

AIAA Orange County Section
Student Launch Initiative 2010-2011

Flight Readiness 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

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Table of Contents

1.0	Summary	5
1.1	Team Summary	5
1.1.1	Team Name	5
1.1.2	Location	5
1.1.3	Team Officials/Mentors	5
1.2	Launch Vehicle Summary	5
1.2.1	Size	5
1.2.2	Motor Choice	5
1.2.3	Recovery System	5
1.2.4	Rail Size	5
1.3	Payload Summary	5
1.3.1	Summary of Experiment	5
2.0	Changes made since CDR	6
2.1	All Changes made since CDR and the reason for those changes	6
2.1.2	Changes made to vehicle criteria	6
2.1.2	Changes made to payload criteria	6
2.1.3	Changes made to activity plan	6
3.0	Vehicle criteria	6
3.1	Design and Testing of Vehicle	6
3.1.1	Flight Reliability Confidence and mission success criterion	7
3.1.2	Proper use of materials in fins – bulkheads – structural elements	8
3.1.3	Composition and rationale behind selection	8
3.1.4	Strength of assembly, proper attachment, load paths	8
3.1.5	Integrity of design	10
3.1.6	Approach to workmanship	10
3.1.7	Safety and failure analysis – modes, causes, effects, mitigation	10
3.1.8	Full scale launch test results	11
3.2	Recovery Subsystem	12
3.2.1	Parachute size for mass, attachment scheme, deployment	12
3.2.2	Safety and failure analysis – modes, causes, effects, mitigation	14
3.3	Mission Performance Predictions	14
3.3.1	State mission performance criterion	14
3.3.2	Flight Profile simulations, altitude predictions	15
3.3.3	Thoroughness and validity of analysis, drag assessment	16
3.3.4	Stability margin, CG and CP relationships	17
3.3.5	Safety and failure analysis, failure modes, causes, effects	18
3.4	Safety and Environment (Vehicle)	18
3.4.1	Identify safety officers for your team	18
3.4.2	Update the preliminary analysis of failure modes	18
3.4.3	Update listing of personnel hazards	18
3.5	Payload integration	18
3.5.1	Describe integration plan	18
3.5.2	Demonstrate compatibility of elements and fit	19
3.5.3	Describe and justify payload housing integrity	20
3.5.4	Demonstrate integration – diagram of components	20

4.0	Payload Criteria	21
4.1	Experiment Concept	21
4.1.1	Creativity and originality	21
4.1.2	Uniqueness or significance	22
4.1.3	Suitable level of challenge	22
4.2	Science Value	22
4.2.1	Describe science payload objectives	22
4.2.2	State the mission success criteria	22
4.2.3	Describe experimental logic and scientific approach	22
4.2.4	Explain how it is a meaningful test – variables and controls	23
4.2.5	Relevance of expected data with accuracy/error	23
4.2.6	Provide detailed experiment process procedures	23
4.3	Experiment Design of Payload	23
4.3.1	Design at a system level with integration plan	23
4.3.2	Provide information regarding precision of instrumentation	24
4.3.3	Discuss application of engineering, functionality, feasibility	25
4.3.4	Flight performance predictions	25
4.3.5	Flight preparation procedures	25
4.3.6	Approach to workmanship as it relates to mission success	25
4.3.7	Discuss completed component functional or static testing	25
4.4	Assembly	26
4.4.1	Clear details of how the rocket is assembled	26
4.4.2	Integration and compatibility simplicity	28
4.4.3	Structural integrity for flight	29
4.4.4	Quality of construction	29
4.5	Safety and environment (payload)	29
4.5.1	Identify safety officers for your team	29
4.5.2	Update the preliminary analysis of the failure modes	29
4.5.3	Update the listing of personnel hazards	30
4.5.4	Environmental concerns	30
5.0	Launch operations	30
5.1	Checklist	30
5.1.1	Recovery preparation	30
5.1.2	Motor preparation	30
5.1.3	Igniter installation	30
5.1.4	Set up on launcher	31
5.1.5	Launch procedure	31
5.1.6	Troubleshooting	31
5.1.7	Post Flight Inspection	31
5.2	Safety and quality assurance	32
5.2.1	Provide data demonstrating the risks are at acceptable levels	32
5.2.2	Provide risk assessment for the launch operations	32
5.2.3	Environmental concerns	32
5.2.4	Individuals responsible for maintaining safety and quality	32
6.0	Activity Plan	32
6.1	Show status of activities and schedule	32

6.1.1	Budget plan	32
6.1.2	Timeline	32
6.1.3	Educational Engagement	32
6.1.3.1	Girl Scouts	33
6.1.3.2	AIAA Professional Society	33
6.1.3.3	Newspaper Articles	33
6.1.3.4	4H	33
6.1.3.5	Youth Expo	33
6.1.3.6	Presentation to Tarbut V' Torah	34
7.0	Conclusion	34
Appendix A	Project Risks and Mitigation	35
Appendix B	Environmental Hazards	39
Appendix C	Vehicle and launch risks	41
Appendix D	Flight Checklist	45
Appendix E	Schedule and status	50
Appendix F	Budget	52
Appendix G	Timeline	54
Appendix H	Black Powder Testing	55
Appendix I	Battery Life Testing	56
Appendix J	GPS Range Testing	60
Appendix K	Vacuum Chamber Testing	62
Appendix L	Ejection Charge Control (Flight Computer) testing	63
Appendix M	Scale Model	64
Appendix N	Recovery Electronics	71
Appendix O	PerfectFlite MAWD configuration and wiring	73
Appendix P	G-Wiz partners HCX Flight Computer	74
Appendix Q	Wind Speed – Range Calculation	77
Appendix R	Construction details and practices	78
Appendix S	GPS Electronics configuration and wiring	80

Flight Readiness Review (FRR)

1. Summary of FRR

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/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 rocket will have an overall length of 87.5 inches, with a diameter of 4 inches. Its liftoff weight will be 17.9 pounds and its descent weight will be 15.44 pounds.

1.2.2. Motor choice (Final)

The motor that the team has chosen is a Cesaroni K635 Redline motor, our rocket will not exceed mach1, or even near that (0.58 mach). Our backup motor is a Cesaroni K490.

1.2.3. Recovery system

The recovery has a dual deployment system, this means the rocket has a 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 PerfectFlite MAWD 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. Our Drogue 'chute is 24 inches in diameter and our main chute is 72 inches in diameter.

1.2.4. Rail size

Our team will be using a one inch launch rail, which will be six feet in length.

1.3. Payload Summary

1.3.1. Summarize experiment

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 CDR

2.1. All changes made since CDR and the reason for those changes

2.1.1. Changes made to vehicle criteria

We have increased the tubular nylon shock cord to 1" to allow for degradation in strength across multiple flights. Bulkheads are now 3 ply with each ply being 3/32" thick. Black powder charge for main has increased.

2.1.2. Changes made to payload criteria

Our payload criteria—collection of data, data must be retrievable, etc.—remained the same. We are still testing hard drive latency vs. rocket acceleration.

2.1.3. Changes made to activity plan

We have added participating Youth Expo and The presentation at Tarbut V' Torah (TVT). We have dropped the Discovery Science Center and the Science Olympics.

3. Vehicle Criteria

3.1. Testing and Design of Vehicle

We have ground tested our recovery. We have simulated flights as well as actually flown the vehicle in 15MPH winds, and our design proves to be stable. Complete details of the vehicle design as well as tests are in other sections of this document. A summary of testing is as follows:

Black Powder

Procedure can be found in Appendix H

Located	Amount	Successful
Scale – Main	1.01 grams	yes
Scale – Drogue	1.14 grams	yes
Full – Main	1.74 grams (inc to 2g)	yes
Full – Drogue	1.74 grams	yes

Battery Life

Procedure can be found in Appendix I

Electronics	Life time (hours)	Successful
HGX G-Wiz Partners	2.5	Yes
MAWD Perfect Flight	36 (and still going)	Yes
Big Red Bee Beeline GPS	18.7 (and still going)	Yes
Payload	3.74 (and still going)	Yes

GPS Range

Procedure can be found in Appendix J

Transceiver Location	Range	Successful
On the ground	3.05 miles	Yes

Vacuum Chamber

Procedure can be found in Appendix K

Electronic	Successful
MAWD Perfect Flight	yes
MAWD Perfect Flight	yes
HCX G-Wiz Partners	No
HCX G-Wiz Partners	Yes
HCX G-Wiz Partners	Yes

Light Simulation

Procedure can be found in Appendix L

Electronic	Successful
MAWD Perfect Flight	Yes
HCX G-Wiz Partners	Yes

Vacuum Chamber (full scale payload)

Electronic	Successful
HCX	No
HCX	No
MAWD	Yes
MAWD	Yes

Beep Sequence test

Electronic	Successful
HCX	No
HCX	Yes
MAWD	Yes
HCX	Yes
HCX	Yes
MAWD	Yes

We learned that we had to have both batteries in for the proper beep for the HCX.

3.1.1. Discuss flight reliability confidence. Demonstrate that the design can meet mission success criteria. Discuss analysis, and component, functional, or static testing.

Our team used Rocksim simulation and hand calculation to see the flight reliability. According to the simulation, our rocket goes up to 5178.02 ft, land with velocity of 20.04~21.45 ft/s, and have range of 834.54 ft with 10mph wind. Without weather cocking, the rocket can land on 2500 ft range when the wind speed is less than 15~16 mph (and with weather cocking, with 20mph wind will have the range of 1659 ft).

These data from Rocksim simulation and hand calculations demonstrate that the rocket qualifies for SLI mission.

The rocket is 286.5 oz, 87.537 in long, 4.024 in wide. It has CG of 55.478 in and CP of 64.308 in, which gives 2.21 stability margin. The rocket contains K635 RL engine, which has total impulse 1973.146 N.s and burn time 3.13 seconds.

We tested amount of black powder, battery life, GPS range, and we launched scaled model to test dual deployment, HCX, and MAWD. Battery lasted for 2.5 hours, GPS worked when it was farther than 3 miles away, and our scaled model had a good flight with the electronics.

3.1.2. Proper use of materials in fins, bulkheads, and structural elements.

Our Rocket is made with a fiberglass: nosecone, .058" thick body tube, couplers, 3 ply bulkheads each ply is 3/32" thick, 2 ply centering rings, and 1/8" thick fins. The "U" bolts that hold the shock cord to the upper bulkhead and the top centering ring are .2" rod steel, the eyebolts in the avionics bay are closed stainless steel made of .26" rod and have a breaking strength of 5,250 pounds. We are using an AeroPak motor retainer and 1/4" diameter threaded rods for the sled in the Avionics bay. These rods go completely through the avionics bay and are secured with washers and nuts on the bulkhead end caps. The sled itself is 1/8" plywood. The shock cord we will be using is 1" Tubular nylon.

3.1.3. Explain composition and rationale behind selection.

Our team used fiberglass for the vehicle because it can survive hard strains and can shear shear pins repeatedly without damage to the body tube. The black powder charges are to ensure a safe recovery of both vehicle and electronics. Parachutes are sized to ensure the correct decent rates and are of 1.1 oz rip stop nylon (main) and 1.9 oz rip stop nylon (drogue) for strength. We used heavy multiple ply fiberglass bulkheads and centering rings for strength. West system epoxy was used to ensure proper assembly and strength in construction. "U" bolts and marine grade stainless steel closed eyebolts were used as attachment points for the shock cords to minimize the possibility of failure of those components during recovery deployment. The 1" tubular nylon shock cords were selected for strength over repeated launches since the nylon will degrade each time it is exposed to the black powder charge. And the nylon shock cords and parachutes are protected with Nomex shields.

3.1.4. Explain strength of assembly, proper attachment and alignment of elements, solid connection points, and load paths. (Looking for optimum assembly quality.) Show sufficient or exemplary motor mounting and retention.

Since this vehicle is using a "K" motor it must be very well constructed, using the proper materials, to prevent it from disintegrating on the way up (a.k.a. "shred"). To that end, the following best practices will be used on construction

- Use only commercial adhesives such as West System Epoxy for the airframe
- Fiberglass needs to be well roughed up – using 60 grit sandpaper to get epoxy to adhere properly.

- Fiberglass needs to be cleaned well using alcohol before applying epoxy
- All joints such as centering rings, bulkheads, and fins have fillets in addition to the adhesive joining the two together
- Closed marine eyebolts and “U” bolts are used and are attached securely with a washer between the bulkhead and the nut to distribute the pressure over a larger area
- Shock cords should be well secured at both ends using metal “U” bolts and eyebolts.
- Nuts from eyebolts and “U” bolts have either have Loctite securing them or be epoxied
- Nylon shock cord is attached to the eyebolt and “U” bolt with a 1200lb test quick link or shackle to the body and 800lb test to the parachute of approximately the same material diameter as the eyebolt or “U” bolt to give a secure connection and allow for service
- All removable pieces of the vehicle that do not separate in flight are secured using metal machine screws
- All removable pieces of the vehicle that do separate in flight are secured using shear pins, using 3 #2 nylon screws
- Avionics bays will endure a high level of tension when the ejection charges fire. The bay has load bearing bolts - $\frac{1}{4}$ ” threaded rods that go completely through the bay and secure to the end caps. Load will then be transferred from the shock cord, to the eye bolt, to the bulkhead end cap on the avionics bay, to the threaded rods through to the other end cap and eyebolt rather than apply pressure to pull the avionics bay apart
- The highest load path is from “U” bolt on a centering ring in the engine/fin body section, through the shock cord to its other attachment point (the avionics bay). The avionics bay withstands the same tension across its length. On the other side of the avionics bay the load continues through attachment to the avionics bay, an eyebolt, through the shock cord, to the final attachment point near the nose cone, U bolt. The 1” tubular nylon shock cord is slightly elastic lessening the shock to the attached components.
- Fins should be carefully aligned using a fin jig to hold them in place while the epoxy is setting.
- The motor is retained using an AeroPak Quick-Change motor retention system. One part is epoxied on to the 54mm fiberglass motor tube and the other is screwed on to the end after the motor is inserted.

Our team will be using three centering rings for the motor mount, and will be using west system epoxy for the assembly. The motor retainer will be mounted on the end of the motor mount to ensure the motor does not leave the rocket.

3.1.5. Discuss the integrity of design and that you have used analysis to improve design. Demonstrate the suitability of shape and fin style for mission.

The design is based upon the Black Brant sounding rocket. Over 800 Black Brants variations have been launched as the design has lived on for 50 years. It has proven to be one of the most popular sounding rockets ever built. We modified the design for our dual deployment, avionics, bay, and to hold a GPS transmitter in the nose cone. We entered the design into RockSim and tailored it to assure suitability as well as stability. The fins are large per the legacy design assuring the rocket is not overstable with the relatively heavy payload in the center of the vehicle.

In addition, the rocket has to be well assembled so it can survive flight and therefore deliver the integrity of the design. We will be using West System Epoxy to construct the rocket, along with fiberglass tape. All the connections have to work for the recovery system and payload; we will check connections before flight and make sure no wires are shorting. We will always make sure that the motor we are using will not propel our rocket to go over mach1. We will make sure that the parachute is big enough to recover the rocket safely.

3.1.6. Specify approach to workmanship as it relates to mission success, including neatness of workmanship, quality of appearance, and attractiveness.

Our approach to workmanship is in Appendix R. This shows how we went about construction of our rocket. Our rocket has to be neatly and properly constructed so the rocket can reach a mile in height and be flown multiple times. Also it must be carefully and logically assembled and tested so our dual deployment system works and we do not travel outside of the 2,500 feet range.

3.1.7. Provide a safety and failure analysis, including a table with failure modes, causes, effects, and risk mitigations.

Risks and mitigations are provided in appendices A, B, and C of the FRR. We have extended this to also cover the scientific payload shown below:

- We used O'Neil lithium-ion batteries since they are more stable than conventional lithium-ion battery packs, which tend to explode or burn under stress. O'Neil battery packs are encased to protect them from shock, and have small circuit boards that regulate the flow of electricity to and from them. If the batteries go unprotected, a fire may start in the avionics bay.
- Two plastic zip ties are looped around each battery—one vertically and one horizontally—to ensure that they don't fall out. If not secured, the power outage will cause total failure and the rocket will crash.

- The cable between the hard drive and the simple net computer is custom-made for a better fit and soldered onto the ports to prevent the cable from falling out during launch. A disconnection here can end the experiment prematurely.
- Key switches regulate the power flow to the components on the recovery as well as the payload. If something goes wrong with any of the components, we can simply cut off power by through these switches. Without the switches, we will have to take apart the avionics bay manually and search for the wire providing power to the malfunctioning element.

3.1.8. Discuss full scale launch test results.

Launch Results

Launch	Results
1 st Launch 3/12/2011	Partial Success
2 nd Launch	TBD

On March 12th we attended the ROC launch at Lucerne Dry Lake in the Mojave desert. They have an FAA waiver to 10,000 feet above ground level. It was dry, but there was a lot of wind (10-15MPH consistently). We prepared the rocket and waited for a small lull in the wind to launch. The launch was partially successful. A Cesaroni K400 motor was used – smaller than our preferred K635 so that we could hopefully keep the flight in sight at all times. We had the HCX and the MAWD flight computers in place and armed. The left the full timing on the ejection charge from the motor as a back-up since it was timed for several seconds after apogee:

- The motor ignited and the rocket lifted off the pad
- The rocket weathercocked into the wind, which was to be expected
- A little after apogee, the drogue 'chute deployed properly
- At approximately 900 feet the ejection charge to deploy the main went off and the rocket separated, but the main 'chute did not fully leave the body tube.
- The rocket descended flat with the drogue and the drag on the body parts slowing its descent enough so we received minimal damage
 - The body and fins were undamaged
 - The only problem was that the tabs on two plastic battery holders broke and needed to be replaced

Examination of the rocket after the flight showed that all black powder charges had fired. The parachute was packed per the manufacturer's instructions which tucked the shroud lines inside the parachute, however their method allowed the shroud lines and shock cord to deploy while leaving the fabric of the parachute inside the body tube. The root cause was the parachute had expanded and was required too much pressure to pull out than the black powder charge provided. Since then we have ground tested the main black powder charge and have made the following corrections:

- The black powder charge will be increased to 2.5 grams from its current 1.74 grams

- The black powder charge will be placed into the body tube before the parachute, allowing the charge to push the parachute out (in our actual flight the charge was placed in last so the avionics bay would pull the parachute out.
- The parachute will be rolled tightly by two people – one rolling and one keeping tension on the parachute
- The shroud lines will be wrapped around the outside of the parachute to keep the tight roll so it can be pushed out easily.
- The attachment point for the main parachute is now right at the avionics bay rather than 1 foot down the shock cord
- We replaced one nomex shield meant to protect the shock cord with a nomex sleeve around the shock cord.

We have scheduled several additional dates to launch the full sized vehicle again.

Launch Date	Comments
3/26/2011	Launch with M.D.A.R.S (Mojave Desert Advanced Rocket Society) near Edwards Air Force Base
4/1/2011 – 4/3/2011	If needed, launch with Tripoli San Diego at Plaster City in the desert
4/9/2011	If needed, launch with R.O.C. (Rocketry Organization of California)

3.2. Recovery Subsystem

3.2.1. Suitable parachute size for mass, attachment scheme, deployment process, test results with ejection charge and electronics

A suitable size for the main parachute is 72 inches and the size for the drogue parachute is 24 inches. Both the parachutes will be attached to separate swivels with the use of a nylon shock cord. This will be able to withstand about 1400 pounds of force which provides a safe margin for the rocket.

The descent rate for the selected parachute sizes was calculated by hand as well as using on-line calculators and RockSim:

- Mass of rocket during descent is 21.65 oz
- Drogue parachute size = 24 inches
- Main parachute diameter = 72 inches

Calculating this by hand:

$$v^2 = 2F_D / (\rho)(C_D)(A)$$

$$C_D = 1.00$$

$$F_D = mg = (6.285 \text{ kg})(9.8 \text{ m/s}^2)$$

$$v_{\text{drogue}} = 60.99 \text{ ft/s (must be between 50 and 100 ft/s inclusive)}$$

$$v_{\text{main}} = 17.43 \text{ ft/s (must be between 17 and 22 ft/s inclusive)}$$

Using the on line calculators yielded:

$$v_{\text{drogue}} = 68.57 \text{ ft/s}$$

$$v_{\text{main}} = 19.59 \text{ ft/s}$$

The recovery system will work with the use of two electronics: the MAWD perfect flight and the HCX G-wiz partners. Once the rocket hits apogee, either one of the electronics will deploy the drogue parachute which will make the rocket descend at a rate of about 65.43 feet per second which was calculated by both internet calculator and hand. Once the rocket descends to an altitude of 900 feet, the main parachute will descend at a rate of about 20.49 which was calculated by both an online calculator and hand. The descent rate starting from 900 feet takes into account the air resistance caused by both the drogue and main parachutes.

We tested the electronics using the following tests: the Christmas tree light test, vacuum chamber test, and two launches in a scaled model. The Christmas tree light test was when we connected to one electronic and a computer. We simulated the flight on the computer and when the simulation hit apogee and 900 feet when descending, the light went off indicating that the parachutes were deployed at their perspective times. In the vacuum chamber test, we put the electronics inside a vacuum and as the pressure increased inside the vacuum, a flight was being simulated. During the test, both electronics would have deployed the parachutes at the designated moments proving, once again, that our recovery system worked. Details of these tests can be found in Appendix H, K, and L.

In the launching of the scaled rocket, we only tested the MAWD. In both flights, the parachutes were deployed allowing for a safe recovery. Video of this test can be found at http://aiaacrocketry.org/?page_id=343.

The black power charges were similarly calculated and compared against an on line calculator. Both the main and drogue provide a 4" diameter bay 17" long area for the parachutes. Both use 3 #2 screws for the shear pins. These screws require approximately 35lbs of force to shear, or 105 lbs total. We add some margin to that for friction and conditions and we will require about 200 – 250lbs of force. The air frame is 4" in diameter, so the surface area is:

$$\text{Surface Area} = \pi * r^2 = 3.14 * 2^2 = 12.56 \text{ in}^2$$

To reach 200 pounds of force then we need
 $200 \text{ lbs} / 12.56 \text{ in}^2 = 15.9 \text{ PSI}$

To reach 250 pounds of force then we need
 $250 \text{ lbs} / 12.56 \text{ in}^2 = 19.9 \text{ PSI}$

These figures agree with the table from info-central.org:

Airframe Diameter and Desired Force				
Airframe Diameter	Pounds of Force			
	100 Pounds	150 Pounds	200 Pounds	250 Pounds
2.6"	19 psi	28 psi	38 psi	47 psi
4.0"	8 psi	12 psi	16 psi	20 psi
6.0"	3.5 psi	5.3 psi	7.0 psi	8.8 psi
7.5"	2.3 psi	3.4 psi	4.5 psi	5.7 psi

To calculate the amount of black powder required we use:

$$\text{Grams of Black Powder} = C * D^2 * L$$

Where:

D = Diameter of the airframe in inches

L = Length of the airframe in inches

C = 0.002 for 5psi
 0.004 for 10psi
 0.006 for 15psi
 0.0064 for 16psi
 0.0072 for 18psi
 0.008 for 20 psi

So for our 4" diameter airframe of 17" long, we require

$$200 \text{ lbs (16 psi)} = .0064 * 4^2 \text{in} * 17 \text{in} = 1.74 \text{ grams}$$

$$250 \text{ lbs (20 psi)} = .008 * 4^2 \text{in} * 17 \text{in} = 2.17 \text{ grams}$$

We ground tested both the drogue with 1.74 grams of black powder and main at 2.0 grams of black powder to verify that we could separate the airframe and deploy the parachutes (Video of these tests are at http://aiaacrocketry.org/?page_id=343)

3.2.2. Safety and failure analysis. Include table with failure modes, causes, effects, and risk mitigations.

Our team must ensure a safe flight. We will check the terminal blocks for our recovery electronics to make sure they are tightened. We will also make sure they are secured tightly to the sled. We will make sure that the black powder charges are put in the right sections, and make sure the E-matches are tight. We will use new batteries every flight and check voltage before launch. We will also make sure the parachutes, nomex shields, and shock cords are in the proper placed and attached securely. All risks analysis with mitigation are presented in appendices A, B, and C.

3.3. Mission Performance Predictions

3.3.1. State mission performance criteria

The mission success criteria for our rocket are as follows:

- The rocket will reach a mile high
- The rocket will not exceed mach1

- The dual deployment electronics and charges will work successfully
- The payload system will work and collect data throughout the flight
- The rocket will not travel outside of a 2,500 feet radius from the launch pad
- The rocket will be able to fly again without repair

3.3.2. Provide flight profile simulations, altitude predictions with real vehicle data, component weights, and actual motor thrust curve. Include real values with optimized design for altitude. Include sensitivities.

Launch Simulations With K-635
(Variable Wind Speed)

Wind Speed	Max Altitude (ft)	Max Velocity (ft/s)	Max Acceleration (ft/s ²)	Time to Apogee (s)	Velocity at Deployment (ft/s)
0 MPH	5266.24	686.16	434.94	17.66	0.04
0-2 MPH	5266.24	686.16	434.94	17.66	0.04
3-7 MPH	5261.81	686.13	433.72	17.66	12.36
8-14 MPH	5233.04	685.91	434.94	17.6	33.82
15-25 MPH	5143.37	685.27	424.76	17.44	64.66

Component Weights

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
Bulkhead	G-10 Fiberglass	1	99	99	n/a	4	0.30
Middle Body Tube	G-10 Fiberglass	1	200	200	8	4	0.06
Avionics Bay							
Coupler	G-10 Fiberglass	1	493	493	16	4	0.06
Bulkhead	G-10 Fiberglass	2	33	66	n/a	4	0.30
Payload Component Total		1	933	933	n/a	n/a	n/a
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

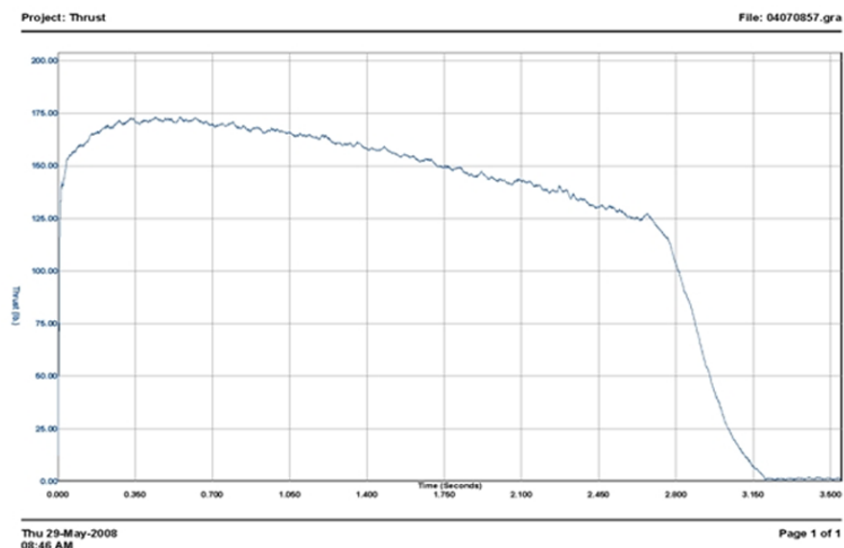
Motor Thrust Curve

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



3.3.3. Thoroughness and validity of analysis, drag assessment, and scale modeling results. Compare math analysis and models to measured values.

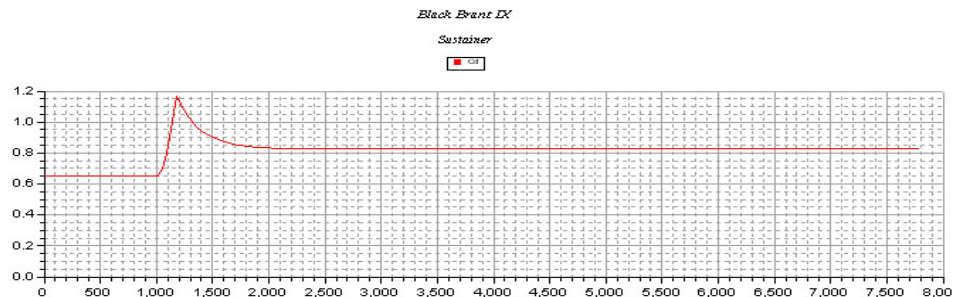
Our design is based upon a design completed fifty years ago in 1961. There have been over 800 Black Brants of various variations launched since then. The design was entered into RockSim and details of the simulation have been compared against desired and reasonable results. These include:

- Stability – center of gravity vs center of pressure (probably one of the more important)
- Motor selection shows that we have an adequate thrust-to-weight ratio together with enough thrust to reach our objective altitude

- The maximum velocity is below mach per the requirements and to avoid unnecessary stresses on the vehicle.
- The Aeropack Qwik Change motor retainer has been used by mentors and countless others to retain the engine without failure.
- Parachute Deployment - black powder calculations show that we are generating enough pressure to separate the vehicle, shear the pins and deploy the parachutes
- Parachute size – on line calculators and hand calculations have determined the vehicle is descending at the safe target velocity for both drogue and main
- The redundant recovery electronics are from two separate manufacturers using different altitude detection to assure an extra margin of safety
- Launch environment – we use a 1” rail capable of launching much larger rockets with a rail exit velocity providing stability.

A fully description and analysis of the scale model test can be found in Appendix M.

The calculated drag was done by RockSim and shows a reasonable coefficient drag of roughly 0.65 up to mach



3.3.4. Provide stability margin, with actual CP and CG relationship and locations. Include dimensional moment diagram or derivation of values with points indicated on vehicle. Include sensitivities.

Our rocket will have its Center of Gravity at 52.4814 inches from the tip of the nosecone and a Center of Pressure at 62.0220 inches from the tip of the nosecone. Using the standard equation of, “stability margin = (CP – CG) / Width of Rocket”, we get stability margin = (62.0220in-52.4814in)/4in = 2.3852.



As weight in the vehicle, the CG will also shift. Including more weight in the nose cone or in most of the payload will cause the rocket to be more stable. As weight is added towards the rear of the rocket, the CG will shift back and the vehicle will be less stable – this would be the case with a larger motor or if weight was added to the drogue area. Lengthening the rocket, or increasing the diameter of any area from the payload forward would shift the CP forward, as would decreasing the size of the fins.

3.3.5. Provide a safety and failure analysis. Include a table of failure models, causes, effects, and risk mitigations.

Appendix A contains the safety and failure analysis.

3.4. Safety and Environment (Vehicle)

3.4.1. Identify safety officer for your team.

The safety officers for our team are Sjoen and Divya.

3.4.2. Update the preliminary analysis of the failure modes of the proposed design of the rocket, payload integration, and launch operations, including proposed and completed mitigations.

Failure modes can be found in Appendix A.

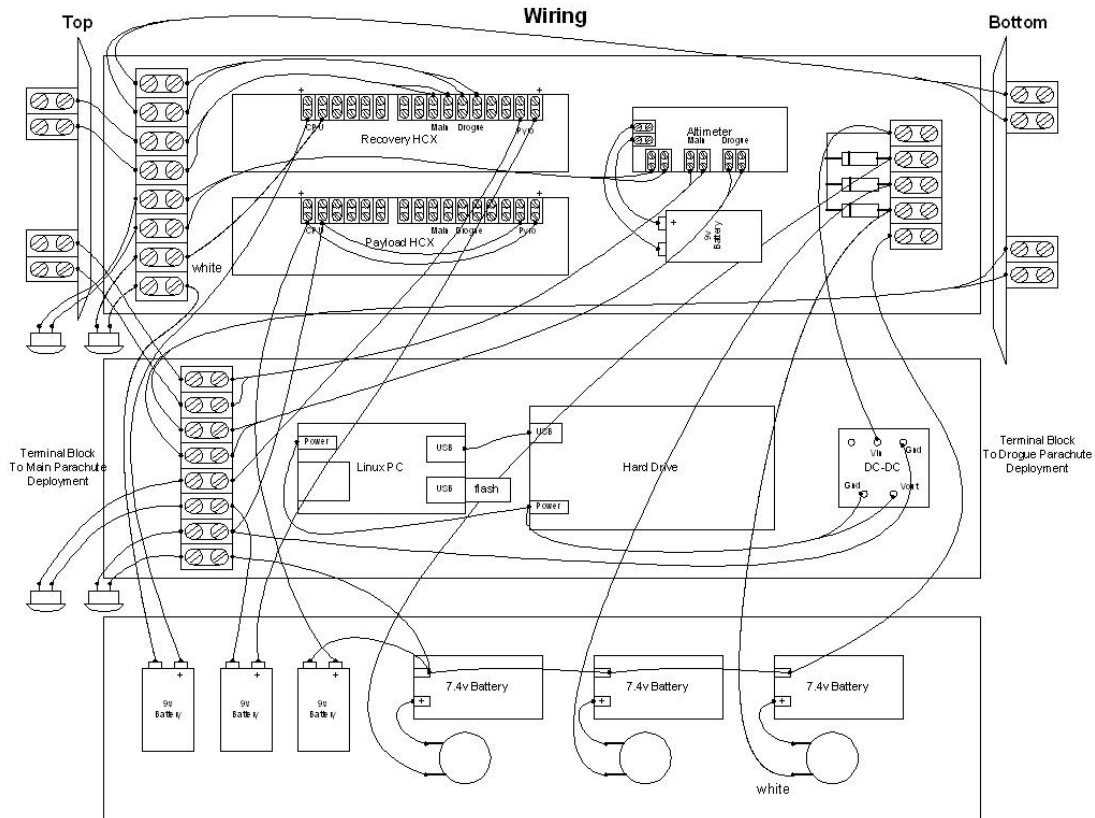
3.4.3. Update the listing of personnel hazards, including data demonstrating that safety hazards have been researched, such as material safety data sheets, operator's manuals, and NAR regulations, and that hazard mitigations have been addressed and accomplished. Discuss any environmental concerns.

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 and have been referenced. 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.

3.5. Payload Integration

3.5.1. Describe integration plan.

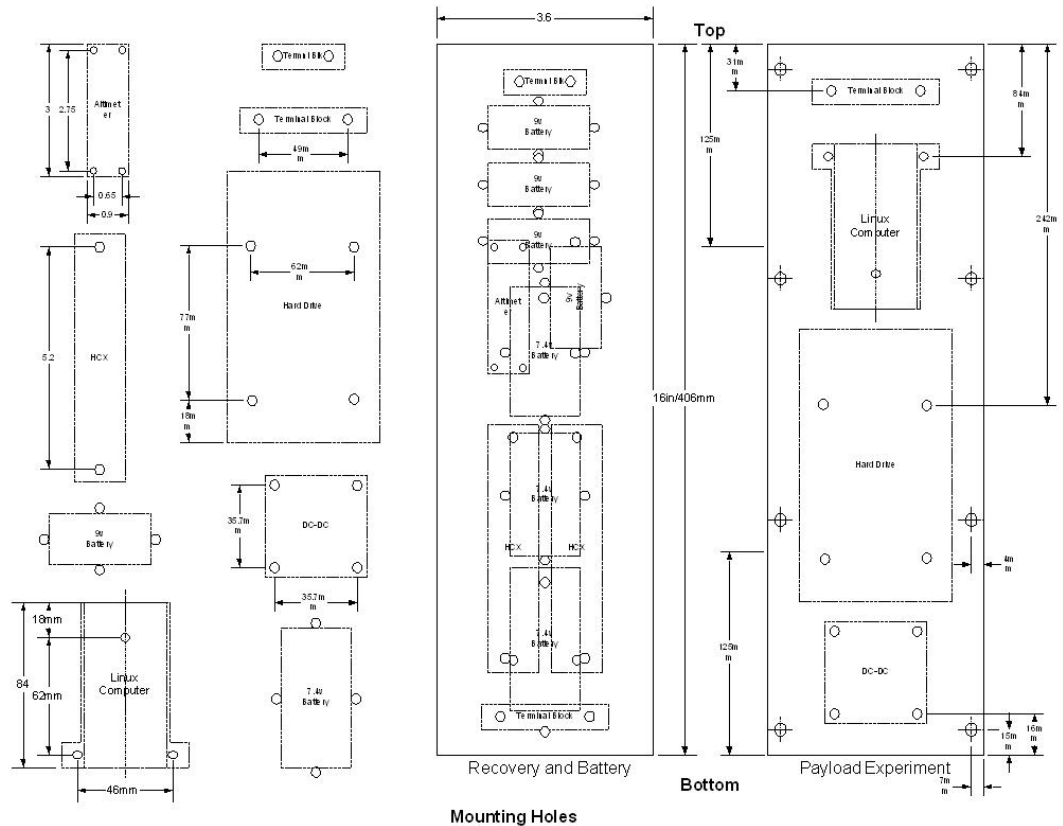
Battery placement remained the same; we installed the 3 Li-ion batteries and 3 9V batteries in the space between the sleds, while the last 9V battery went on top of the recovery sled. The 9V batteries power both G-Wiz HCX flight computers and the altimeter, and the Li-ion batteries the payload section. All the batteries are held in place by zip ties.



We originally had all the switches wired to the terminal blocks on the payload sleds. If we had the switches wired this way, we would have to cross over more wires between the payload and the recovery sleds, increasing the risk of failure. To reduce the wiring complexity, we moved two of the switches to the recovery, with one of the switches controlling the recovery HCX and one of the switches controlling the altimeter. The pyro wires for the drogue chute from the HCX and the pyro wires for the main chute from the altimeter are displaced to the payload sled. We also color coded the wires going to the switches to facilitate the wiring even further. We used heat-shrink tubing to bundle the wires, and screwed down an extra terminal block down on each sled to secure the drogue chute wires. We also decided to use hot glue to secure the USB cable running from the Linux PC to the hard drive and the flash memory stick into the Linux PC.

3.5.2. Demonstrate compatibility of elements and show fit at interface dimensions.

We were surprised at the leftover space on both the payload and recovery sleds. There are no overly stressed wires—wires run easily from component to component. For the screws that must go under the batteries, we used flathead screws and recessed the area under the batteries.



3.5.3. Describe and justify payload-housing integrity.

The payload-housing is composed of G-10 fiberglass. Besides the ventilation hole for the G-Wiz HCX flight computers and the MAWD altimeter, the avionics bay is completely sealed off with fiberglass endcaps. We will use silicone glue to seal the ejection charge wire holes and the area around the key switches. Two steel rods running through the wooden support blocks in the avionics bay penetrate to the outside of the endcaps and are secured with butterfly bolts. A stainless steel eyebolt is screwed into each endcap, where we will thread D-links for the shock cords.

3.5.4. Demonstrate integration: show a diagram of components and assembly with documented process.

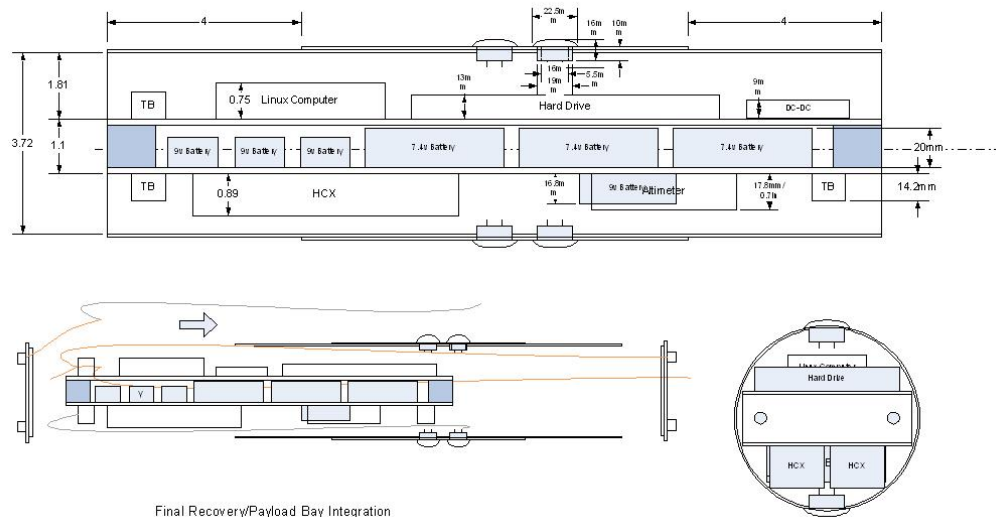
Wooden supporting blocks are constructed using a CNC machine, and epoxied on to the payload sled. The 9V batteries and the Li-ion batteries are slotted onto the bottom of the payload sled, and secured with plastic zip ties. The recovery sled is screwed onto the wooden support blocks. Both G-Wiz Partners HCX flight computers, the MAWD altimeter, and terminal blocks are mounted onto the recovery sled with screws. The top HCX flight computer is the recovery HCX—1 9V battery from under the sled powers the CPU and another powers the pyro for the main and drogue chutes. The bottom HCX flight computer is for monitoring the acceleration of the rocket only, and 1 9V from in between the sleds is used to power its CPU. The MAWD altimeter is powered by the 9V battery situated on the

same sled, and similarly have wires for the main and drogue pyros. All the wire ends are crimped.

The payload side is powered by the 7.4V Li-ion batteries, wired in parallel. These connections are soldered instead of crimped. The hard drive, Linux PC, and power converter are all screwed onto the sled. In order to cool down the Linux PC, we fitted it with a copper sled. The USB cable and flash memory are held down with daubs of hot glue.

Top

Bottom



Final Recovery/Payload Bay Integration

Assembling

4. Payload Criteria

4.1. Experiment Concept (This concerns the quality of science. Give clear, concise, and descriptive explanations.)

Since a hard drive involves moving parts in order to store data, we were curious to see how a hard drive will be affected if it itself was in motion, particularly when placed inside a rocket. A hard drive has an assembly head that moves over the hard drive disk, and we believe that the launch of the rocket can potentially interfere with the head's ability to move, or the disk's ability to rotate into reading position. Our question was: will outside force affect hard drive latency?

4.1.1. 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 bit or character to be stored in a location.

4.1.2. Uniqueness or 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.

4.1.3. Suitable level of challenge

Our experiment will help explain why disc latency will increase due to the addition of external forces. This is a suitable level of challenge for our payload because it requires a basic knowledge of how a computer works. It also requires the integration of the payload to be a certain way because it takes a lot of space. It required a lot of “thinking out of the box” in order to work for the purpose of a launch.

4.2. Science Value

4.2.1. Describe science payload objectives in a concise and distinct manner.

The science payload objectives are:

- Experiment must be practical
- Control variable can be set
- Collect data
- Data must be retrievable from the Simple Net computer
- A conclusion can be reached from the data accumulated

4.2.2. State the mission success criteria.

The mission success criteria is as follows:

- Experiment is practical (not too expensive, not too large, etc.)
- Control variables can be set
- Collects data
- Data must be retrievable from the simple net computer
- A conclusion can be reached from the data accumulated (hypothesis proved or disproved)
-

4.2.3. Describe the experimental logic, scientific approach, and method of investigation.

We approach the procedure of the payload by setting up the avionics bay with the linux computer, hard drive, power converter, lithium ion batteries, and HCX G-Wiz partners. We will have the payload running during the launch; so when the flight is over, the payload would have gathered the information necessary to prove our payload objectives. When looking at the captured data, we will compare the data from the linux computer and the data from the HCX. We will observe that as the rocket's thrust changed, the force exerted would have changed. During the time of force exerted,

whether or not the force increases or decreases, the disc latency should always increase until the forces cease to act, or when the rocket lands, not including the force exerted by gravity.

4.2.4. Explain how it is a meaningful test and measurement, and explain variables and controls.

Measuring acceleration to find the force exerted, and calculate disc latency by measuring the speed of the programs being executed. Air pressure due to wind and height, will also be a independent variable. The rate at which the disc latency increases will be changed as the outside forces act against it. First, we will have the linux computer run a script over and over, and it will measure the amount of time to complete the job. Eventually, the linux computer will work slower and slower revealing that the outside forces do indeed work.

4.2.5. Discuss the relevance of expected data, along with an accuracy/error analysis, including tables and plots.

By doing this, we will show that there is disc latency and that will effect the way a computer will work. We expect the disc latency to increase due to the thrust of the rocket. The overall accuracy of the experiment will vary since disc latency is always present whether or not a force is acting upon it. Nonetheless, the accuracy of our test should be very high.

4.2.6. Provide detailed experiment process procedures.

To do the experiment correctly, we would need to make the linux computer run a job over and over again during the job in order to determine the disc latency. While the computer is working, we would launch the rocket and after the rocket lands, we would retrieve the rocket and hook up the linux computer to a monitor and look at the data comparing it to the data gathered with the HCX G-Wiz partners. In the end, we should be able to conclude that our findings will match our hypothesis.

4.3. Experiment Design of Payload

4.3.1. Review the design at a system level, describe integration plan, and demonstrate that the design can meet all mission goals.

The payload is composed of:

- Payload G-Wiz Partners HCX flight computer
- Hard drive
- Linux simple net computer
- Power converter
- 3 rechargeable Li-ion batteries
- 1 9V alkaline battery
- Flash drive

The recovery subsystem is composed of:

- Recovery G-Wiz Partners HCX flight computer

- MAWD flight altimeter
- 3 9V alkaline batteries

Most of the batteries will go into the space between the sled assemblies. All the payload components except for the payload HCX will go onto one sled, the rest will be installed on the other sled. The power to these components is controlled by key switches to avoid accidental activation or damage. The experiment is practical—payload can be easily assembled. Before launch, we will conduct tests on both the payload and the recovery for normal functionality. We picked a flash drive for storage of our light data because it is a force-resistant medium and takes up very little volume. On one of our previous flights, we were able to retrieve data from the flash media, and found that the hard drive has survived—we were still able to access the hard drive.

4.3.2. Provide information regarding the precision of instrumentation and repeatability of measurement. (Include calibration with uncertainty.)

We finally calibrated the simple net computer to measure hard drive latency every 0.1s. Since the launch only lasts about several seconds, the rate of measurement is ideal.

Our source code is as follows:

```
#!/bin/sh
PATH=/bin
while true
do
    date >>/var/ftp/LEXAR/log.txt
    time dd if=/dev/zero of=/dev/sda2 bs=65536 count=32
    skip=64>>/var/ftp/LEXAR/log.txt 2>&1
    time sync >>/var/ftp/LEXAR/log.txt 2>&1
    time dd if=/dev/zero of=/dev/sda2 bs=65536 count=32
    skip=128>>/var/ftp/LEXAR/log.txt 2>&1
    time sync >>/var/ftp/LEXAR/log.txt 2>&1
    tail -n 10 /var/ftp/LEXAR/log.txt
done
```

At startup, the simple net computer will look for this shell script. The script is while loop, so it is executed again and again. The “date>>” command tells the computer to fix the time stamp to each measurement.

The computer will then start writing/copying (dd command) 32 KB (count=32) of zeros (if=/dev/zero) to the hard drive again and again, and measure the time it takes for this to happen (time command). Since we partitioned the hard drive into two partitions, in order for the assembly head to move to different sectors of the hard disk, we skipped blocks (skip=64).

The time is written to the flash media (var/ftp/LEXAR/log.txt). 2>&1 is a redirection to the next line.

The sync command tells the hard drive to dump, or flush, the contents of the cache memory in the hard drive directly to the disk immediately. We want to bypass the cache memory completely, since we mainly care about how the hard drive is performing. The amount of data we want showing up on screen is dictated by the tail command (-n 10 for 10 lines of text). All data is written to flash media.

4.3.3. Discuss the application of engineering, functionality, and feasibility.

Hard drives were commonplace and relatively inexpensive, and so was the simple net computer. Getting the computer to measure every 0.1s was no problem; we told the computer to write more separate files to the hard drive in one loop rather than one big file every loop. In our first launch, we found that hard drives can survive a launch, and gathering data from them is possible.

4.3.4. Provide flight performance predictions (flight values integrated with detailed experiment operations).

The Toshiba 60GB SuperSlim MK6026GAX hard drive was working smoothly right up until the launch. We speculated that the failure might be attributed to its age—the company states that the drive can withstand up to 200 g forces when operational. The computer still detects the hard drive's presence after the launch, but cannot communicate with the hard drive, as its shock protection system kicked in.

4.3.5. Discuss flight preparation procedures.

The flight preparations procedure can be found in Appendix D. This checklist is followed when prepping our rocket to ensure that it is properly assembled.

We install the batteries in the payload section pre-launch to avoid any power leakage. These batteries will be fastened with zip ties. The sled assembly is slotted into the fiberglass coupler and wired to the 4 switches: payload, recovery HCX CPU, recovery HCX pyros, and MAWD altimeter. The two steel screws are threaded through the sled assembly, and the fiberglass endcaps seal the avionics bay. Switches are turned on separately to make sure that each component is working. The simple net computer has been modified to run our source code upon startup, so we do not have to initialize the computer via any external device (i.e. Ethernet cable).

4.3.6. Specify approach to workmanship as it relates to mission success.

Workmanship must be neat and reliable. Without this many things within our payload will go wrong. Our wiring must be done correctly; if not then our electronics will not work as we needed it to. If our sleigh is too complex and

it cannot be loaded then we won't be able to launch it, and no data will be collected. If the vehicle is not well constructed then it couldn't be launched or couldn't be launched multiple times. Workmanship is very important in our project.

4.3.7. Discuss completed component, functional, or static testing

We tested the hard drive for functionality through the simple net computer. Once we have started up a ssh session on the simple net computer, we can look for the hard drive mount on the simple net. If the hard drive shows up, the hard drive is functional, for it can communicate with the simple net computer—otherwise we get an error. We then ran our perf.sh file, our source code, on the hard drive. The hard drive latency we got with a static hard drive was around 12 ms, about the same as stated by the manufacturer:

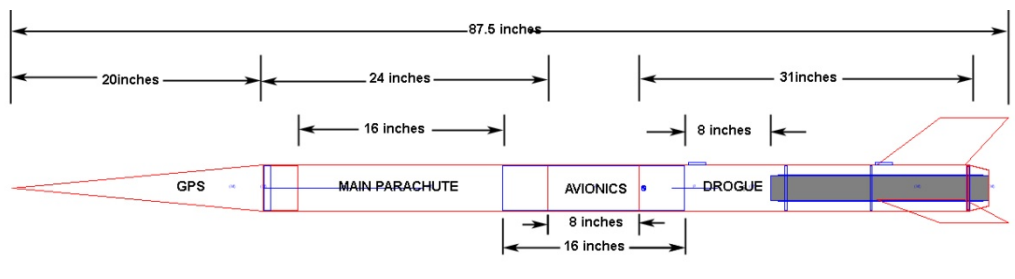
http://www.superwarehouse.com/Toshiba_60GB_SuperSlim_MK6026GAX__Hard_Drive/HDD2194/ps/394084. Shaking the hard drive resulted in higher hard drive latency, indicating that the hard drive was working normally.

4.4. Assembly

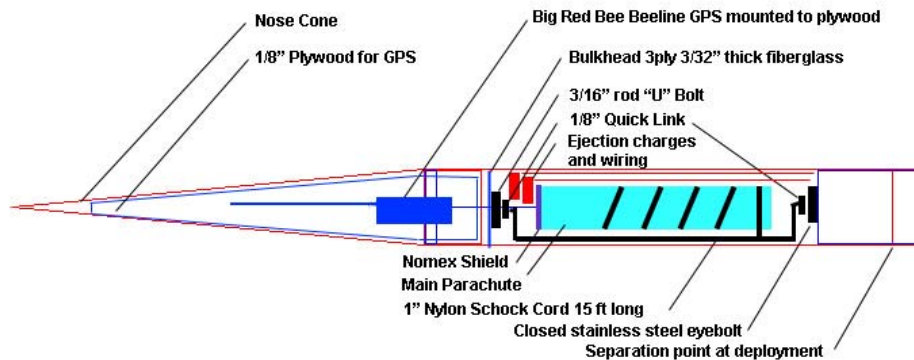
4.4.1. Clear details of how the rocket is assembled.

Overall:

The diagram below shows an overall picture of the vehicle with dimensions of each section

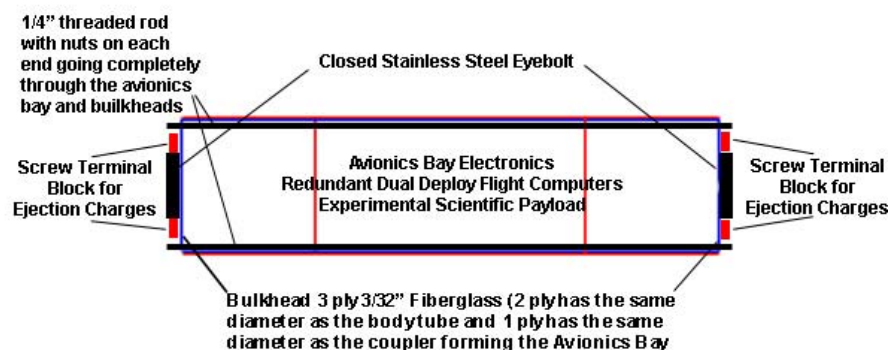


The forward portion of the rocket sits above the avionics bay and houses the GPS locating system as well as the main parachute:



Our nose cone houses the GPS; the GPS is mounted on a triangular section of 1/8" plywood that fits snugly in the nose cone. The back end of the plywood rests against a bulkhead (layers of 3/32" fiberglass) 4" down from the upper end of the upper body tube. The nosecone is secured to the upper body tube. A "U" bolt with 0.2" rod for 1/2" pipe is connected to this bulkhead, the side facing towards the section that holds the parachute. A 1200 pound test stainless steel quick link attaches the 15 feet long 1" tubular nylon shock cord to U bolt. The other end of the shock cord attaches to another 1200 pound test stainless steel quick link that in turn attaches to a closed marine stainless steel 5250 lb test eye bolt on the avionics bay. The main parachute sits in that cavity, the main parachute is 72 inch diameter TAC-1 protected by a Nomex shield. The ejection charges for the dual deploy system is in the nose cone end of this forward body tube.

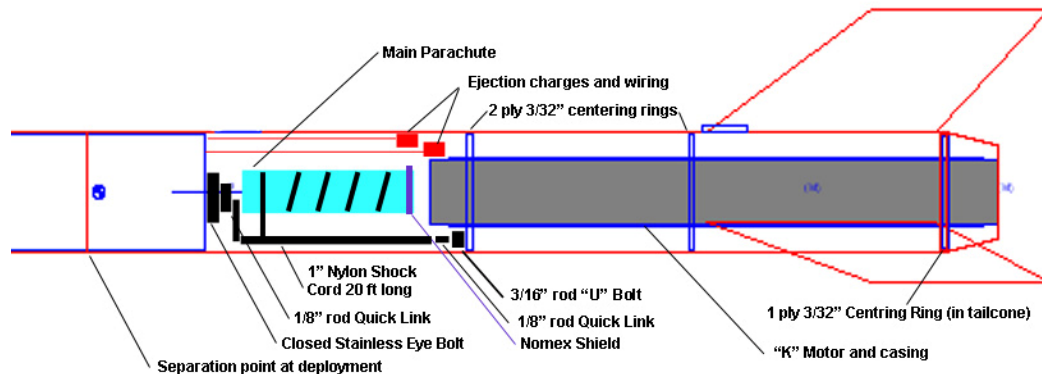
Behind this section is the avionics bay:



The avionics bay is two 8" fiberglass couplers centered in an 8" body tube, all epoxied together using the West System. Inside is the recovery electronics and the scientific payload. The closed eyebolt described above is secured to the bulkhead on each end of the avionics bay. This bulkhead is 3 layers of 3/32" fiberglass. Two layers are bulkheads of a diameter that fits inside the body tube; the third layer fits inside the coupler help with

alignment. Two $\frac{1}{4}$ " threaded rods go completely through the avionics bay to hold it together and provide a reliable path for tension when the parachute is deployed. The four inches of coupler stick out on both sides on the avionics bay. This slides into the top and bottom sections.

The rear body tube holds the drogue parachute, fins, and motor:



The closed stainless steel eye bolt identical to the main end of the avionics bay is the first connection point for the shock cord for the drogue parachute. The second connection point is a second "U" bolt identical to the one described above on a centering ring. A quick link provides a serviceable connection between the eye or "U" bolts and the shock cord. This section also houses the drogue parachute with its Nomex shield protection and the ejection charges for the drogue.

4.4.2. Integration and compatibility simplicity

The entire vehicle has been designed for simplicity and ease of integration.

- The GPS is all self contained and mounted on a $\frac{1}{8}$ " triangular piece of plywood. This slides into the nose cone and a single screw holds the nose cone to the top of this body tube section.
- The shock cords for the main and drogue parachutes are attached to the "U" and eyebolts on either end via quick links to allow easy assembly and disassembly.
- The main and drogue parachutes are connected to the shock cord via a swivel and quick link, again for quick assembly and disassembly
- The e-matches are connected to the avionics bay with a screw terminal block
- All avionics – recovery and scientific payload are on a single assembly that slides into the avionics body tube along $\frac{1}{4}$ " threaded rods.
- Safety switches and the terminal blocks on the end cap bulkheads all attach to the avionics assembly via screw terminal blocks

- The motor is retained via an Aerotech Quick-Change motor retention device. On single screw cap and the motor is locked in place.
- All sections slide together and overlap approximately 3 places.
- Shear pins are #2 screws that are press-fit into place.
- Even after installation of the electronics into the avionics bay, no power is applied. Four external switches with “Remove Before Flight” tags on the keys keep power off. Power can then be applied one at a time to:
 - Scientific payload
 - MAWD flight computer
 - HCX CPU
 - HCX Pyro

This is for safety and allows powering up each one individually for validation of continuity by the beep sequences.

4.4.3. Structural integrity for flight

The vehicle body is made entirely of .060” thick fiberglass. The nose cone and tail cones are also a thicker fiberglass with a cosmetic gel coat over the exposed surface. All pieces of the vehicle overlap by one body tube diameter (4”) and are secured by metal screws when they should not come apart in flight (the nose cone), or by 3 #2 screw shear pins for those joints that should come apart in flight. All anchor points have been described above with materials far exceeding the stresses that are expected. Materials such as the 1” tubular nylon shock cords have plenty of margin for strength degradation across multiple flights.

4.4.4. Quality of construction

Our rocket is well assembled. West system epoxy was used to construct the rocket. Fillets have been placed on bulk heads and centering rings, excluding the payload. All eyebolts and “U” bolts have been glued in using west systems epoxy, this excludes the payload. The rocket’s fins are through the wall fins and are fiberglass. The fins are glued on using a fin jig to ensure that they are straight. Fiberglass tape has been used along the entire length of the fin. Holes have been drilled for pressure holes, shear pins and screw holes, all were done so at a 90 degree angle. Construction details can be found in Appendix R.

4.5. Safety and Environment (Payload) (This will describe all concerns, research, and solutions to safety issues related to the payload.)

4.5.1. Identify safety officer for your team.

The safety officers for our team are Sjoen and Divya.

4.5.2. Update the preliminary analysis of the failure modes of the proposed design of the rocket, payload integration, and launch operations, including proposed and completed mitigations.

Failure modes can be found in Appendix A.

4.5.3. Update the listing of personnel hazards, including data demonstrating that safety hazards have been researched, such as material safety data sheets, operator's manuals, and NAR regulations, and that hazard mitigations have been addressed and enacted.

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 and have been referenced. 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.

4.5.4. Discuss any environmental concerns.

The environmental hazard can be found in Appendix B.

5. Launch Operations Procedures

5.1. Checklist

The complete recovery check list can be found in Appendix D

5.1.1. Recovery preparation

- Make sure the mechanics within the avionics bay are locked into their designated spots
- Replace the used batteries with brand new 9volt Duracell
- Turn the key switch on and once again, make certain that everything is functioning correctly
- Turn off the Key switch
- Check both the drogue and main parachute in case of tangles within the shroud lines and shock cord, refold them properly and pack them in correctly
- Protect the parachutes from scorching with the use of a Kevlar shield.
- Place the black powder in their designated areas
-

5.1.2. Motor preparation

- You must first make sure that your hands are clean and your working station in order to keep unwanted debris out of the engine
- Remove the engine from the packaging material
- Check to make sure there is no damage to the motor casing
- Remove the black powder from the engine for a dual deployment launch, and place masking tape as a replacement for the black powder.
- Load the engine inside the casing, and load the engine inside the rocket without an igniter in the engine.
- Fasten the motor retainer to keep the engine in place
-

5.1.3. Igniter installation

- Once the rocket is on the launch pad, then you can install the igniter

- Before installation you must make sure that you lead wires are twisted together so the engine does not pre-ignite
- To install the igniter you must first measure the depth of which the igniter can travel inside the engine (or until it stops against the igniter pellet
- Then loop the igniter around your finger at the location that was measured to ensure a more compact fit of the igniter
- Insert the igniter in the engine while the wires are still twisted together
- Slide the nozzle cap up to the loop that was made earlier with the igniter and push the cap over the nozzle of the engine
- Separate the twisted wire leads and attach them to the alligator clips if only the launch pad system is turned off.
- Check to makes sure that there is continuity going to the igniter

5.1.4. Setup on launcher

- First assemble the launch pad and place it 200 feet as required to the launch table
- Ensure that the launch rail is vertical and has most residue off the rail to ensure the rocket does not get caught on the rail
- Run the launch wires from the table to the pad
- Place the launch control on the table with the key removed
- Connect batteries on both ends of the wires and attach the wires to the launch controller and the alligator clips
-

5.1.5. Launch procedure

See Flight Check List in Appendix D

5.1.6. Troubleshooting

In case of any problems occurring in the engine, recovery system, other parts of the rocket, we have a series of way to back up each system depending on the system itself. For instance, the recovery has a dual deployment recovery meaning we have two different pressure sensors that will run at the same time in case of failure in one of the two electronics. In case of malfunctioning with the motor, we would have to take the precautions of the motor very seriously due to the damage that would occur if something were to operate incorrectly. In the case where it does malfunction, we will have may have extra engine cases and engines.

5.1.7. Post flight inspection

For our post flight inspection we will check over the rocket to make sure that it is in proper condition. If we were to do a post flight inspection now we would conclude our rocket is O.K. to launch. It does however have a chip out of the gel coat on the nose cone and stress cracks around the shear pin holes.

5.2. Safety and Quality Assurance (Provide detailed safety procedures for each of the categories in the Launch Operations Procedures checklist.) Include the following:

5.2.1. Provide data demonstrating that risks are at acceptable levels.

The risks that could occur during launch operations and their mitigations are in Appendix C.

5.2.2. Provide risk assessment for the launch operations, including proposed and completed mitigations.

See Appendix C for the risks and mitigations that could occur during the launch.

5.2.3. Discuss environmental concerns.

Environmental concerns can be found in Appendix B.

5.2.4. Identify individual that is responsible for maintaining safety, quality and procedures checklists.

Sjoen and Divya are team safety officers. They are in charge of following the safety checklist to make sure that the vehicle is suitable for flight. The flight checklist is located in Appendix D.

6. Activity Plan

6.1. Show status of activities and schedule

The activity status can be found in appendix E.

6.1.1. Budget plan

Our budget is in Appendix F. 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 have written a letter asking for donations, but are still waiting on the contact names. 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. The register article will be in April, and the other articles will be written by the end of February.

6.1.2. Timeline

The complete time line is in Appendix G

6.1.3. 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.

6.1.3.1. 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 Irwin dale, 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.

6.1.3.2. AIAA Professional Society

Our team gave a PowerPoint presentation to AIAA OC section and we received very good feedback. With the presentation we got to say what this team and program is all about. Because of the presentation it has made it easier to better communicate with our organization.

6.1.3.3. 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 had an article in our neighborhood newspaper , “The Foothills Sentry”. And the Sunny Hills High School has already published one article on the team and plans to release another soon.

6.1.3.4. 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.

6.1.3.5. Youth Expo

Youth Expo is a mini Orange County fair in our County this fair is very popular. At Youth expo 4-H, girl scouts and a science fair all participate. We will reach a few hundred kids at our booth at youth expo. This event is happening April 9th to 11th.

6.1.3.6. Presentation to Tarbut V' Torah (TVT)

TVT is a high school one our team member attends. The presentation will be on about what the project is and everything that had to be done. The presentation will be given in May.

7. 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 our team's writing skills (technical and otherwise).

The team web site at <http://AIAAOCRocketry.org> has photos, videos, the MSDS, manuals for the equipment used, and all documents available.

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	<ul style="list-style-type: none"> -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	<ul style="list-style-type: none"> -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"	<ul style="list-style-type: none"> -We will use a single use Engine for our rocket, That will be a Cesaroni engine, manufacture made
The engine explodes	<ul style="list-style-type: none"> -We will use a single use engine for our rocket, That will be a Cesaroni engine, manufacture made
The Drogue parachute does not deploy	<ul style="list-style-type: none"> -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	<ul style="list-style-type: none"> -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

	<p>delay because of weather conditions or other such things that would prevent launching</p> <ul style="list-style-type: none"> -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	<ul style="list-style-type: none"> -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	<ul style="list-style-type: none"> -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	<ul style="list-style-type: none"> -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	<ul style="list-style-type: none"> -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	<ul style="list-style-type: none"> -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	<ul style="list-style-type: none"> -We will tape in battery(s) so they will not fall out
The battery(s) 'die' during launch	<ul style="list-style-type: none"> -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	<ul style="list-style-type: none"> -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	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> -We will double check the programming of our altimeters is correct
The altimeter isn't set to fire the main 'chute	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> -We will double check the programming of our altimeters is correct
Tracking device isn't accurate	<ul style="list-style-type: none"> -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	<ul style="list-style-type: none"> -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	<ul style="list-style-type: none"> - 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 launching 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 *Rocksims, 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	13 The Drogue 'chute fires at the launch	23 sheer pines aren't put in place
2 The rocket folds upon itself	wrong altitude	24 The car running over the rocket
3 rocket struggles off the launch pad	14 The battery(s) 'die' during launch	25 The altimeter isn't set to fire the main 'chute at the correct height
4 The engine "chuffs"	15 The Drogue 'chute misfires	26 The electric match doesn't ignite the black powder
5 The Rocket weather cocks	16 The altimeter isn't set to fire the drogue 'chute	27 The black powder blows the rocket apart
6 Payload isn't set up	17 The altimeter isn't set to fire the drogue 'chute at correct height	28 The altimeter isn't set to fire the main 'chute
7 The Payloads HCX isn't accurate	18 The Main 'chute fires at the wrong altitude	29 No recovery system
8 The *Linn Ex Computer isn't programmed correctly	19 The Main 'chute misfires	30 The battery(s) of our electronics bay fall1 out
9 The rocket landing in a dangerous area	20 Tracking device isn't accurate	
10 The rocket landing in mud	21 Tracking device doesn't transmit radio waves	
11 The rockets fin breaking	22 Tracking device is damaged in	
12 The engine explodes		

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 | 19 Suppliers not having our items in |
| 2 Parts delivery is delayed | stock |
| 3 Large amounts of people leaving
for the holidays | 20 Not following the schedule |
| 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 | |

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

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 (see manuals – this should have already been completed)



HAZARDOUS MATERIAL – SEE MSDS

- Make certain that the 3 recovery and one payload power switches are in the OFF position
- Remove the old 9VDC batteries and discard correctly. Replace with new batteries and secure with tie wraps.
- Verify that the rechargeable payload 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**

- Pull all switch wires to the upper (main) end of the avionics bay
- Begin to insert the bulkhead and sled assembly with the recovery electronics and payload into the lower (drogue) end of the avionics bay
- Pull all 4 wires from the drogue bulkhead assembly through the avionics bay to the upper (main end)
- Connect the 4 wires from the drogue bulkhead assembly to the terminal block on the upper (main end) – 2 orange to orange and 2 purple to purple
- Connect the 4 wires from the main bulkhead assembly to the terminal block on the upper (main end) – 2 yellow to yellow and 2 blue to blue

- Connect the 2 wires from the switch #1 (gray wires marked SW #1) to the terminal block locations marked switch #1
- Similarly connect the 2 wires from each of the switches #2, #3, and #4 to their terminal block locations marked switch #2, #3, and #4 respectively
- Carefully slide the sled with the electronics into position in the avionics bay
- Put the upper (main end) bulkhead in place and secure with washers and wing nuts

☐ **Test the flight computers**

- Turn ON the MAWD
- Verify the two beeps for Mach delay and the 900 foot altitude deploy beeps (9-10-10 beeps) then silence (this indicates all the MAWD is working but there is no continuity)
- Short out the drogue pyro terminals for the MAWD and verify you hear 1 beep – repeated as long as you have the terminals shorted – this indicates continuity
- Remove the short above and short out the main pyro terminals for the MAWD and verify you hear 2 beeps – repeated as long as you have the terminals shorted – this indicates continuity
- Turn OFF the MAWD and turn ON the HCX CPU and PYRO
- You should hear two beeps (for JP7 enabled for stage) and no warble (bad battery) followed by a series of four sets of two beeps each (2 – 2 – 2 – 2) (this indicates the HCX is working but there is no continuity)
- Short out the drogue pyro terminals for the HCX and verify the series of 4 sets of beeps changes so the second is 1 beep (2 – 1 – 2 – 2) – this indicates continuity
- Remove the short above and short out the main pyro terminals for the HCX and verify the series of 4 sets of beeps changes so the third is 1 beep (2 – 2 – 1 – 2) – this indicates continuity.
- Turn OFF both HCX switches
- Briefly power on the payload power switch and verify power on beeps from the HCX accelerometer



HAZARDOUS OPERATION – SEE SAFETY 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 narrow masking tape
- Make certain the payload power switch is in the OFF position
- Untwist the ends of the e-matches and connect to the **DROGUE** terminal blocks
- Secure the glove finger/e-match/black powder so it won't shift during launch

**HAZARDOUS OPERATION – SEE SAFETY 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 narrow masking tape
 - Make certain the payload power switches are in the OFF position
 - Untwist the ends of the e-matches and connect to the **MAIN** terminal blocks
 - 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
 - Slide the triangle shaped plywood with the GPS transmitter into the nose cone
 - 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
 - Roll the shock cord in a figure “8” and 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 e-match and black powder charge into the empty rear body tube

- Place the **DROGUE** parachute into the Nomex shield and wrapping the shield around the parachute
- Roll the shock cord in a figure “8” and put the shock cord into the rear 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
- Slide the vehicle onto the launch rail
- Arm the MAWD recovery electronics and verify the following beeps
 - Warble, then one long beep followed by the setting of the mach delay (2 beeps)
 - Long beep followed by the setting of the deployment altitude (9 beeps followed by 10 beeps followed by 10 beeps for 900 feet)
 - Series of beeps indicating altitude of last flight
 - Continuing series of 3 beeps indicating the two e-matches are properly connected (if you do not hear these, there is something wrong)
- Arm the HCX recovery electronics and verify the following beeps
 - Two low pitched beeps indicating we are not set for multiple stages or clustering
 - A pause
 - A series of two beeps, followed by one beep, followed by one beep, followed by two beeps, a pause, then this series repeats
 - If you hear any other series of beeps, there is a problem. Consult the beep table on the next page
- Arm the scientific electronic payload and validate the payload is functional. You should hear beeps similar to those above for the HCX:
 - Two low pitched beeps indicating we are set for recording only
 - A pause
 - A series of two beeps, followed by two beep, followed by two beep, followed by two beeps, a pause, then this series repeats
 - If you hear any other series of beeps, there is a problem. Consult the beep table on the next page

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

☐ The vehicle can now be launched

G-Wiz HCX Flight Computer Beep Code Table

Flight Computer Status Codes Normal Status Code	
<ol style="list-style-type: none"> 1. LED turns on then off. 2. The LED turns on and the beeper gives one (JP7 OUT) or two (JP7 IN) low pitch beeps. 3. LED turns off. 4. There is a half second pause. 5. Starting with pyro port one, each pyro port reports status with either a single quick "beep" (for good continuity) or a double "beep" if the port has incomplete continuity. 6. A one second pause, and then the sequence repeats from step 2. 	
Low Battery <ol style="list-style-type: none"> 1. LED turns on, then off. 2. The LED turns on and the beeper gives one (JP7 OUT) or two (JP7 IN) low pitch beeps. 3. After a half second pause, the beeper gives a short warble. 4. LED turns off. 5. There is a half second pause. 6. Pyro port report status 7. A one second pause, and then the sequence repeats from step 2. 	SD Card is Unplugged <ol style="list-style-type: none"> 1. The LED turns on then off. 2. Long, High pitch beep. 3. Long, low pitch beep. 4. 3/4 second delay. 5. Normal status code starts.
Power-On Self-Test Failure (POST Failure) <ol style="list-style-type: none"> 1. Long warble. 2. Then a half second delay. 3. 1 – 7 high pitch beeps giving a failure code. <ul style="list-style-type: none"> o For 1 to 4 beeps: Hardware error. Do not fly. See manual. o For 5 or 6 beeps: Reformat or replace card. See manual for more information. o For 7 beeps: The SD card is full. Reformat or replace card. 4. A 1 second pause, and then the sequence repeats. 	Break Wire Error <ol style="list-style-type: none"> 1. Short warble. 2. A 1 second pause, and then the sequence repeats. <p>For Breakwire Flight</p> <ol style="list-style-type: none"> 1. Power HCX off. 2. Correctly attach ends of break wire to TB2 pins3/4. <p>For Non-Breakwire Flight</p> <ol style="list-style-type: none"> 1. Power HCX off 2. Attach a wire to TB2 pins3/4. 3. Connect HCX to FlightView 4. In Configuration window, Main tab, check Analog Input.

Appendix E

The checkmarks indicate the events that have already been passed and completed whereas the 'x' marks indicate upcoming events.

- ✓ August 23, 2010 – First SLI meeting
- ✓ August 30, 2010 – Second SLI Meeting
- ✓ September 12, 2010 – Third SLI Meeting
- ✓ September 24, 2010 – Proposal Due for Review
- ✓ September 26, 2010 – Forth SLI Meeting
- ✓ September 27, 2010 – Electronic Proposal Due to NASA
- ✓ October 9-10, 2010 – ROCTober Fest
- ✓ October 12, 2010 – NASA Accepts Proposal
- ✓ October 16, 2010 – Girl Scouts: Presentation/Workshop
- ✓ October 21, 2010 – Trial Web-Ex Conference
- ✓ October 24, 2010 – Fifth SLI Meeting/SLI Team Conference
- ✓ October 30, 2010 – Girl Scouts: Presentation/Workshop
- ✓ November 1, 2010 – Website Presence Established
- ✓ November 6, 2010 – Girl Scout Launch
- ✓ November 7, 2010 – Sixth SLI Meeting
- ✓ November 12, 2010 – Seventh SLI Meeting
- ✓ November 13, 2010 – Eighth SLI Meeting
- ✓ November 14, 2010 – Ninth SLI Meeting
- ✓ November 19, 2010 – PDR and Presentation on Website
- ✓ December 6, 2010 – PDR Presentation (Start)
- ✓ December 10, 2010 – PDR Presentation (Finish)
- ✓ December 18, 2010 – Test GPS Functionality and Range
- ✓ January 1, 2011 - Launch Scale Model Rockets
- ✓ January 8, 2011 – Tenth SLI Meeting
- ✓ January 9, 2011 – Eleventh SLI Meeting
- ✓ January 15, 2011 – Twelfth SLI Meeting
- ✓ January 16, 2011 – Thirteenth SLI Meeting
- ✓ January 22, 2011 – Fourteenth SLI Meeting
- ✓ January 23, 2011 – Fifteenth SLI Meeting
- ✓ January 24, 2011 – CDR Reports and Presentation
- ✓ January 29, 2011 – Test Gunpowder For Dual Deployment
- ✓ February 2, 2011 – CDR Presentations (Start)
- ✓ February 6, 2011 – Test Gunpowder For Dual Deployment
- ✓ February 8, 2011 – CDR Presentation (Final Day)
- ✓ February 12, 2011 – Launch Scale Model Rocket
- ✓ March 12, 2011 – Launch Full Sized Rocket
- ✓ March 21, 2011 – FRR Reports and Presentation on Website
- × March 26, 2011 – Car Wash in Fullerton
- × March 26, 2011 – Flight #2 of full sized vehicle near Edwards AFB
- × March 31, 2011 – FRR Presentation (Start)
- × April 1-3 – Next flight of full sized vehicle at Plaster City (if needed)

- × April 6, 2011 – FRR Presentation (Finish)
- × April 8-10 – Youth Expo boot at the Orange County Fair Grounds
- × April 9, 2011 – Next flight of full sized vehicle at Lucerne Dry Lake (if needed)
- × April 13, 2011 – Travel to Huntsville
- × April 14-15, 2011 – Flight Hardware and Safety Checks
- × April 16, 2011 – Launch Day
- × May 9, 2011 – Post-Launch Assessment Review

Appendix F

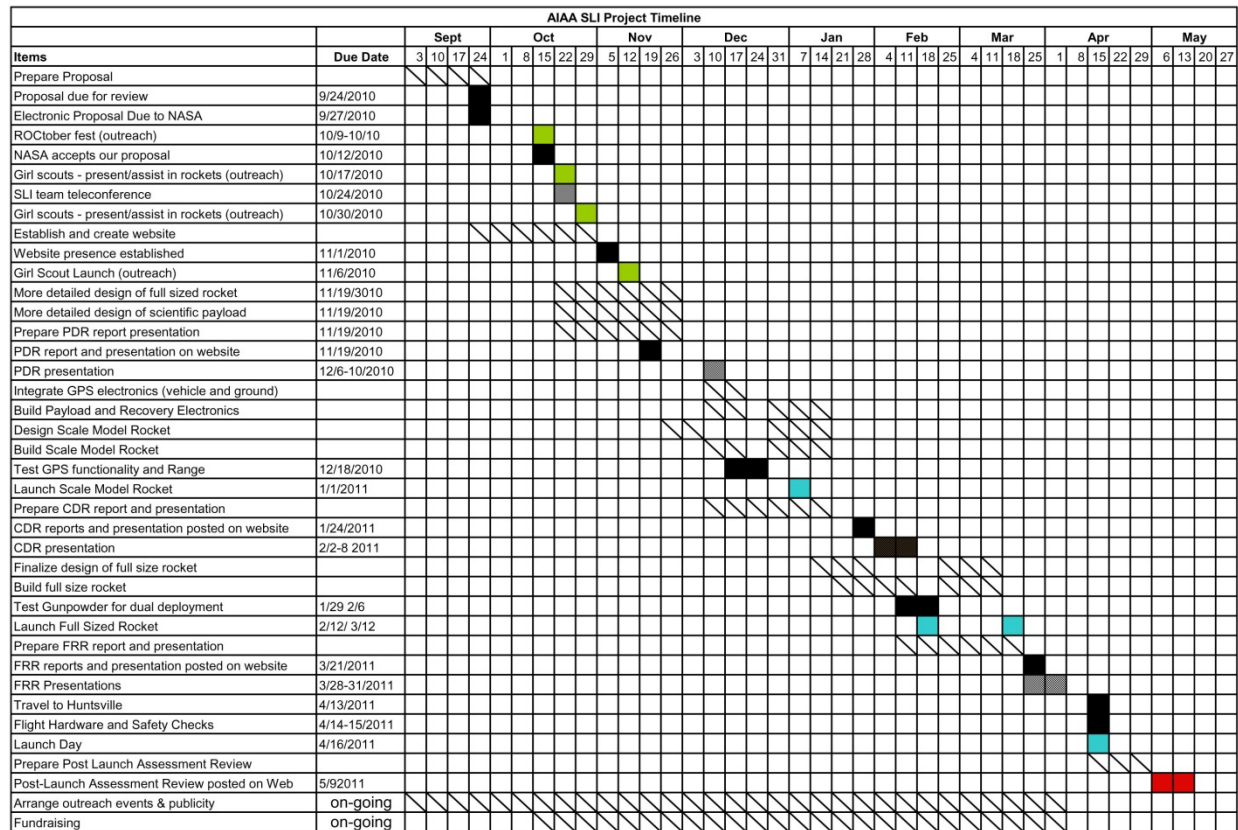
Budget:

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 G

Timeline:



Appendix H

1. Black Powder

a. Equipment

- i. Vehicle
- ii. Vise
- iii. Black Powder
- iv. Wire
- v. Nine Volt Battery

b. Procedure

- i. Connect wire to a terminal block that is attached to either a drogue or main Terminal block and twist end of wire that is not attached to a terminal block.
- ii. Measure out black powder
- iii. Put black powder in a cut off finger glove
- iv. Put a Electrical match in the black powder and twist the end of the glove finger
- v. Tape igniter and glove shut and label amount
- vi. Set up charge and go to testing area
- vii. Put vehicle in vise and make sure that it is not gripping a separation pieces
- viii. Set away from the vehicle
- ix. Untwist wires
- x. Touch end of batteries to the wires making sure they do not short
- xi. Observe Reaction.

c. Observation

The procedure is very delicate and you have to make sure you label the amounts so you don't mix them up. Both black powder tests that our team performed worked.

d. Conclusion

150 pounds of pressure for our scale model is more than enough to eject the parachutes. The full scale testing will be done once the rocket itself is completed.

The AIAA OC Rocketry SLI 2010-2011 web site has photos of this testing. The general photo gallery page can be found at:

<<http://aiaaocrocketry.org/SlideshowWebGalleries/SLI2011/>>.

The testing slide show that contains the battery life testing as well as other testing can be found at

<<http://aiaaocrocketry.org/SlideshowWebGalleries/SLI2011/8/slideshow.htm?1>>.

Appendix I

1. Battery Life – Common equipment

a. Equipment common to all battery life tests

- i. Fluke 73III Multimeter
- ii. Dataq Instruments DI-194RS Recording Analogue to Digital Converter
- iii. Dataq Instruments WinDaq Serial Acquisition software version 3.38
- iv. WinDaq Waveform Browser Version 2.67
- v. Two Christmas tree light bulbs to simulate electric matches

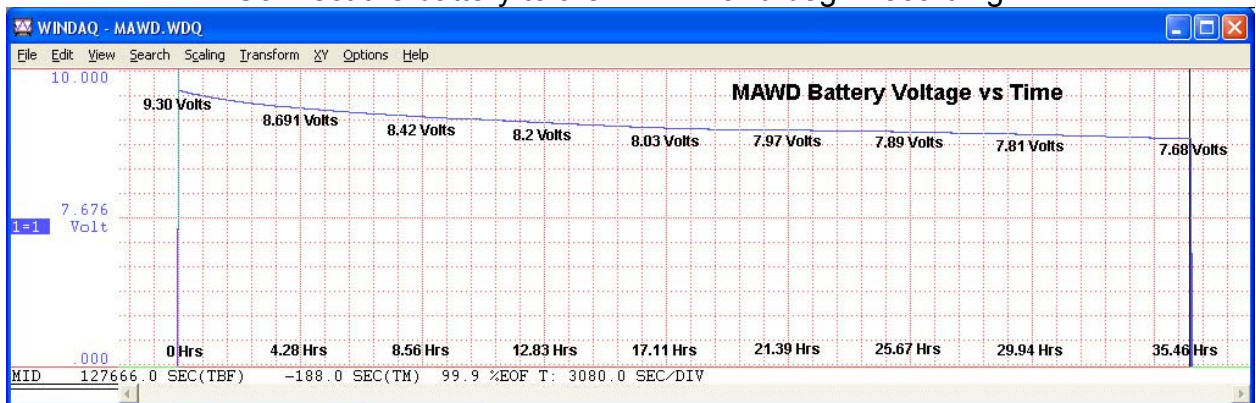
2. Battery Life - MAWD

a. Equipment

- i. One MAWD Flight Computer
- ii. One brand new Duracell MN1604 9V Battery

b. Procedure

- i. Connect Christmas tree bulbs to the MAWD in place of electric matches for the Main and Drogue parachutes
- ii. Plug the WinDaq A/D converter into COM1 of the PC and start the WinDaq Software
- iii. Connect Channel 1 of the WinDaq A/D converter to the positive lead of the battery and the A/D converter ground to the negative lead of the battery
- iv. Connect the battery to the MAWD and begin recording



c. Observation

The operating voltage of the MAWD flight computer is 6 – 10 Volts. The 9 Volt Duracell battery maintained a voltage well above the 6 volt minimum for the duration of the test. The test was discontinued at 36 hours with a battery voltage of 7.68 Volts. Even though the electric matches were not fired during this time, the short duration of the higher current should not affect this battery life dramatically.

d. Conclusion

The single Duracell battery will provide more than enough life to power the MAWD flight computer for the target 2.5 hours (1 hour pad dwell time and flight and recovery time)

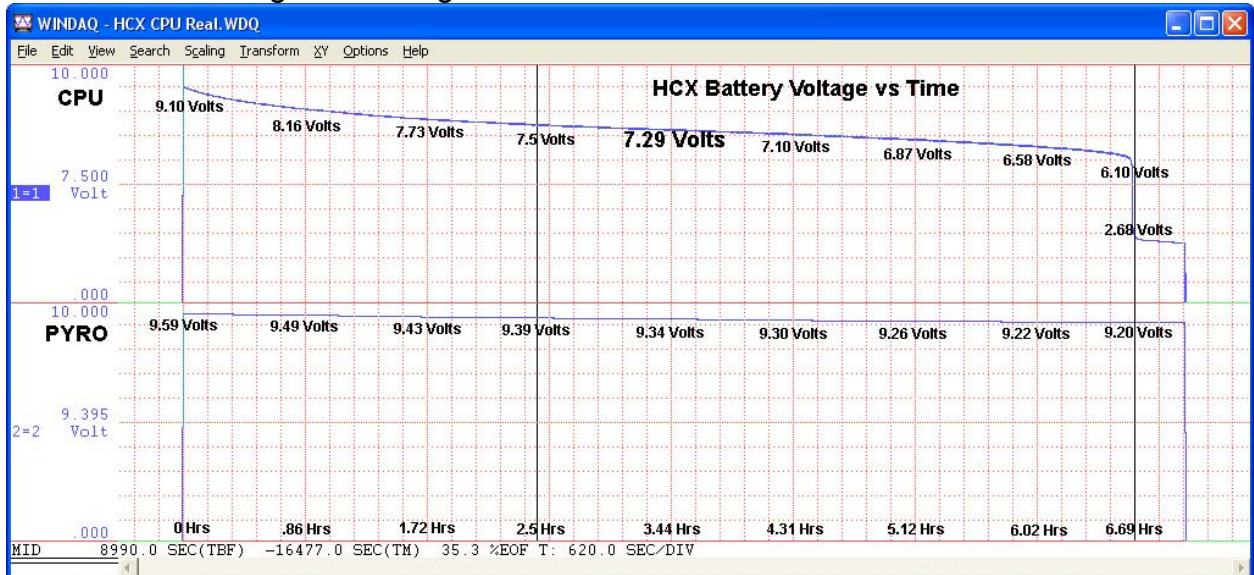
3. Battery Life - HCX

e. Equipment

- i. One HCX Flight Computer
- ii. Two brand new Duracell MN1604 9V Battery

f. Procedure

- i. Connect Christmas tree bulbs to the HCX in place of electric matches for the Main and Droque parachutes
- ii. Plug the WinDaq A/D converter into COM1 of the PC and start the WinDaq Software
- iii. Connect Channel 1 of the WinDaq A/D converter to the positive lead of the CPU battery and the A/D converter ground to the negative lead of the battery
- iv. Connect Channel 2 of the WinDaq A/D converter to the positive lead of the PYRO battery and the A/D converter ground to the negative lead of the battery
- v. Connect the CPU battery to the HCX flight computer CPU
- vi. Connect the PYRO battery to the HCX flight computer PYRO and begin recording



g. Observation

The operating voltage of the HCX flight computer CPU is 7.5 – 12 Volts and PYRO is 7.5 – 15 Volts. The 9 Volt Duracell battery maintained a voltage of 7.5 volts for 2.5 hours.. . The test was discontinued at 6.69 hours when the CPU battery died; the PYRO battery was still at 9.22 volts.

h. Conclusion

The Duracell 9 Volt battery powered the CPU for the minimum target time of 2.5 hours. That minimum time includes 1 hour pad dwell time plus 1.5 hours for flight and recovery which we feel is more than adequate. The PYRO battery at 9.22 volts still had more than adequate life at 6.69 hours when the CPU battery died. Even though no electric matches were fired, the short duration should not affect battery life dramatically.

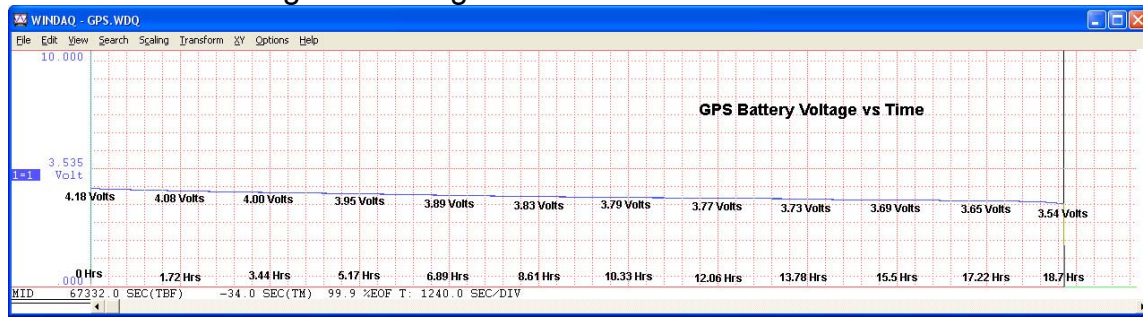
4. Battery Life – GPS

a. Equipment

- i. One Big Red Bee Beeline GPS transmitter with battery fully charged
- ii. One Yaesu VX-6R transceiver

b. Procedure

- i. Connect the power to the Big Red Bee GPS and verify it is transmitting by listening to the transmitted signal on 433.92 MHz (a burst of tones every 5 seconds)
- ii. Plug the WinDaq A/D converter into COM1 of the PC and start the WinDaq Software
- iii. Connect Channel 1 of the WinDaq A/D converter to the positive lead of the GPS battery and the A/D converter ground to the negative lead of the battery
- iv. Begin recording



c. Observation

The battery would have lasted far longer than the 18.7 hours of the test. The minimum battery voltage per the manufacturer's specification is 3 volts; at 18.7 hours the battery was still at 3.54 volts. The transmitter could still be heard in the VX-6R transceiver.

d. Conclusion

The battery life of the GPS transmitter is more than adequate for the targeted 2.5 to 3 hours needed (one hour dwell time on the pad plus flight and recovery time).

5. Battery Life – Payload

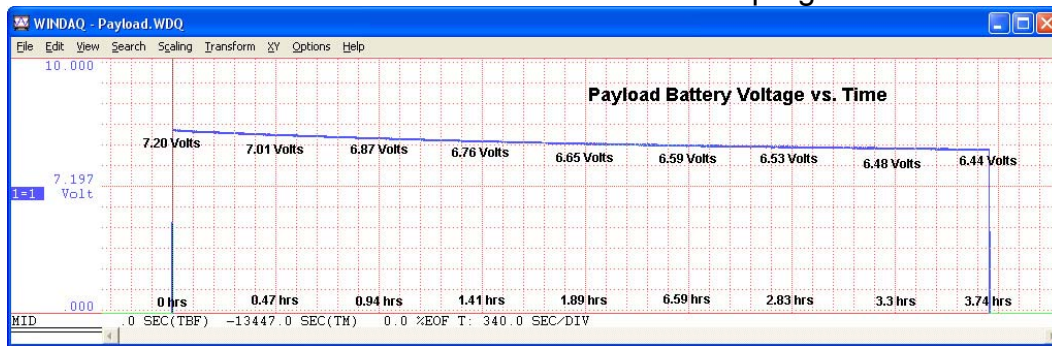
a. Equipment

One payload section containing

- One small Linux computer
- One hard disk drive and USB interface
- One power regulator
- One flash drive
- Three rechargeable 2200mAh Lilon batteries connected in parallel
- One router with network connection to the PC and the Linux computer
- One terminal program

b. Procedure

- i. The Lilon batteries are fully charged and connected to the payload electronics
- ii. Channel 1 of the WinDaq A/D converter is connected to the positive lead of the Lilon batteries after the diode isolation and the A/D converter ground is connected to the negative lead of the batteries
- iii. The program is started and output is fed to the Flash drive (which will be checked later) AND simultaneously to the network so the PC screen can be monitored to assure the program is still active



c. Observation

The test was discontinued after 3.74 hours and the battery voltage was still 6.44V. This test could have continued to run, but we only need 3 hours lifetime.

d. Conclusion

There is adequate battery available to run the scientific experiment payload for the 1 hour dwell time plus flight and recovery time.

The AIAA OC Rocketry SLI 2010-2011 web site has photos of this testing. The general photo gallery page can be found at:

<<http://aiaacrocketry.org/SlideshowWebGalleries/SLI2011/>>.

The testing slide show that contains the battery life testing as well as other testing can be found at

<<http://aiaacrocketry.org/SlideshowWebGalleries/SLI2011/8/slideshow.htm?1>>.

Appendix J

6. GPS Range Testing

i. Equipment

- i. One Big Red Bee Beeline GPS transmitter with battery fully charged
- ii. Receiving ground station consisting of
 1. Yaesu VX-6R Transmitter
 2. Byonics Tiny Track 4 TNC
 3. Garmin eTrex Vista GPS receiver

j. Procedure

- i. Connect the power to the Big Red Bee GPS and install in the nose cone of the rocket and wait for it to acquire satellites
- ii. Turn on the Yaesu, Byonics, and Garmin devices and wait for the Garmin to acquire satellites
- iii. Lay the rocket on its side as if it had just returned from a flight
- iv. Verify you can see the GPS transmitter in the nose cone – it will appear as a waypoint identified as AA6TB (amateur call sign)
- v. Watch the lights on the Byonics Tiny Track 4 – the Blue Light indicates power is ON, the Orange light will flicker ON every 5 seconds when the GPS signal is received (the Big Red Bee Beeline GPS transmits every 5 seconds) and the green light indicates the device is connected to the GPS receiver.
- vi. Walk away from the GPS transmitter with the receiving ground station, watching the range to AA6TB and the flickering Orange light
- vii. Record the distance – when the orange light no longer flickers at least once every 20 seconds (at far distances some transmissions will be missed) record the distance between the GPS transmitter and receiving station as indicated on the Garmin.

k. Observation

The signal as indicated by the yellow light on the TinyTrack 4 remained strong and flashed every 5 seconds up to about 1.8 miles where it started missing an occasional transmission. The signal remained usable up until 3 miles. At that range several transmissions would be missed, then a good decodable signal would come in to update the position. This test was done along a relatively straight road, with some small hills, so it does not exactly replicate the launch terrain. The owner of Big Red Bee indicated that the range in the Mojave Desert, where we frequently launch, tends to be less due to the nature of the soil.

l. Conclusion

The GPS system appears to have sufficient range for our approximately ½ mile required range on the ground. And there should be sufficient range to receive GPS location from the rocket even at an unobstructed 1 mile in altitude.

The AIAA OC Rocketry SLI 2010-2011 web site has photos of this testing. The general photo gallery page can be found at:

<<http://aiaacrocketry.org/SlideshowWebGalleries/SLI2011/>>.

The testing slide show that contains the GPS range testing as well as other testing can be found at

<<http://aiaacrocketry.org/SlideshowWebGalleries/SLI2011/8/slideshow.htm?1>>.

Appendix K

7. Vacuum Chamber Testing

m. Equipment

- i. MAWD Perfect Flight
- ii. HCX G-Wiz Partners
- iii. Christmas Tree Light
- iv. Vacuum Chamber

n. Procedure

- i. Connect Christmas tree lights to drogue and main terminal blocks on MAWD
- ii. Place Battery Into battery holder and Place in Vacuum Chamber
- iii. Once you hear a three beep sequence start to suck the air out of the Vacuum Chamber
- iv. Release air slowly and watch for lights, both main and drogue, flash
- v. Connect MAWD to computer and download information
- vi. Connect Christmas tree lights to drogue and main terminal blocks on HCX
- vii. Place Battery Into battery holder and Place in Vacuum Chamber
- viii. Once you hear a three beep sequence start to suck the air out of the Vacuum Chamber
- ix. Release air slowly and watch for lights, both main and drogue, flash

o. Observation

The Vacuum chamber allowed us to put the flight computers through a simulated flight. This allows us to see whether or not they are set correctly

p. Conclusion

Both flight computers work at least on the second time around.

The AIAA OC Rocketry SLI 2010-2011 web site has photos of this testing. The general photo gallery page can be found at:

<<http://aiaaocrocketry.org/SlideshowWebGalleries/SLI2011/>>.

The testing slide show that contains the GPS range testing as well as other testing can be found at

<<http://aiaaocrocketry.org/SlideshowWebGalleries/SLI2011/8/slideshow.htm?1>>.

Appendix L

8. Ejection charge control testing using lights

q. Equipment

- i. MAWD
- ii. HCX G-Wiz Partners
- iii. Christmas Tree Light
- iv. Cables
- v. Computer

r. Procedure

- i. Connect Christmas tree lights to drogue and main terminal blocks on MAWD
- ii. Place Battery Into battery holder and connect to computer
- iii. Fire both Charges
- iv. Run flight simulation
- v. Pull data from flight computer
- vi. Connect Christmas tree lights to drogue and main terminal blocks on HCX
- vii. Place Battery Into battery holder and connect to computer
- viii. Fire both Charges
- ix. Run flight simulation
- x. Pull data from flight computer

s. Observation

The flight computers reacted and responded how the team predicted they would

t. Conclusion

Pyro outputs all work meaning our flight computers are not defective.

The AIAA OC Rocketry SLI 2010-2011 web site has photos of this testing. The general photo gallery page can be found at:

<<http://aiaaocrocketry.org/SlideshowWebGalleries/SLI2011/>>.

The testing slide show that contains the GPS range testing as well as other testing can be found at

<<http://aiaaocrocketry.org/SlideshowWebGalleries/SLI2011/8/slideshow.htm?1>>.

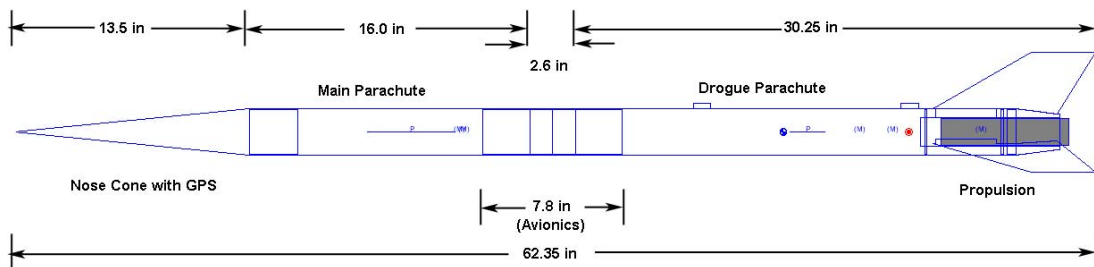
Appendix M

1. Scale Model Vehicle

The scale model vehicle was built to show the design was stable before building the full sized vehicle. Our full sized vehicle uses a 4 inch body tube; the next smaller body tube available locally is 2.6 inch, so our scale is 2.6:4 or 65%. Not all sections scaled exactly due to constraints with parts availability, avionics bay, parachutes, and engines:

Section	Original Full Sized Dimension (in)	Ideal Scale Dimension (in)	Actual Scale Dimension (in (actual scale))
Overall	80	52	62.35 (77%)
Nose Cone	22	14.3	13.5 (61%)
Upper Body Tube	20	13	16 (80%)
Avionics Body Tube	4	2.6	2.6 (65%)
Avionics Coupler	12	7.8	7.8 (65%)
Lower Section	34	22.1	30.25 (88%)

1.1. Design Details - Vehicle



The vehicle was constructed of the same G-10 material as the full sized model with a scaled avionics bay. The vehicle can be flown with engine ejection and a single main parachute in place of the drogue, or with dual recovery with a drogue parachute as well as a main parachute.

Section	Material	Description
Nose Cone	Fiberglass with Gel Coat	2.6" diameter x 13.5" Long
Upper Body Tube	.047 " thick G10 fiberglass	2.6" diameter x 16" long .047" thick bulkhead with 3/16" eyebolt
Lower Body Tube	.047" thick G10 fiberglass	2.6" diameter x 25.25" long
Fins	.068" thick G10 fiberglass	See drawing above
Engine Tube	.047" thick G10 fiberglass	38mm diameter x 7.5" long
Centering Rings	.047" thick G10 fiberglass	2 rings adapt engine tube to body One ring has 3/16" eye bolt
Motor Retention	54mm commercial	Aeropac Quick-Change
Avionics bay	.047" thick G10 fiberglass	Two 3.9" coupler sections One 2.6" long body tube centered
Avionics bay end caps	.125" Plywood	Four bulkheads (two each end) One fits inside body tube One fits inside coupler for alignment
Avionics bay other	2 – 1/4" steel threaded rod 9" long with nuts and washers	

	8 – 1.5" long ¼" launch lugs attached to sleds 2 - .125" Plywood sleds 7.75" long 2 – 3/16" eyebolts
Avionics bay Electronics	MAWD flight computer, HCX flight computer Terminal blocks, wiring, three 9V batteries and holders
Rear Parachute	5/8" x 15 foot long Nylon shock cord Two 3/16" quick link 3" long Nomex shock cord cover 9" Square Nomex parachute shield 36" Rip-Stop Nylon parachute (for engine ejection) 18" Rip-Stop Nylon parachute (drogue for dual deployment)
Front Parachute	½" x 10 foot long Nylon shock cord Two 3/16" quick link 9" Square Nomex parachute shield 30" Rip-Stop Nylon parachute (main for dual deployment)

1.2. Design details and flight properties

The scale vehicle was designed and simulated using RockSim. We began with the original 4" body tube design, then scaled everything down to a 2.6" body tube. Scaling was not exact in all areas due to parts fit (the rear section is longer than it should be to allow using a main with engine ejection as well as a drogue with dual deployment. And some pieces (like the pre-formed nose cone) were not available in the exact size. Some selections, such as the parachutes, were limited by what we was available. The engine was in stock at the launch and was one that we had run simulations on. The table below shows the critical design parameters:

Vehicle Properties		Motor Properties	
Diameter	2.6"	Motor Mfg	Cesaroni
Length	62"	Motor designation	H152
Gross Liftoff wt	81 oz – 5.1 lbs	Max Avg Thrust	152 Newtons (34.2 lbs)
Launch button	For 1" rail	Total Impulse	276 Newton-Seconds
Motor Retention	Aeropak Qwik Change	Mass before/after	298g / 70g
Stability Analysis		Ascent Analysis	
CP (in fm nose)	51.18 in	Max Velocity	334.2 ft/s
CG (in fm nose)	43.99 in	Max Mach No.	.31
Thrust to weight	6.7	Max Acceleration	271.2 ft/s/s
Rail size/length	1" square rail 6 ft long	Peak Altitude	1675 ft
Rail Exit Velocity	50.7 ft/s		
Recovery System – Drogue		Recovery System - Main	
Mfg/model	Top Flight	Mfg/model	Top Flight

Size	18"	Size	36"
Altitude at deploy	Apogee	Altitude at deploy	900 ft
Velocity at deploy	0.03 ft/s	Velocity at deploy	74.3 ft/s
Descent rate	74.3 ft/s	Descent rate	27 ft/s (a little too fast)
Black Powder	1.14 grams	Black Powder	1.01 grams
Recovery System Electronics			
Make/Model	PerfectFlite MAWD		

1.3. Design details for recovery

1.3.1. Parachute Sizes

The parachute sizes were calculated using an on line calculator at Aerocon Systems <http://www.aeroconsystems.com/tips/descent_rate.htm> for an 73 ounce vehicle:

Parachute Size (inches)	Descent Rate
12	78
18	52
24	39
30	31
36	26
42	22
48	19

Formula used for these calculations is in the main vehicle design section.

Based upon these calculations, we should use a minimum parachute diameter of 42 inches for the main and 12-18 inches for the drogue.

Parachutes selected were 36 inches for motor deployment and 18 inches for the drogue and 36 inches for the main parachute for dual deployment.

1.3.2. Black Powder Ejection Charges

For the dual deployment tests we need to use electric matches and black powder charges. We used an on-line calculator in the form of an Excel Spreadsheet at:

<http://www.aeroconsystems.com/tips/Ejection_ChargeCalc.xls>

The results of that calculation are shown below (for a 2.6" body tube):

Body tube section	Cross section (sq in)	Body tube length (in)	Ejection Pressure (PSI)	Ejection Force (lbs)	Black Powder (g)
Main	5.3	13.3	28	150	1.01
Drogue	5.3	15.1	28	150	1.14

Videos of the black powder ejection charge tests are on the AIAA OC Rocketry web site SLI 2010-2011 vide page at:

<http://aiaaocrocketry.org/?page_id=343>

The direct link for the main parachute black powder test video is:

<<http://aiaaocrocketry.org/Videos/SLI2011/SLI%202011%20Scale%20Main%20Black%20Powder%20Test.wmv>>

The direct link for the drogue parachute black powder test video is:
<http://aiaacrocketry.org/Videos/SLI2011/SLI%202011%20Scale%20Drogue%20Black%20Powder%20Test.wmv>

1.4. Motor Selection and simulation results





The motor selected for the flight was a Cesaroni 276H152 BlueStreak. We had done simulations based upon several “H” motors. This impulse range of motors was selected to make certain we could have the entire flight visible without going too high to see. We did all of the motors since we were unsure of which motors would be in stock at the launch we attended. The table below summarizes the simulations run on RockSim for the Cesaroni “H” motors:






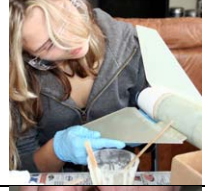
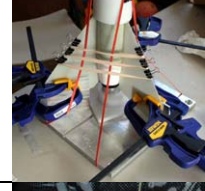


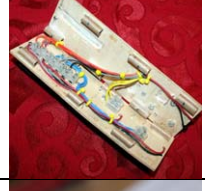

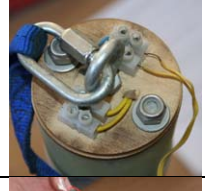


Motor	Wind MPH	Total Impulse (N)	Rocket Mass (oz)	Maximum Altitude (ft)	Maximum Velocity (ft/s)	Maximum Acceleration
H100	0-2	286	82	1636	310	144
H110	0-2	269	82	1502	298	145
H120	0-2	261	81	1491	304	179
H125	0-2	266	81	1543	315	189
H143	0-2	247	83	1320	292	205
H152	0-2	276	81	1675	334	271
H225	0-2	273	81	1636	349	340

1.5. Construction details

The rocket was glued together with West Systems 105 Epoxy and 404 Adhesive Filler. All surfaces to be glued were sanded well with 60 grit sandpaper and thoroughly cleaned with alcohol. Fillets were applied between all bulkheads and centering rings and the mating body tube whenever possible (either by applying directly or by over-applying epoxy and standing the tube on end to allow the epoxy to flow down to the joint). Epoxy fillets were also applied to the fin and body tube joint. Aluminum rail guides were glued in place on the fiberglass body tube with JB Weld. A slideshow documenting the entire construction process can be found on line at

<http://aiaacrocketry.org/SlideshowWebGalleries/SLI2011/5/slideshow.htm?1>

		Left: Engine mount is prepared and glued with centering rings and eyebolt Right: Two tube coupler sections are glued inside a body tube section for the avionics bay
		Left: All surfaces to be glued are thoroughly roughed up with 60 grit sand paper Right: Surfaces as then cleaned with Isopropyl alcohol

		Left: Epoxy is applied thickly before the engine mount is inserted to form fillet when stood on end while glue sets Right: The engine mount assembly is slid into the body tube
		Left: Epoxy is applied after the first centering ring is inserted but before the second to assure both have adequate bonding Right: Final epoxy applied before tailcone goes on
		Left: Epoxy is applied for fins – with the tail cone in place (needed before fins to fit) we could not get access to apply filets later Right: Fins are inserted into the slots and placed
		Left: A fin jig is used to assure near-perfect alignment of fins while the epoxy sets Right: Fillets of epoxy are applied by controlled pouring along the joint between fin and body tube
		Left: Assembling the electronics in the Avionics bay Right: Final assembly of dual deploy in 2.6" body tube (MAWD and HCX) but we would later fly them separately
		Left: Outside of Avionics bay showing the safety switches to disable all power Right: End bulkhead of the avionics section showing eyebolt, threaded rod ends, and terminal blocks for e-matches
		Left: The bulkhead normally in the nose cone is placed down 2.5" in the top body tube to allow easy insertion and removal of GPS Right: The GPS on a triangular plywood sled slides into the nosecone without bulkhead

1.6. Test Flight Results

The scale rocket was flown twice at the Tripoli San Diego launch at Plaster City, California on January 1, 2011. It was our intent to make three flights:

- One using motor ejection with the MAWD used as a passive recording altimeter only
- One using dual deployment with the PerfectFlite MAWD
- One using dual deployment with the G-Wiz Partners HCX

We were able to make only the first two flights and ran out of time and daylight for the third. Results of the flights are as follows:

Flight No.	Weight (g)	Altitude (ft)	Analysis
1	2152	1938	Motor ejection with an 8 second delay and the MAWD used as altimeter only. The flight was very straight with the parachute ejecting a little after apogee. With no wind it returned close to the launch pad.
2	2211	1740	<p>Dual deployment with the MAWD computer. We used shear pins in the lower drogue parachute section but relied on friction on the top main section (as we were advised by our AdHoc mentor at the site – “that rocket is so small it does not need shear pins”. The flight started out perfect, but became a little wobbly as it approached apogee. When the drogue charge fired, not only the drogue deployed but also the main. Looking at the video, it appears the rocket was intact until the drogue charge fired, but when the payload section reached the end of the shock cord it separated and the main was also deployed. This proved to be a valuable lesson on two fronts:</p> <ul style="list-style-type: none"> • Always use shear pins on heavier dual deploy rockets • Follow your design and don't let “experts” on site misguide you <p>We felt the wobble at higher altitudes might be caused by the beginning of drag separation, but the video does not show this. The other cause might be the breaking of the epoxy bond of the fins to the gel-coated tailcone which happened during the first launch. Gel coat is hard to adhere to and we will fiberglass strips between the fins and tail cone to prevent this from happening again</p>

Since we were unable to launch with the HCX computer, and our MAWD dual deployment launch was flawed, we plan another launch on either February 5, 2011 at Plaster City with Tripoli San Diego or February 12, 2011 at Lucerne Dry Lake with ROC (Rocketry Organization of California). We feel we should have a flawless launch with both devices before proceeding to the full scale vehicle. Videos of these launches are posted on the AIAA OC Rocketry web site SLI 2010-2011 video page at: <http://aiaaocrocketry.org/?page_id=343>. The direct link to the video for launch 1 is: <<http://aiaaocrocketry.org/Videos/SLI2011/SLI%202011%20Scale%20First%20Launch.wmv>>

The direct link to the video for launch 2 is:

<<http://aiaacrocketry.org/Videos/SLI2011/SLI%202011%20Scale%20Second%20Launch.wmv>>

Appendix N

Recovery Electronics

The redundant dual deploy recovery electronics shares the payload bay with the scientific payload. The avionics bay is 16" long and consists of two sleds of 1/8" plywood. All recovery electronics is on one sled; the space between the two sleds is used for batteries for the recovery electronics and the payload electronics. The bay is wired with 18 gauge stranded wire. Ferrules are used to assure a good connection under screw terminals whenever there was enough room for them physically. All wires are color coded and labeled to minimize errors during assembly before flight.

Recovery electronics in Avionics Bay

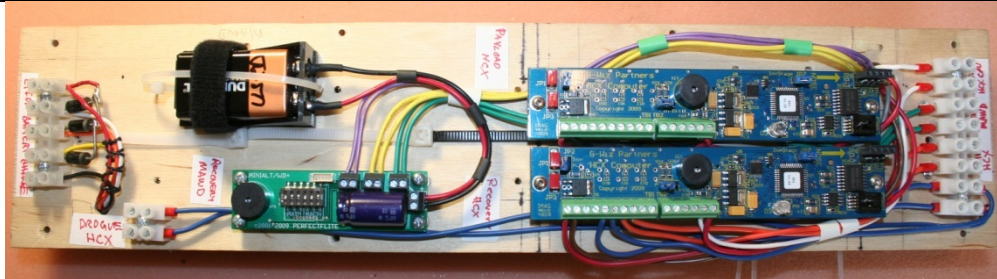


Photo of Recovery side of the Avionics Bay sleds

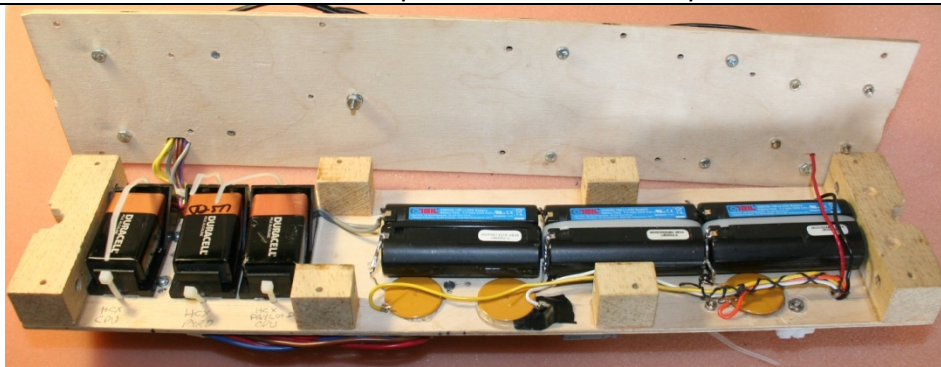
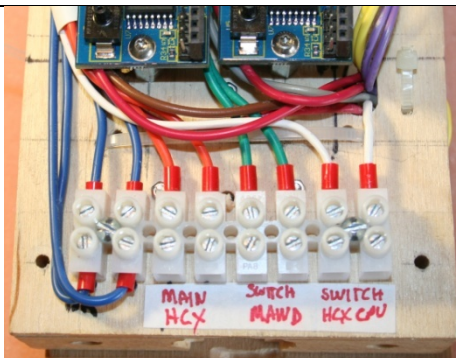
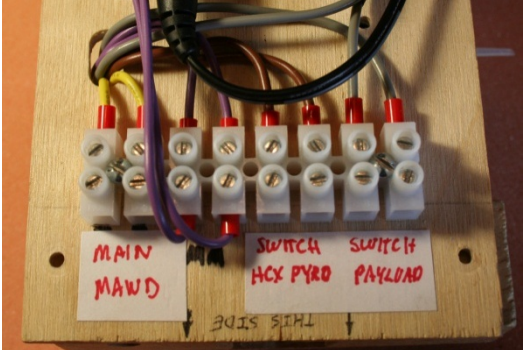
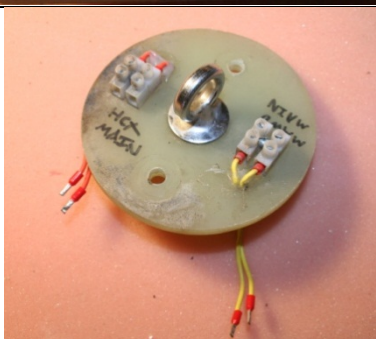


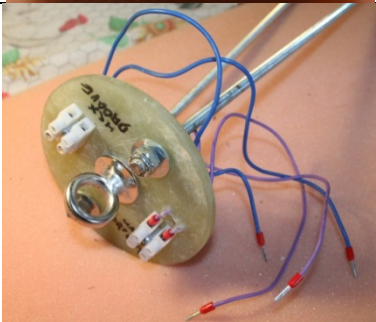


Photo of the area between the Recovery and Scientific Payload sleds



Connection terminal block at MAIN end of bay – recovery electronics sled:

- MAIN HCX connects to a terminal block on the top Avionics Bay bulkhead that in turn attaches to 1 of 2 MAIN e-matches
- SWITCH MAWD connects to a keyswitch to turn the MAWD electronics ON
- SWITCH HCX CPU connects to a keyswitch to turn the HCX CPU ON

	<p>Connection terminal block at the MAIN end of bay – scientific payload sled:</p> <ul style="list-style-type: none"> MAIN MAWD connects to a terminal block on the top Avionics Bay bulkhead that in turn attaches to 1 of 2 MAIN ematches SWITCH HCX PYRO connects to a keyswitch to turn the HCX PYRO battery ON SWITCH PAYLOAD connects to a keyswitch to apply power to the scientific payload
	<p>Bulkhead mounted terminal blocks for the MAIN e-match connections for the black powder charges. The bulkhead is made of 3 ply 3/32" thick fiberglass bulkheads – two designed to fit inside the outside body tube and one to fit inside the coupler used for the avionics bay to help with alignment. The eyebolt is a closed stainless steel marine bolt made of 5/16" stock from Sea Dog rated at 5,250 lbs breaking strength.</p>
	<p>Connection terminal block at the DROGUE end of bay – recovery sled</p> <ul style="list-style-type: none"> DROGUE HCX connects to a terminal block on the bottom Avionics Bay bulkhead that in turn attaches to 1 of 2 DROGUE ematches Lilon BATTERY CHARGE is used to connect a charger to the Lilon batteries used for the Scientific Payload
	<p>Connection terminal block at the DROGUE end of the bay – scientific payload sled</p> <ul style="list-style-type: none"> DROGUE MAWD connects to a terminal block on the bottom Avionics Bay bulkhead that in turn attaches to 1 of 2 DROGUE ematches
	<p>Bulkhead mounted terminal blocks for the DROGUE e-match connections for the black powder charges. The bulkhead is made of 3 ply 3/32" thick fiberglass bulkheads – two designed to fit inside the outside body tube and one to fit inside the coupler used for the avionics bay to help with alignment. The eyebolt is a closed stainless steel marine bolt made of 5/16" stock from Sea Dog rated at 5,250 lbs breaking strength.</p>

Appendix O

Wiring and configuration of the PerfectFlite MAWD Flight Computer

The PerfectFlite MAWD flight computer measures altitude based upon a barometric pressure sensor. It has two pyro outputs that can be used to fire charges. The MAWD is configured using the DIP switches.

PerfectFlite MAWD Physical Wiring

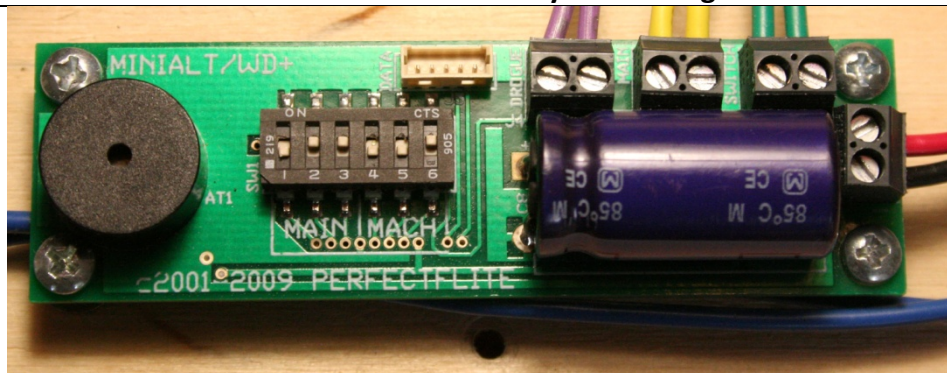
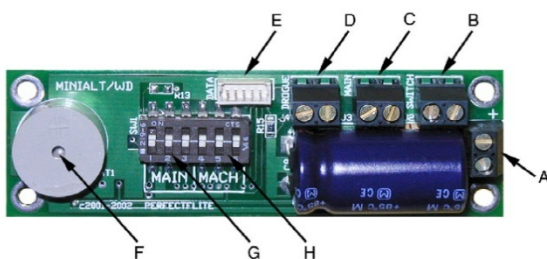


Photo of MAWD as wired in the Avionics Bay



- A – Battery terminals (upper terminal is positive)
- B – Power switch (shorted is ON)
- C – Main pyro ejection charge terminals
- D – Drogue pyro ejection charge terminals
- E – Serial data download cable connector
- F – Beeper
- G – Main deployment altitude (SW1-3)
- H – Drogue deployment altitude (SW4-6)

SW1	SW2	SW3	Altitude
off	off	off	300 feet AGL
off	off	on	500 feet AGL
off	on	off	700 feet AGL
off	on	on	900 feet AGL
on	off	off	1100 feet AGL
on	off	on	1300 feet AGL
on	on	off	1500 feet AGL
on	on	on	1700 feet AGL

Selection of altitude for main deployment – we have main deployment set at 900 feet :

- SW1 = OFF
- SW2 = ON
- SW3 = ON

SW4	SW5	SW6	Delay
off	off	off	0 seconds
off	off	on	2 seconds
off	on	off	4 seconds
off	on	on	6 seconds
on	off	off	8 seconds
on	off	on	10 seconds
on	on	off	12 seconds
on	on	on	14 seconds

Selection of Mach delay – we have this set to 2 seconds:

- SW1 = OFF
- SW2 = OFF
- SW3 = ON

Appendix P

Wiring and configuration of the G-Wiz Partners HCX Flight Computer

The G-Wiz partners HCX flight computer measures acceleration and altitude based upon an accelerometer and barometric pressure. It has four pyro outputs that can be used to fire charges or ignite multi stage rockets. And it has other features that are not applicable to this flight. The HCX uses separate batteries for the CPU and PYRO. The HCX is configured using the G-Wiz Flight View software and jumpers. It not only allows the configuration of the computer for flight, but also allows some testing of the computer.

G-WIZ Partners HCX Physical Wiring

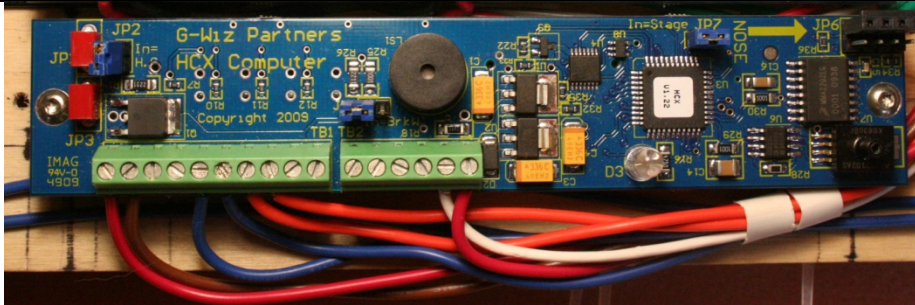


Photo of HCX as wired in the Avionics Bay

TB1 - Pyro Port Pin Assignments									
Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Pin 10
P Batt+	P Batt-	Pyro 1	Pyro 1	Pyro 2	Pyro 2	Pyro 3	Pyro 3	Pyro 4	Pyro 4
Pyro Battery	Cluster / Stage	Apogee	Low Altitude	Programmable					

- Pin 1 – Pyro Battery Positive (switched)
- Pin 2 – Pyro Battery Negative
- Pins 3-4 – Pyro 1: unused
- Pins 5-6 – Pyro 2: Droogie Ejection Charge
- Pins 7-8 – Pyro 3: Main Ejection Charge
- Pins 9-10 – Pyro 4: unused

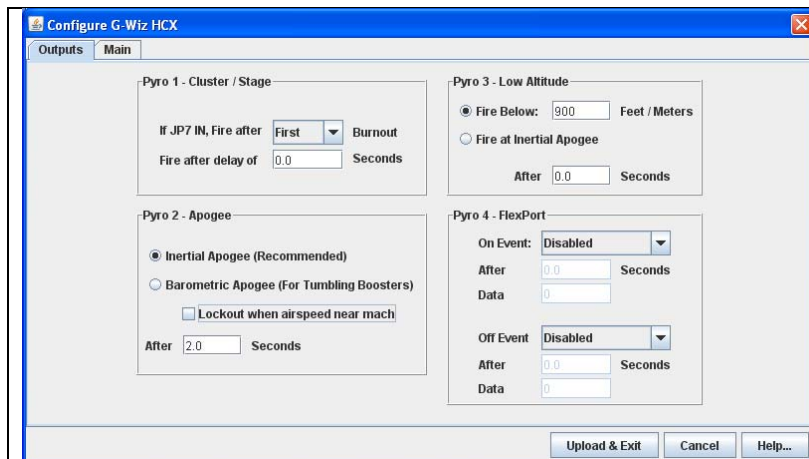
TB2 - Power / Special					
Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6
Shunt	Shunt	Input	Input	C Batt-	C Batt+
Pyro Shunt	B Wire / Analog	CPU Battery			

- Pins 1-2 – Pyro Shunt: unused
- Pins 2-3 – Breakwire/Analog: unused
- Pin 5 – CPU Battery Negative
- Pin 6 – CPU Battery Positive (switched)

G-WIZ Partners HCX Jumpers

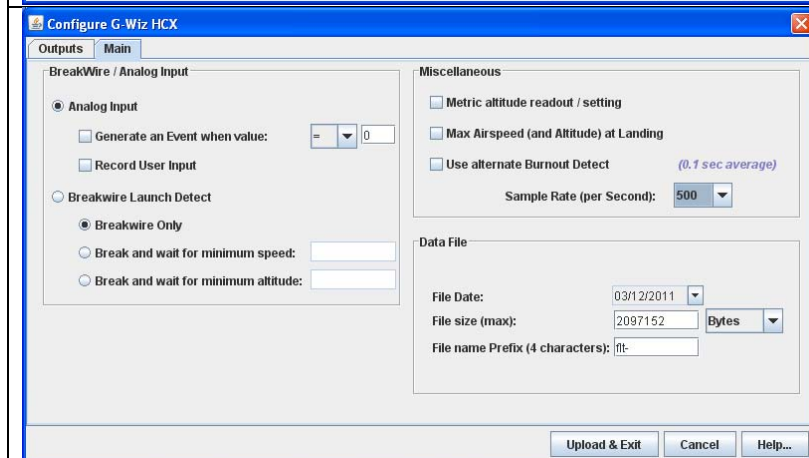
Jumper Position Number	With Jumper IN	With Jumper OUT
JP 2 -- Pyro current selection	System allows High Current – two batteries must be used	System limited to low current – one battery can be used
JP 7 -- Cluster or stage selection	Stage mode enabled	Cluster mode enabled
JP 5 -- Breakwire Bypass	Breakwire launch detection enabled	User analog input (0-5v) enabled

- JP2: Pyro Current Selection – Configured with jumper IN to allow higher current without disturbing the CPU battery
- JP7: Cluster or stage selection – Really a don't care but configured with jumper IN for stage mode
- JP5: Breakwire Bypass – Configured with jumper OUT for user analog input rather than breakwire which is not used



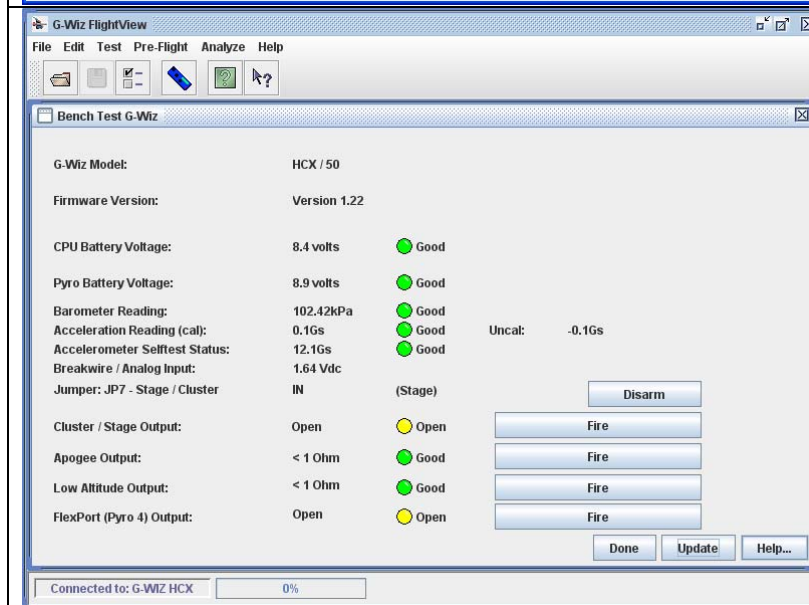
OUTPUT CONFIGURATION

- PYRO 1 is not used (for cluster or staging)
- PYRO2 is used to fire the drogue at apogee
- PYRO3 is used to fire the main at 900 feet well after the drogue deploys
- PYRO4 is not used (configurable)



MAIN CONFIGURATION

- Analog input unused
- Breakwire unused
- Misc – nothing selected
- Data File – set current



HCX BENCH TEST

This test was used to determine that the HCX was wired properly. The battery voltage is displayed and sensor values are displayed. We validated that we had a good connection to the HCX drogue to be deployed at apogee, and the main to be deployed at 900 feet by connection Christmas tree light bulbs. We armed the HCX then fired the Apogee output and Low Altitude outputs and validated the Christmas tree light bulbs lit.



HCX TEST FLIGHT

This test was an automated test similar to the bench test above. The HCX runs through a flight and shows status as each sequence lights brighter. We validated that the Christmas tree light bulbs lit at Apogee and Low Altitude.

Appendix Q

Wind Speed – Range Calculation

Velocity drogue : 63.51 ft/s
velocity main : 20.09 ft/s

Time drogue : 68.97 s
Time main : 44.80 s
Time total : 113.77 s










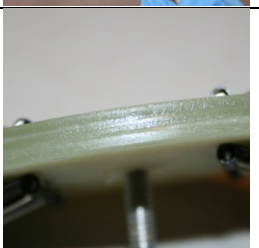


Wind (mph)	Wind (ft/s)	Drogue Range (ft)	Main Range (ft)	Total Range (ft)
0	0	0	0	0
5	7.33	505.5	328.4	833.9
10	14.67	1012	657.2	1669
11	16.14	1113	723.1	1836
12	17.6	1214	788.5	2002
13	19.07	1316	854.3	2170
14	20.54	1417	920.2	2337
15	22.01	1517	986	2503






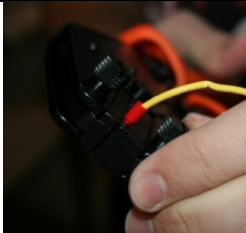
- This range is calculated by hand, without considering weather cocking. Weather cocking will reduce the range.
- The maximum wind speed that keeps the rocket in the range of 2500ft is 14.98 mph.
- The data is assuming that the rocket will go up to 1 mile.

Appendix R

Construction Details

The forces on the airframe under a “K” motor can be rather severe. If good construction practices are not followed the airframe may come apart (or “shred”) under load which, besides destroying the rocket, can be dangerous.

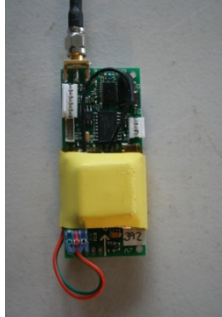
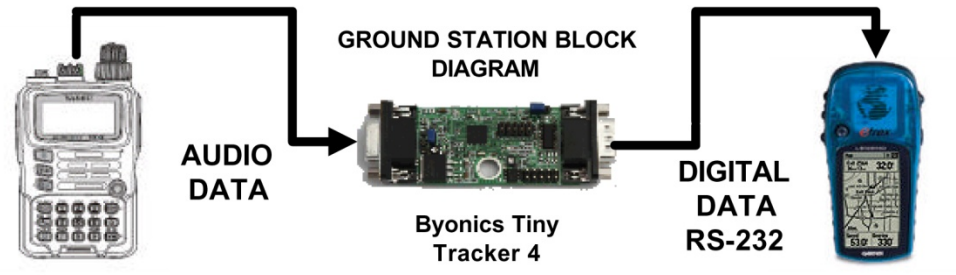
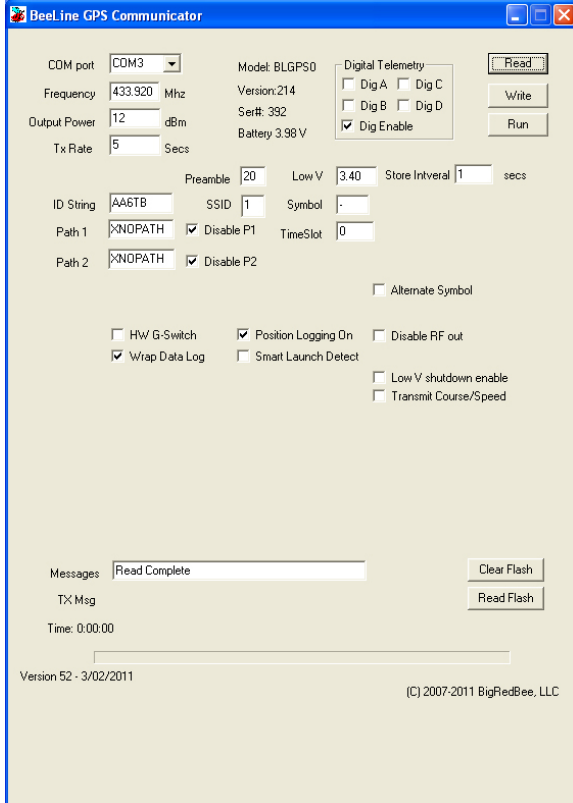
		All fiberglass surfaces are fully scuffed and scratched before they are epoxied.
		After scuffing the surfaces are fully cleaned with Isopropyl alcohol to remove dust and any oils or other contamination
		Any fiberglass surfaces that have gel coat applied are ground down to remove the gel coat before applying epoxy. Gel coat has oils and wax that prevent proper adhesion
		Left: The West System Epoxy is used throughout the construction process since it is substantially stronger than hobby shop epoxy. Right: Epoxy is liberally applied to all joints – and reapplied if insertion of parts (e.g. centering rings) will disturb what was previously applied
		Left: Fillets are applied to all joints for added strength Right: Since the bulkheads were only 3/32” thick, three bulkheads were glued together for added strength
		Left: The bulkheads on the end of the Avionics bay were also three ply, with the diameters of two the same as the inside of the body tube and the third to fit inside the coupler used for the avionics bay to help align. Right: Fiberglass tape was applied to the body tube – fin joint to help reinforce that area subject to added loads especially upon landing

		<p>Left: The Avionics bay uses closed eye bolts since the stresses at ejection can open eyes that are not continuous or welded shut</p> <p>Right: "U" Bolts are used on the centering rings and top bulkhead also for strength</p>
		<p>To assure things fit properly we dry-fit parts together and inserted an engine casing .</p>
		<p>Left: A fin jig was used to assure the fins are on straight and solid</p> <p>Right: Whenever possible, ferrules were crimped on to the end of wires to keep the strands together and make certain there is good connection in the terminal blocks</p>

Appendix S

GPS Electronics

The GPS electronics consists of a Big Red Bee Beeline GPS transmitter mounted in the vehicle. This is a fully integrated unit with GPS receiver, 440 MHz ($\frac{3}{4}$ meter) transmitter, and rechargeable battery, recharging through the USB port. The ground station consists of a Yaesu VX-6R transceiver capable of receiving on 504KHz to 998.99 MHz. This is connected to a Byonics Tiny Trak 4 TNC (Terminal Node Controller) to decode the audio location. And a Garmin eTrex Vista provides the display for humans. The vehicle's location is displayed on the Garmin as a waypoint.

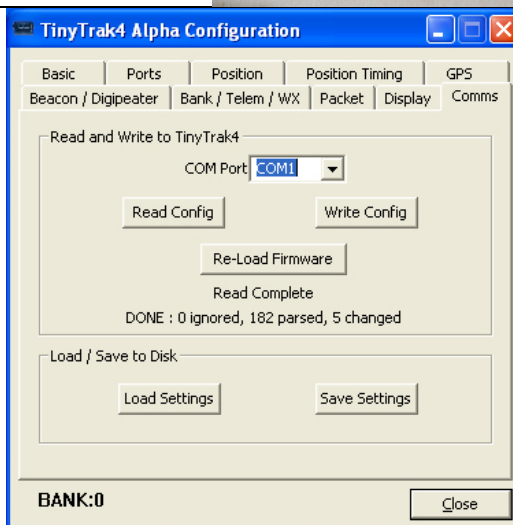
GPS System – Transmitter in vehicle and ground station		
 <p>Transmitter in Nose Cone</p>	 <p>GROUND STATION BLOCK DIAGRAM</p> <p>Yaesu VX-6R Byonics Tiny Tracker 4 GARMIN eTrex Vista</p> <p>AUDIO DATA DIGITAL DATA RS-232</p>	
Ground Station		
CONFIGURATION OF TRANSMITTER		
	<p>The Beeline GPS Transmitter is configured using a special USB cable connected to a PC. Beeline furnishes a program named "BeelineGPS.exe" to talk to and configure their device. Since this device operates on the Amateur Radio frequencies, someone in the team must have an Amateur Radio license (one mentor is AA6TB). Verify the following:</p> <ul style="list-style-type: none"> Call sign set (this will show up as the waypoint on the GPS) – for us it is AA6TB Frequency set: 433.92 MHz Transmit rate (every 5 seconds conserves power but allows frequent updates) Output Power: 12 dBm is pretty much the maximum Low V: At 3.4 volts the device shuts off to avoid damaging the battery <p>Note: Once the transmitter is powered up, you have approximately 10 seconds to establish a connection ("Read") or the transmitter goes into its operational mode of transmitting its position.</p>	

CONFIGURATION OF THE GROUND STATION RECEIVER

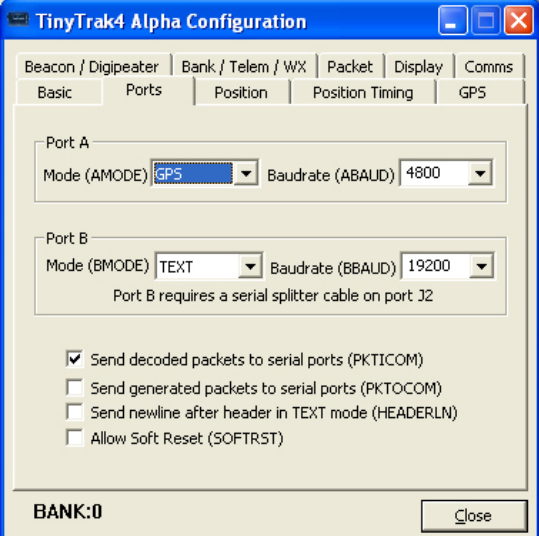
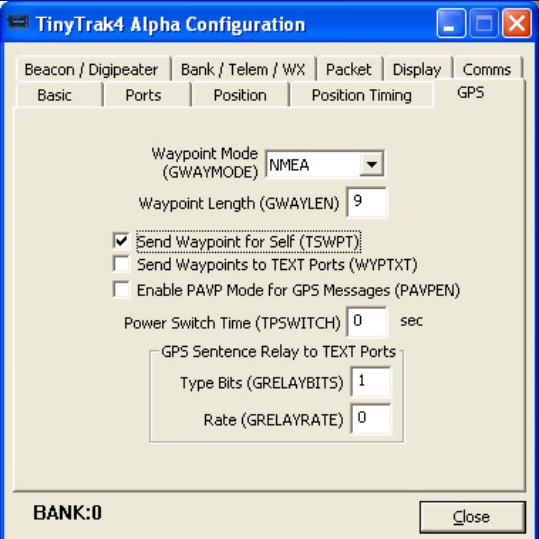



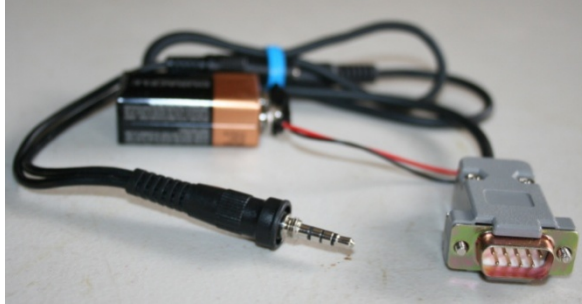
The ground station receiver does not need any special configuration – it needs only to be set to FM on 433.92 MHz (or whatever frequency the Beeline GPS transmitter is set to).

CONFIGURATION OF THE TINY TRACK 4 TNC



The Byonics Tiny Trak 4 TNC (TT4) is configured using the TinyTrak 4 configuration program from Byonics running on a PC. The PC is connected to the TT4 using a Null Modem serial RS-232 cable. Select the COM port, then select Read Config, disconnect and reset power to the TT4 and the two are talking. Very little needs to be configured – much is used when the TT4 and GPS is connected to a transmitter to report the station's position

	<p>Most of the settings can be left at their default. It is important that the “Ports” be set:</p> <ul style="list-style-type: none"> • Port A mode (AMODE) be set to GPS • Port A Baud (ABAU) be set to 4800
	<p>Under the “GPS” tab:</p> <ul style="list-style-type: none"> • The Waypoint Mode (GWAYMODE) must be set to NMEA
<h3 style="text-align: center;">CONFIGURATION OF THE GARMIN eTREX VISTA</h3>	
	<p>Only one parameter needs to be set on the Garmin eTrex Vista:</p> <ol style="list-style-type: none"> 1. Press the jog stick to bring up a drop down menu, then select “Main Menu” 2. Use the jog stick to select “Setup” 3. Use the jog stick to select “Interface” 4. Make certain that: <ol style="list-style-type: none"> a. Serial Data Format is set to NMEA In/NMEA Out b. BAUD is set to 4800
<h3 style="text-align: center;">CABLING</h3>	



Yaesu to TT4



TT4 to Garmin

CABLE – YAESU TO TINY TRAK 4

TT4 Radio/Power Connector

Pin	Function	Description
1	Audio out	Generated packet or other audio tones to be transmitted via the radio microphone jack.
2	Carrier Detect	Digital carrier detect state from radio. Can either be active high or active low.
3	PTT Out	This line is grounded when the radio should transmit. Connect to radio PTT input.
4	JP1	Optional J1 interface to the JP1 line. Can be an analog or digital input, or output, depending on firmware.
5	Audio in	Audio received from the radio via the earphone or speaker jack.
6	Ground	Ground return for power, audio, PTT and all other signals.
7	Power In	Power input to the TinyTrak4. Can be 6V to 18V.
8	PTT In	State of optional external microphone PTT switch. Grounded during transmit.
9	No connection	May be end-user wired for custom features.

This needs to be a custom cable – DB-9 to an audio plug and 9VDC battery connector. From the DB-9 Male:

- Pin 5 goes to the center post of a miniature audio connector
- Pin 6 goes to the ground of the miniature audio connector AND the battery negative
- Pin 7 goes to the positive battery terminal

The audio connector plugs into a commercial cable that brings the audio and microphone out of the Transceiver (Yaesu Part Number CT-91).

CABLE – TINY TRAK 4 TO GARMIN

The cable from the TT4 to the Garmin is a standard cable provided by Garmin - Part Number: 010-10206-00

GROUND STATION OPERATION

Connect the Yaesu to the TT4, and the TT4 to the Garmin and power all devices on. Set the Yaesu to the receive frequency (433.92MHz) and mode (FM) of the transmitter. Once all GPS devices have locked on to satellites (this can take several minutes and must be done outdoors), look at the lights on the TT4.

- The Blue LED should be ON indicating the TT4 is powered
- The Yellow CD LED should flash ON each time a transmission from the Beeline GPS is received
- The Green GPS LED should flash ON or be solid ON when the TT4 and the Garmin are properly connected and talking to each other

The location and distance to the Beeline GPS will be displayed on the Garmin as a Waypoint (AA6TB-1). You can watch the waypoint on the map, or select it and “go to” it. Then the Garmin will display a compass showing the bearing of the Beeline GPS as well as range to it.