiberglass	1	763	763	31	4	0.06	Home for drogue and propulsion
Drogue Parachute	Ripstop Nylon	1	153	153	24	n/a	0.005	1/2 mil
Swivel	Steel	1	23	23	2.33	0.85	n/a	1500 lb test
	Nylon	1	135	135	180	16-Sep	0-Jan	15 ft flat nylon strap 2000lb test
Shock Cord	Kevlar	1	25	25	36	1	.015	Protect Shock Cord during eject
Kevlar Sleeve	Nomex	1	33	33	n/a	12	.015	Protect Parachute during eject
Nomex Shield	Steel	2	33	66	2	1	0-Jan	Between Nylon shock cord and "U" bolt
Quick Link Centering Rings	G-10 Fiberglass	3	25	75	n/a	4	0.09	Inside body tube - outside engine tube
54mm engine tube	G-10 Fiberglass	1	180	180	18	2.125	0.06	Hold engine casing
	Steel	2	37	74	2	2.1	0.2	Attachment for shock cord
"U" Bolt Assembly	G-10 Fiberglass	3	138	414	12	5	0.06	3 fins
Fins Launch Rail Lugs	Aluminum	1	4	4	1.526	0.75	0.29	For 1" square launch rail
	Balsa, G10 Fiberglass	1	75	75	6	4	n/a	Behind body tube - minimize base drag
Tailcone assembly Motor Retention	Aluminum	1	42	42	1	2.6	0.09	Keep motor from ejecting
Miscellaneous								
	Epoxy	1	150	150	n/a	n/a	n/a	Estimate
Epoxy Adhesive	Enamel	1	100	100	n/a	n/a	n/a	Estimate
Paint VEHICLE AND PAYLOAD TOTAL				6228.5				219.70385986 Ounces

Propulsion

5 Grain Motor Casing	Aluminum	1	484	484	18.83	2.125	n/a	Cesaroni for 5Grain motor
Cesaroni K635 Motor	APCP, Plastic	1	1989	1989	18	2	n/1	Burnout = 658g
PROPULSION TOTAL				2252				79.43695792 Ounces
GRAND TOTAL				8480.5				299.14081778 Ounces

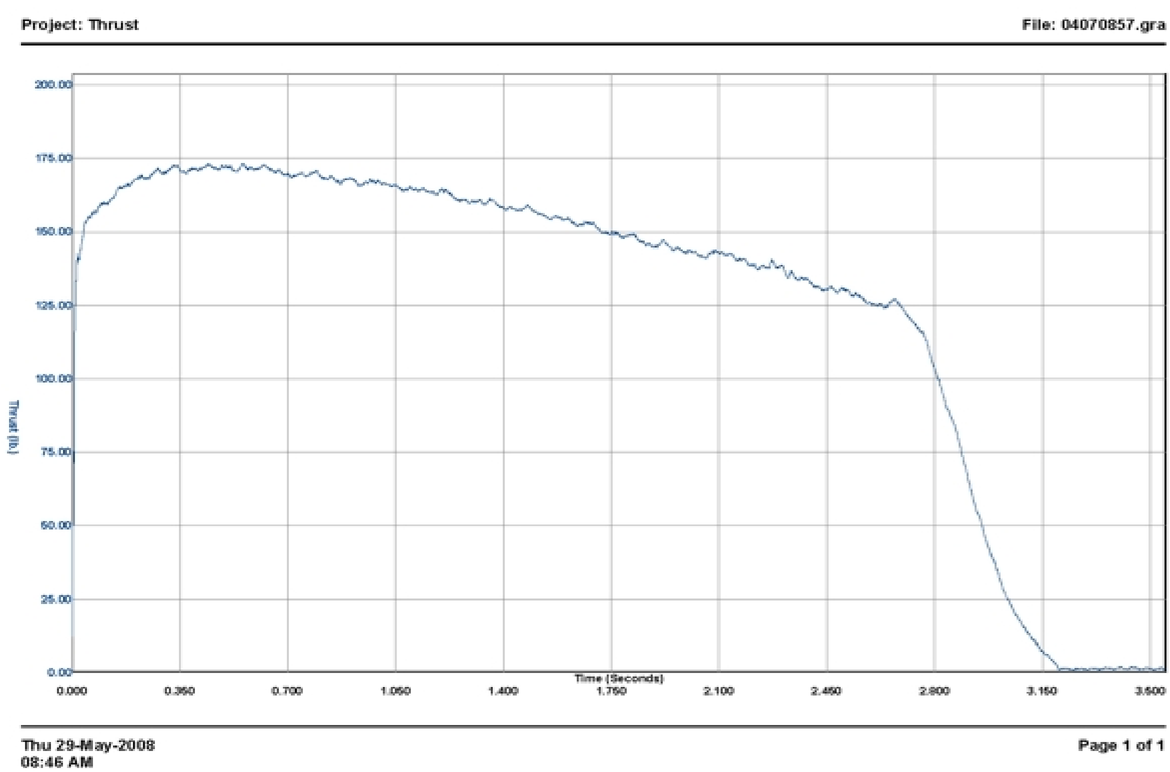
APPENDIX E

Pro54 1994K635-17A

Motor Data

Brandname	Pro54 1994K635-17A	**Manufacturer**	Cesaroni Technology
Man. Designation	1994K635-17A	**CAR Designation**	1994-K635-17A
Test Date	7/6/2003		
Single-Use/Reload/Hybrid	Reloadable	**Motor Dimensions mm**	54.00 x 488.00 mm (2.13 x 19.21 in)
Loaded Weight	1989.90 g (69.65 oz)	**Total Impulse**	1749.50 Ns (393.64 lb.s)
Propellant Weight	1281.00 g (44.84 oz)	**Maximum Thrust**	728.70 N (163.96 lb)
Burnout Weight	658.40 g (23.04 oz)	**Avg Thrust**	656.00 N (147.60 lb)
Delays Tested	17 - 7 secs	**ISP**	139.30 s
Samples per second	1000	**Burntime**	2.66 s
Notes	Red Lightning™		

Representative CMT Thrust Curve



APPENDIX F

Flight Checklist

Pre-preparation

☐ Remove both parachutes and set them aside

☐ Remove the payload bay and remove the sleds assembly from inside the bay

HAZARDOUS MATERIAL – SEE MSDS

☐ Remove any spent engine from the rocket and the engine itself from the engine casing and dispose of properly

☐ Wash off any residue from the casing and set it aside to dry

Visual inspection before proceeding

☐ Verify that both shock cords are not frayed or burned (replace if needed)

☐ Verify that both shock cords are attached securely with quick links to the “U” bolts

☐ Verify that both Nomex parachute shields are in good shape and not burned through

Payload and recovery

☐ Verify that both flight computers are programmed correctly

HAZARDOUS MATERIAL – SEE MSDS

☐ Make certain the recovery power switch is in the OFF position

☐ Remove the old 9VDC batteries and discard correctly. Replace with new batteries.

☐ Make certain the payload power switch is in the OFF position

☐ Verify that the rechargeable batteries are at full charge by measuring with a voltmeter. They should measure at least 7.7VDC and may be as high as 8.4VDC if recently removed from the charger.

☐ Assemble the avionics bay connecting any cables and securing the bulkhead with the wing nuts

☐ Short out the pyro outputs and turn the power ON switch to ON to make certain that the MAWD and the HCX do not beep out any error codes (see beep chart). Turn the power switch back OFF again and remove the shorts on the pyro outputs

☐ Briefly power on the payload power switch and verify power on beeps and the external red power LED is ON. Turn the power switch back OFF again

HAZARDOUS OPERATION – SEE SAFTEY PLAN

☐ Prepare the TWO **DROGUE** parachute ejection charges

- ☐ Measure the black powder for each **DROGUE** parachute ejection charges
- ☐ Cut off an end of a rubber glove finger and pour in the black powder
- ☐ Twist the wire ends of the e-match together
- ☐ Insert an e-match and into the glove finger with the black powder
- ☐ Compress the each glove finger and seal tightly with a zip tie
- ☐ Make certain the payload power switch is in the OFF position
- ☐ Untwist the ends of the e-match and connect to the **DROGUE** terminal block
- ☐ Secure the glove finger/e-match/black powder so it won't shift during launch

HAZARDOUS OPERATION – SEE SAFTEY PLAN

☐ Prepare the TWO **MAIN** parachute ejection charges

- ☐ Measure the black powder for each **MAIN** parachute ejection charges
- ☐ Cut off an end of a rubber glove finger and pour in the black powder
- ☐ Twist the wire ends of the e-match together
- ☐ Insert an e-match and into the glove finger with the black powder
- ☐ Compress the each glove finger and seal tightly with a zip tie
- ☐ Make certain the payload power switch is in the OFF position
- ☐ Untwist the ends of the e-match and connect to the **MAIN** terminal block
- ☐ Secure the glove finger/e-match/black powder so it won't shift during launch

Nose cone with GPS preparation

☐ Verify that the battery for the GPS is fully charged by measuring it with a voltmeter. It should measure between at least 3.85 volts and may be as high as 4.2 volts if just removed from the charger

☐ Connect the battery and verify the GPS has locked on to satellites (may take several minutes – verification process TBD)

☐ Verify the transmitter is working using the ground tracking station and Garmin display

☐ Remove the cover on the bulkhead in the nose cone and insert the GPS transmitter into the cavity

☐ Replace the bulkhead tightly enough to seal against ejection gas leaking into the electronics

☐ Secure the nose cone to the forward body tube with the three steel screws.

Vehicle preparation – MAIN parachute

☐ Open the **MAIN** parachute completely and verify the shroud lines are in good shape and not tangled

☐ Connect the **MAIN** parachute to the shock cord using the swivel

☐ Carefully fold and roll the **MAIN** parachute, rolling the shroud lines ½ way around the parachute, then reversing direction and continue rolling

☐ Place the **MAIN** parachute into the Nomex shield and wrapping the shield around the parachute

☐ Put the shock cord into the forward body tube followed by the parachute in the Nomex shield verifying the parachute is completely protected by the Nomex shield

☐ Insert the **MAIN** end of the payload bay into the forward body tube and secure with three #2 nylon shear screws

Vehicle preparation – DROGUE parachute

☐ Open the **DROGUE** parachute completely and verify the shroud lines are in good shape and not tangled

☐ Connect the **DROGUE** parachute to the shock cord using the swivel

☐ Carefully fold and roll the **DROGUE** parachute, rolling the shroud lines ½ way around the parachute, then reversing direction and continue rolling

☐ Place the **DROGUE** parachute into the Nomex shield and wrapping the shield around the parachute

☐ Put the shock cord into the read body tube (with fins) followed by the parachute in the Nomex shield verifying the parachute is completely protected by the Nomex shield

☐ Insert the **DROGUE** end of the payload bay into the rear body tube (with fins) and secure with three #2 nylon shear screws

Vehicle preparation - propulsion

☐ Remove the Cesaroni engine from its cardboard tube and locate the igniter

☐ Twist the bare metal ends of the igniter together and set it aside

☐ Locate the delay element and use the delay drill to set the desired delay

☐ Place the delay element on the end of the propulsion grains

☐ Lightly grease the outside of the plastic grain and delay case and insert into the metal casing

☐ Insert the motor into the vehicle and secure with the motor retaining cap

☐ Secure the igniter to the outside of the vehicle

Final vehicle preparation for launch

☐ Submit the vehicle for inspection to the range safety officer – when approved proceed to the assigned launch rail

☐ Side the vehicle onto the launch rail

☐ Arm the recovery electronics and validate there are no errors based upon the beeps

☐ Arm the scientific electronic payload and validate the red LED is ON and the payload is functional

☐ Untwist the bare metal ends of the igniter and insert completely into the motor and secure

☐ The vehicle can now be launched

APPENDIX G

From Rocksim Simulation Details:

Black Brant IX - Simulation results

Engine selection
[K635-RL-None]
Simulation control parameters
Flight resolution: 800.000000 samples/ second
Descent resolution: 1.000000 samples/ second
Method: Explicit Euler
End the simulation when the rocket reaches the ground.

Launch conditions
Altitude: 0.00000 Ft.
Relative humidity: 50.000 %
Temperature: 59.000 Deg. F
Pressure: 26.5770 In.
Wind speed model: Custom speed range
Low wind speed: 10.0000 MPH
High wind speed: 10.0000 MPH
Wind turbulence: Constant speed
Frequency: 0.000000 rad/ second
Wind starts at altitude: 0.00000 Ft.
Launch guide angle: 0.000 Deg.
Latitude: 33.000 Degrees

Launch guide data:
Launch guide length: 72.0000 In.
Velocity at launch guide departure: 54.7897 ft/ s
The launch guide was cleared at : 0.256 Seconds
User specified minimum velocity for stable flight: 43.9993 ft/ s
Minimum velocity for stable flight reached at: 47.7012 In.

Max data values:
Maximum acceleration:Vertical (y): 582.180 Ft./ s/ sHorizontal (x): 5.329 Ft./ s/ sMagnitude: 582.180 Ft./ s/ s
Maximum velocity:Vertical (y): 653.5531 ft/ s, Horizontal (x): 14.6667 ft/ s, Magnitude: 657.3360 ft/ s
Maximum range from launch site: 788.60633 Ft.
Maximum altitude: 5200.28144 Ft.

Recovery system data
P: Main Parachute Deployed at : 66.055 Seconds
Velocity at deployment: 91.4704 ft/ s
Altitude at deployment: 899.91401 Ft.
Range at deployment: -81.39800 Ft.
P: Drogue Parachute Deployed at : 17.836 Seconds
Velocity at deployment: 44.8169 ft/ s
Altitude at deployment: 5200.28143 Ft.
Range at deployment: -788.60633 Ft.

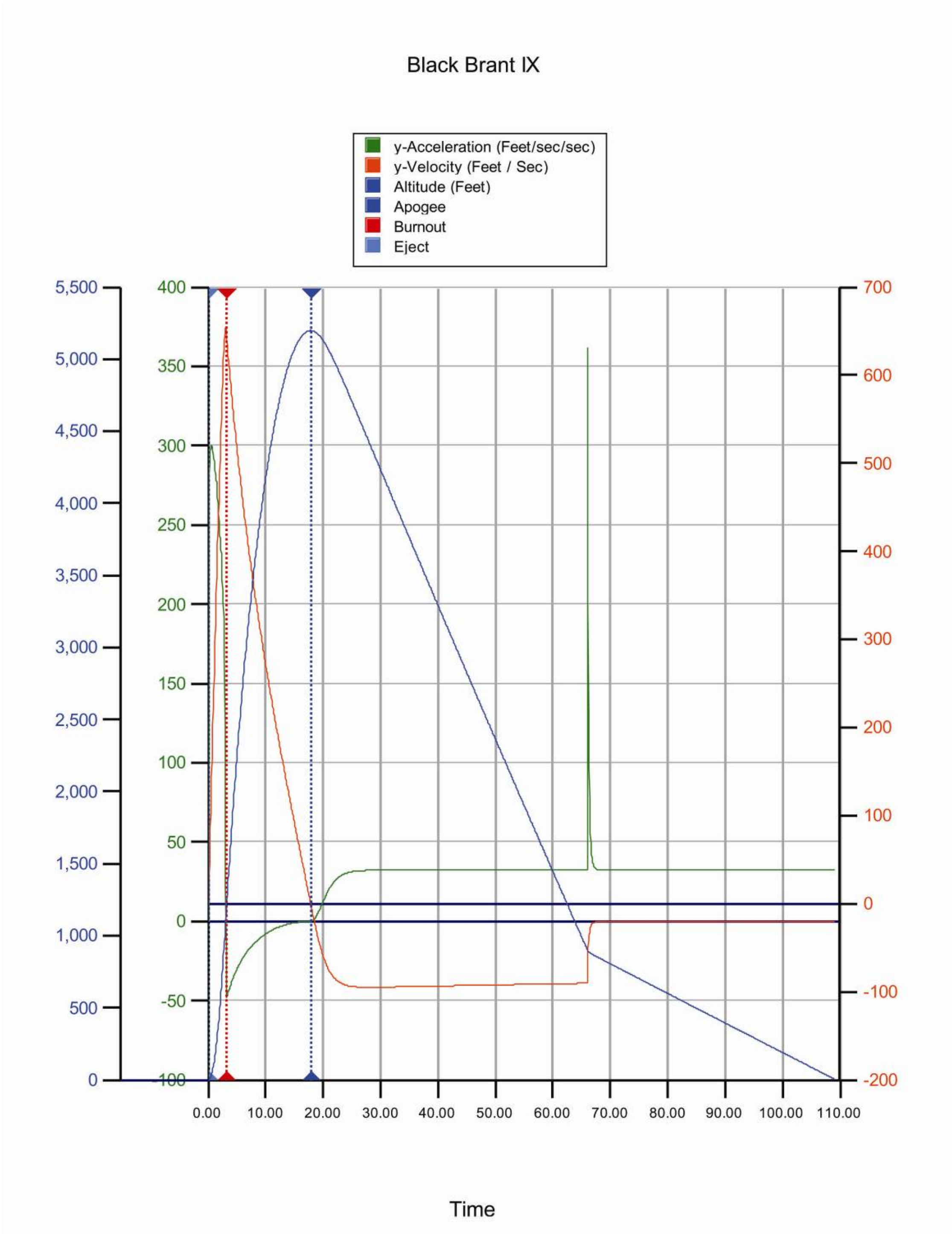
Time data
Time to burnout: 3.130 Sec.
Time to apogee: 17.836 Sec.
Optimal ejection delay: 14.706 Sec.

Landing data
Successful landing
Time to landing: 108.697 Sec.
Range at landing: 544.02533
Velocity at landing: Vertical: -23.1817 ft/ s , Horizontal: 14.6667 ft/ s , Magnitude: 27.4318 ft/ s (NOTE: calculations from on-line calculator shows landing rate at 19 ft/sec)

Competition settings
Competition conditions are not in use for this simulation.

APPENDIX H

From Rocksim Simulation Plot:



APPENDIX I

Budget:

Description	Unit Costs	Extended Costs
Scale Vehicle and engines		
Scale Vehicle and engines and engine retainers	250.00	
Total Scale Vehicle		$250.00
Contingent second rocket just in case first is destroyed		$250.00
Vehicle		
4" Fiberglass Black Brant	240.00	
West System Epoxy	120.00	
Paint	100.00	
Others: Tape, Paper Towels	12.00	
Engine Retainer	50.00	
Total Full Size Vehicle Total Vehicle Cost		$522.00
Contingent second rocket just in case first is destroyed		$522.00
Recovery		
Perfectflight MAWD Altimeter/Flight Computer	100.00	
Download Cable for HXC	20.00	
G-Wiz Partners HCX/50 flight computer	235.00	
Download Cable for HCX	35.00	
Mini Sd card for HCX 8GB	20.00	
Electric Matches - 30 at $1.50 each	45.00	
Gun Powder FFFF 1 Lb	20.00	
Batteries	10.00	
Terminal Block (Estimated)	10.00	
Safety Switches (Estimated)	10.00	
Remove before flight tags 2 at $5.00 each	10.00	
Misc (wiring, rubber gloves, cable ties, etc.	25.00	
84" Parachute (TAC-1 from Giant Leap)	130.00	
24" Drogue (TAC-Drogue from Giant Leap)	28.00	
Total Recovery Cost		$698.00
Contingent second recovery just in case first is destroyed		$698.00
Payload		
Linux Computer	75.00	
Storage Memory(flash card)	15.00	
USB Converter	15.00	
Hard Drive	60.00	
Accelerometer Data Recorder	235.00	
Batteries	25.00	
Total Payload Cost		425.00
GPS System		
Beeline GPS (70cm)	300.00	

Byonics Tiny Track 4	75.00	
Garmin Legend Handheld GPS Navigator	120.00	
Misc (wiring, connectors etc.)	50.00	
Total GPS cost		$545.00
Contingent GPS Rocket Transmitter (Beeline)		$300.00
Motors (full sized vehicle)		
5 Grain 54 mm Cesaroni casing	100.00	
Rear Closure	62.00	
Pro Dat Delay Drill	28.00	
K635 Motor (3 at 124 each)	372.00	
Total Full Size Vehicle Total Engine Cost		$562.00
Educational Outreach		
Travel to local launches (per vehicle)	50.00	
Travel to Educational Events (per vehicle)	25.00	
Printing Costs (flyers, brochures)	100.00	
Rocket Kits	100.00	
Total Educational Outreach		275.00
Travel (16 team member 4 days)		
Travel to Huntsville, Alabama ($450 per person)	7,200.00	
Cost of food ($30 a day per person)	1,680.00	
Cost of hotel ($400 per person)	5,600.00	
Car Rental (3 vans $120 a day)	1,440.00	
Total Travel (Estimated)		$15,920.00
Total Estimated Project Expenses		$20,967.00

APPENDIX J

Timeline:

AIAA SLI Project Timeline

		Sept				Oct					Nov				Dec					Jan				Feb				Mar				Apr					May			
Items	**Due Date**	3	10	17	24	1	8	15	22	29	5	12	19	26	3	10	17	24	31	7	14	21	28	4	11	18	25	4	11	18	25	1	8	15	22	29	6	13	20	27
Prepare Proposal																																								
Proposal due for review	9/24/2010																																							
Electronic Proposal Due to NASA	9/27/2010																																							
ROCtober fest (outreach)	10/9-10/10																																							
NASA accepts our proposal	10/12/2010																																							
Girl scouts - present/assist in rockets (outreach)	10/17/2010																																							
SLI team teleconference	10/24/2010																																							
Girl scouts - present/assist in rockets (outreach)	10/30/2010																																							
Establish and create website																																								
Website presence established	11/1/2010																																							
Girl Scout Launch (outreach)	11/6/2010																																							
More detailed design of full sized rocket	11/19/3010																																							
More detailed design of scientific payload	11/19/2010																																							
Prepare PDR report presentation	11/19/2010																																							
PDR report and presentation on website	11/19/2010																																							
PDR presentation	12/6-10/2010																																							
Integrate GPS electronics (vehicle and ground)																																								
Build Payload and Recovery Electronics																																								
Design Scale Model Rocket																																								
Build Scale Model Rocket																																								
Test GPS functionality and Range	12/18/2010																																							
Launch Scale Model Rocket	12/18 1/17																																							
Prepare CDR report and presentation																																								
CDR reports and presentation posted on website	1/24/2011																																							
CDR presentation	2/2-8 2011																																							
Finalize design of full size rocket																																								
Build full size rocket																																								
Test Gunpowder for dual deployment	1/29 2/6																																							
Launch Full Sized Rocket	2/12/ 3/12																																							
Prepare FRR report and presentation																																								
FRR reports and presendtation posted on website	3/21/2011																																							
FRR Presentations	3/28-31/2011																																							
Travel to Huntsville	4/13/2011																																							
Flight Hardware and Safety Checks	4/14-15/2011																																							
Launch Day	4/16/2011																																							
Prepare Post Launch Assessment Review																																								
Post-Launch Assessment Review posted on Web	5/92011																																							
Arrange outreach events & publicity	on-going																																							
Fundraising	on-going																																							

APPENDIX K

AIAA OC Section Launch Safety Rules
For all rockotry activities (Youth – TARC – modified for SLI)

In an emergency, dial 911
California Poison Control Center: 1-800-222-1222

Our teams own rules completely comply with the rules stated above. The AIAA Orange County Sections rules are stated below and contain a table similar to the one included above.

- The materials that will be used will be lightweight materials such as; paper, wood, rubber, plastic, fiberglass or only when it's necessary, metal.
- The motors that will be used will be certified commercially made rocket motors. They will not be tampered with or used for anything except recommended by the manufacturer. There will not be smoking, open flames or any other heat sources within 25 feet of the motors.
- The rocket will be launched with an electrical launch system, and with electrical motor igniters that are installed when the rocket is on the launch pad or in the designated prepping area. The launch system will have a safety interlock that is in series with the launch switch that is not activated until the rocket is ready for launch and will use a launch switch that returns to the off position when released. If the rocket has an onboard ignition systems for motors and or recovery devices, they will have safety interlock that interrupts the current path until the rocket is at the launch pad. If the ignition systems has a second battery and relay at the pad, than the batter will be disconnected while the rocket is placed on the launch pad and the igniter is connected to the launch system.
- The launcher that is used will be a stable device that provides rigid guidance until the rocket has attained a speed that ensures a stable flight , and is pointed within twenty degrees of vertical. If the wind is over five miles per hour then the launcher length that permits the rocket to attain safe velocity before separation from the launcher. A blast defector will be used to prevent the motors exhaust from hitting the ground. There will be no dry grass around each launch pad in accordance with the minimum distance table.
- If the rocket doesn't launch, then the launchers safety interlock or disconnect the battery. Sixty seconds will be waited after the launch attempt before allowing anyone to approach the rocket. If the ignition system has a second battery and relay at the pad, that battery will be disconnected before approaching the rocket.
- The rocket will be checked for stability, a sound construction and any previous damage before it is allowed to fly. The rocket will not have a total thrust more than 40,960 N-Sec.
- The launch pad area will be checked to make sure there is no one closer to the launch pad than the minimum distance table states. The sky will be checked above the launch site to make certain there is no airplanes, helicopters or any other aircraft in the area

before launching. Stating “Range is clear” and “Sky is clear” before proceeding to launch. This will be followed by a five second count down to warn anyone in the area of launch.

- The rocket will not be launched at targets into clouds or obscuring phenomena, near airplanes or on trajectories that make it directly over the heads of spectators or beyond the boundaries of the launch site and will not have a flammable or explosive payload in the rocket. The rocket will not be launched to an altitude where the horizontal visibility is less than five miles. If the wind exceeds twenty miles an hour the rocket will not be launched. The person(s) launching the rocket will comply with the Federal Aviation Administration airspace regulations when flying and will make sure our rocket does not exceed any applicable altitude limit in effect at the launch site.

- The rocket will not be launched between sunset and sunrise e.g. not in the dark.

- The rocket will be launched outdoors in an open area where trees, power lines, buildings and person(s) not involved in the launch do not represent a hazard, and that is at least as large on its smallest dimension as one-half of the maximum altitude which rockets are allowed to be flown at that site, or 1500 feet, whichever is greater.

- The launcher location will be at least 1500 feet away from any inhabited building or from any public highway on which traffic flow exceeds ten vehicles per hour, not including traffic flow related to the launch. It will also be no closer than the appropriate Minimum Personnel Distance from the accompanying table from any boundary of the launch site.

- No person(s) shall be closer to the launch of our rocket than the person who is actually flying the rocket. All spectators shall remain behind the person launching the rocket. No person(s) shall be closer to the launch that the minimum safe distance table.

- The rocket will use a recovery system so that all parts of the rocket return safety and undamaged and can be flown again. We will use only flame-resistant or fireproof recovery system wadding and heat shields in our rocket.

- No person(s) will attempt to recovery the rocket from power lines, tall trees, or other dangerous places, fly it under conditions where it is likely to recovery in spectators areas or outside the launch site, nor attempt to catch it as it approaches the ground.

Two jobs exist to ensure safety, the range safety officer and the launch control officer.

The RSO (Range Safety Officer): has the overall control responsibility for the safety of the range and can shut down the launch site if it deems necessary. They are responsible to make certain that each rocket that is flown is safe to fly before it is launched. They make certain the fins and launch lug are present and securely fastened to the body tube. They make certain that the engine is installed properly and that the recovery system is functional. Although all persons responsible for designing and building a rocket need to make certain it is safe to fly, the range safety officer has the ultimate responsibility.

The LCO (Launch Control Officer) is responsible for supervising the actual launching of the rockets and that all conditions are safe to do so. This includes making sure that the launch pads are not armed when people are close to them. Before each launch they must check for people, including spectators, in an unsafe location and nearby aircraft. For the first launch of a rocket or if the launch includes any unusual risks, the flight will be announced as a "Heads-Up" flight. This person must track each flight until the rocket returns to ground level. Again, although all persons are responsible for designing and building the rocket, need to take these same precautions, the launch control officer has the ultimate responsibility.

APPENDIX L

AIAA OC Section Shop Safety Rules
For all rocketry activities (Youth – TARC – modified for SLI)

In an emergency, dial 911
California Poison Control Center: 1-800-222-1222

There is always a risk when someone is handling shop tools or near someone who is handling shop tools. Great precaution should always be there. Here are the AIAA Orange County Section shop rules

In general:

- Keep work area clean and orderly; neatly arrange equipment and material. Put all tools and materials back where you found them.
- If you are unsure about safe operation or process, request assistance from the program manager or mentor.
- When working with chemical, X-Acto knives, electrical tools or any tool where there is a danger of fumes or particles entering your eyes where safety glasses.
- If there is any unsafe conditions report them to your program manager or Mentor immediately. Rely on your own judgment an knowledge of safety to guide you.
- Horseplay is forbidden.
- If lifting a heavy object, lift with your legs not with your back, keep your back straight.
- Flammable liquids such as paints, solvents and thinners have to be stored in their original containers or in an approved safety cans with flamer arresters.
- Never use an air hose for cleaning or dusting yourself off. Never point it at anyone.
- If you have long hair you must tie it back or tuck it under a cap so it won't be caught in rotating tools.
- Think through the entire tasks before starting them and never rush or take chances.
- Using heavy glues and house hold chemicals should only be done in well ventilated areas; heavy sanding, painting and use of chemicals should only be done outdoors.
- When creating documents that require work with potentially hazardous tools or operations, that section will be marked with the following:

HAZARDOUS OPERATION – SEE SAFETY PLAN

Electrical Tools

- Don't work with power tool sunless there is at least one other person present.
- Before operating any machine or equipment be certain alls safety guards are in place. The guards must be in replaced as soon as repairs or servicing on a machine has been completed and put into operation.
- Never tie down, block out or otherwise make inoperative of any type of safety device, attachment method or guard.
- Before energizing or operating any equipment verify the safety of all personnel.
- When a machine is de-energizing for the purpose of changing the setup or making a minor adjustment, turn off the machine and pull the plug. Allow the machine to come to a complete before proceeding with your task.
- Never oil, remove guards or attempt to repair machinery while it is on and in motion.
- Never use electrical equipment while standing on damp or wet surfaces or when your hands are wet.
- Wear clothes suitable for the work that you are doing. Loose clothing, neckties, rings, and watches, and even gloves create a hazard when operating tools. Long sleeves non-synthetic clothes should be worn when sparks or hot metal is present.
- Never use a rag near moving machinery.

APPENDIX M

Safety Rules when using Hazardous Materials

In an emergency, dial 911
California Poison Control Center: 1-800-222-1222

In the course of completing the launch vehicle, team members will come into contact with many hazardous substances. These substances will not pose a threat to the team members as long as rules are followed when handling. Material of concern includes adhesives and paints as well as the actual materials used to build the vehicle. The manufacturer of that material knows best the hazards posed. The manufacturer and safety organizations publish MSDS for each product.

An MSDS (Material Safety Data Sheet) is there to provide the overview of how to work safely with or how to handle this chemical or material. This is compiled by the manufacture of the particular chemical. MSDS do not have a particular format but are required to have certain information per OSHA (Occupational Safety and Health Administration) 29 CFR 1910.1200. A listing of the required information can be found on this website;
<http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10099>.

Threats to team member's safety that must be accounted for include (see details below the table):

Risk	Mitigation
Impact to the body	Gloves, apron, goggles
Cut or puncture	Gloves and Apron
Chemicals – fumes and/or direct contact	Gloves, respirator, goggles
Heat/cold	Gloves
Harmful Dust and small particles	Mask and Goggles
Loud noises	Earplugs

The team will keep a copy of the MSDS for all materials used in the construction of the vehicle, when an MSDS exists for that material. In addition, the following items will be present and available for use by team members whenever they are working or constructing the vehicle or payload, or whenever launching.

- Safety goggles
- Rubber gloves
- Leather gloves
- Respirators / Dust Masks
- Protective aprons
- Ear Plugs

Eye protection must be worn whenever there is a danger of

- Dust, dirt, metal or wood chips entering the eye. This can happen when sawing, grinding, hammering, or using power tools. When at a launch this can occur during strong winds (common at Lucerne Dry Lake)
- Chemical splashes including use of paints, solvents, or adhesives
- Objects thrown (intentionally or inadvertently) or swinging into a team member

Gloves must be worn to protect the team member's hands whenever there is a danger of contact with a hazardous material

- Latex or rubber gloves for possible contact with a hazardous chemicals such as adhesive, paint, or thinners, or even some solid materials
- Leather gloves to protect against impact or getting cut or abraded (e.g. in the use of some power tools such as grinders)

Team members will always work in a clean, well-ventilated area. Protection for a team member's lungs (dust mask or respirator) must be used whenever:

- Working with a chemical emitting fumes (e.g. paints and solvents) the team member must wear a respirator
- Working in an environment where there is dust (e.g. sanding and working with power tools) the team member must wear a dust mask.

Body protection, such as an apron must be worn whenever there is danger of

- Splashes or spills from chemicals
- Possible impact from tools

Ear protection (plugs or ear muffs) must be worn whenever there are loud noises present, which includes

- Using loud power tool or hammers
- At launches when launching larger rocket motors

When creating documents that require work with potentially hazardous materials including chemicals, that section will be marked with the following:

HAZARDOUS MATERIAL – SEE MSDS

A sample MSDS is included in the next appendix to show what is included. As materials are identified during the research and design phases of this project, suitable MSDS for all materials used will be obtained and made available to all team members in hard copy form in the work area as well as being posted on the web site.