AIAA Orange County Section

Student Launch Initiative 2010-2011

Critical Design Review

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

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

Submitted to:
Marshall Space Flight Center
Huntsville, Alabama

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Image From: XPRS.ORG

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Critical Design Review Report

1. Summary

1.1. Team Summary

1.1.1. Team name

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

1.1.2. Location

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

1.1.3. Team official/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 84.5 inches, with a diameter of 4 inches. It will have a weight of 221.65 Oz without the engine loaded and a weight of 284.02 Oz with the unburnt engine.

1.2.2. Motor Choice

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).

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 MAWD Perfect Flight and a G-Wiz Partners HCX, along with three nine volt batteries, and associated wiring. This will be located in the electronics bay along with the payload.

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. Summary of 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 PDR

2.1. Changes made to vehicle criteria

The original Rocksim file used for the Proposal was also used for the PDR and the CDR, but it was modified again as well as much more detail which changed:

- The length is now 84.5
- The payload bay has increased in length and is now 16 inches long to accommodate all of the scientific payload, the recovery electronics and necessary wiring
- The weight is now 17.75
- Black Powder charges are now: 1.43 grams for the main ‘chute and 1.54 grams for the drogue ‘chute

2.2. Changes made to payload criteria

The payload in the Preliminary Design Review was very crowded so we have made some changes.

- Changed the Avionics bay to be 16 inches
- Added a copper heat sync which is mounted to the simple net computer
- Added a wooden block to create more room in-between sleds
- Hanged the layout of the sleds
- Added a Ethernet port to the outside of the bay to initialize computer
- Changed the Linux script from copying 32 Mb of 0’s to 8 Mb of 0’s to increase recording rate so it can measure hard drive latency more efficiently

2.3. Changes made to activity plan

We haven’t made much change in this section. We have though added detail about the AIAA presentation and have added helping with the ABC Unified School District Science Olympics.

3. Vehicle Criteria

3.1. Design and Verification of Launch Vehicle

Design and verification of launch vehicle is included in each relevant section

3.2. Flight Reliability Confidence

3.2.1. Mission statement, requirements, and mission success criteria

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

The requirements for our rocket are as follows:

- The team will design build and fly the rocket
- The rocket will reach a mile high
- The rocket will not exceed mach1
- The rocket will use dual deployment
- The rocket will remain reusable

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

3.2.2. Major milestone schedule

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

- December 17: Will Call
- December 18-23: Build Scale Model
- January 1: Scale Model Launched
- January 24: CDR Due
- January 19-31: Finalize Full Scale Design
- February 1: Order Parts
- February 2: Will Call Parts
- February 2-8: Web-Ex CDR Presentation
- February 9-31: Build Full Sale Rocket
- March 12: Launch Full Scale Rocket
- March 21: FRR Due
- March 28-31 (TBD): Web-Ex FRR Presentations
- April 13: Travel to Huntsville
- April 14-15: Flight Hardware and Safety Checks
- April 15: Launch Day
- Ongoing: Fundraising
- Ongoing: Testing gunpowder, recovery and tracking

3.2.3. Review of the design at a system level.

3.2.3.1. Updated drawings and specifications

Updated drawings and specifications are included in each relevant section.

3.2.3.2. Analysis results

The team has so far seen that the systems work. The vehicle is stable and is cable of holding and keeping up with all systems. The vehicle scale model has been launched and it worked successfully. The tracking device has been tested and is proven to work over three miles. The recovery electronics have been tested on the ground and in the rocket, we still are going to test the recovery further.

3.2.3.3. Test results

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	1.43 grams	Rocket not completed
Full – Drogue	1.54 grams	Rocket not completed

Battery Life

Procedure can be found in Appendix I

Electronics	Life time (hours)	Successful
HCX 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

3.2.3.4. Preliminary motor selection

The motor that we have selected is a Cesaroni K635 Redline. In our simulations we should reach an altitude of 5,255.41

3.2.4. Design meets all system level functional requirements

The design is stable and with the Cesaroni K635 will reach to almost a mile; we do not want to exceed the mile. The rocket is able to be launch because it is stable and has a recovery system. The GPS Transceiver will be located in the nose cone on a piece of wood; the transmissions are far enough away from our other electronics so they won't interfere with one another. The rocket uses dual deployment recovery that is located in the avionics bay, and uses a MAWD Perfect flight and a HCX G-Wiz Partners flight computer to eject both the drogue and main 'chute to safely return the rocket. The rocket is light enough for the team members to retrieve the rocket. The team will then collect data from both flight computers and payload by disassembling the avionics bay.

3.2.5. Approach to workmanship as it relates to mission success

The rocket has to be well assembled so it can survive flight. 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.

3.2.6. Planned additional component, functional, or static testing

We plan on doing more functional testing, on February 12 we are going to launch our rocket and test dual deployment further. Our last launch dual deployment wasn't perfect because of drag separation we couldn't come to a valid conclusion on whether or not both ejection charges worked successfully. We are also going to do more static testing by further testing electronics on the ground.

3.2.7. Status and plan of remaining manufacturing and assembly

As of right now we have all of our parts for construction of the rocket which will be done February 9th till the 31st. We have all of the electronics and cables for the GPS system, and for the Recovery system. We still need another G-Wiz Partners HCX for the payload. If we need to make additional back up sleds our team has equipment availed to them to do so.

3.2.8. Integrity of design

3.2.8.1. Suitability of shape and fin style for mission

We chose these fins because our design is based off of the Black Brant 4in model rocket kit from Mad Cow Rocketry and these are the fins that come standard with the kit. Considering that the stability margin needed no adjustment while using these fins, we saw no need to change them. They have also had the edges sanded into a point to allow for minimal air resistance during the flight.

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

Our Rocket is made with a fiberglass: nosecone, body tube, couplers, bulkheads, centering rings, and fins. The eye bolts that hold the shock cord to the rest of the rocket is metal, along with the motor retainer and the rods for the sled in the Avionics bay. The sled itself is wood. The shock cord we will be using is 3/16th Kevlar.

3.2.8.3. Proper assembly procedures, proper attachment and alignment of elements, solid connection points, and load paths

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 will have fillets in addition to the adhesive joining the two together
- Eyebolts should be 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 eyebolts.
- Nuts from eyebolts should either have Loctite securing them or be epoxied
- Nylon shock cord should be attached to the eyebolt with a quick link or shackle of approximately the same material diameter as the eyebolt to give a secure connection and allow for service
- All removable pieces of the vehicle that do not separate in flight should be secured using metal machine screws
- All removable pieces of the vehicle that do separate in flight should be secured using shear pins, using 2 to 4 #2 nylon screws
- Avionics bays will endure a high level of tension when the ejection charges fire. The bay should have load bearing bolts, such as ¼” threaded rods that secure 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 then apply pressure to pull the avionics bay apart
- The highest load path is from the engine/fin body section, through the shock cord to its other attachment point (usually the avionics bay). The avionics bay must withstand the same tension across its length. On the other side of the avionics bay the load continues through attachment to the avionics bay (usually an eye bolt or U bolt), through the shock cord, to the

final attachment point near the nose cone (another eye or U bolt).

- Fins should be carefully aligned using a fin jig to hold them in place while the epoxy is setting.

3.2.8.4. Sufficient motor mounting and retention

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

3.2.8.5. Status of verification

Our status of verification is complete meaning we have launched the scale model of our rocket. We are though are going to launch the scale model again and further test our dual deployment.

3.2.9. Safety and failure analysis

The scale model launch correctly, meaning it was safe had a safe descent rate and acted how we predicted it would. It was safe, the parachute deployed at apogee and it did not travel far away from the launch pad. The only safety hazard that could happen is a defect in the engines.

3.3. Recovery Subsystem

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

Our team will use a 24 inch parachute for the drogue, which will have a decent rate of 80.50 feet per second. This will be deployed at apogee. Our main ‘chute is 96 inches and descends at a rate of 20.1 feet per second. This parachute will be ejected at 900feet. For the drogue, the shock cord will be attached to an eye bolt on the centering ring on the motor mount, a D link will hold the shock cord to the eye bolt, the other end of the shock cord will be attached to the avionics bays eye bolt, a D link will attach the shock cord to the D link. The main ‘chute shock cord will be attached to the other end of the avionics bay, a D link will attach the shock cord to the eye bolt. The other end of the shock cord will be attached to an eye bolt on a bulkhead, a D link will attach the two. The ejection charges and electronics tests are in section 3.2.3.3

3.3.2. Safety and failure analysis

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.

3.4. Mission Performance Predictions

3.4.1. Mission performance criteria.

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

3.4.2. Flight profile simulations, altitude predictions with real vehicle data, component weights, and actual motor thrust curve

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
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	0.06
Bulkhead Shaved	G-10 Fiberglass	2	32	64	n/a	3.8	0.06

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

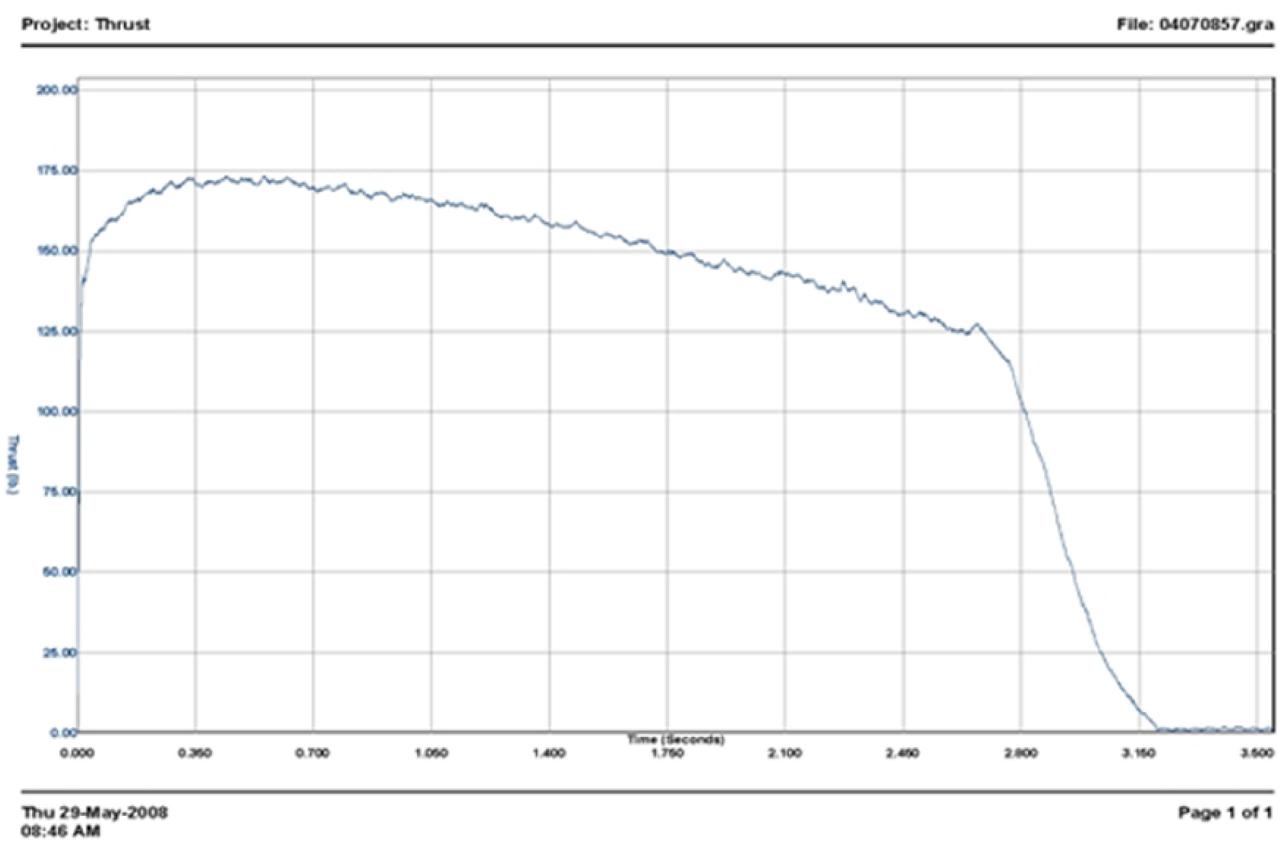
Motor Thrust Curve

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



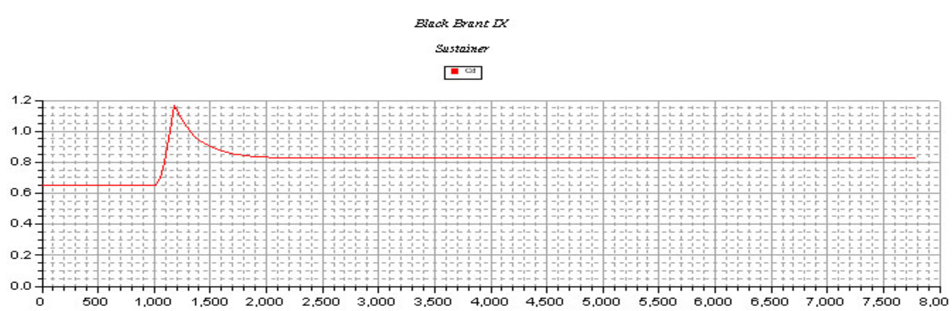
3.4.3. Thoroughness and validity of analysis, drag assessment, and scale modeling results

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.

The calculated drag was done by RockSim and shows a reasonable coefficient drag of roughly 6.5 up to mach



Results on scale modeling were favorable and can be found in the scale model appendix.

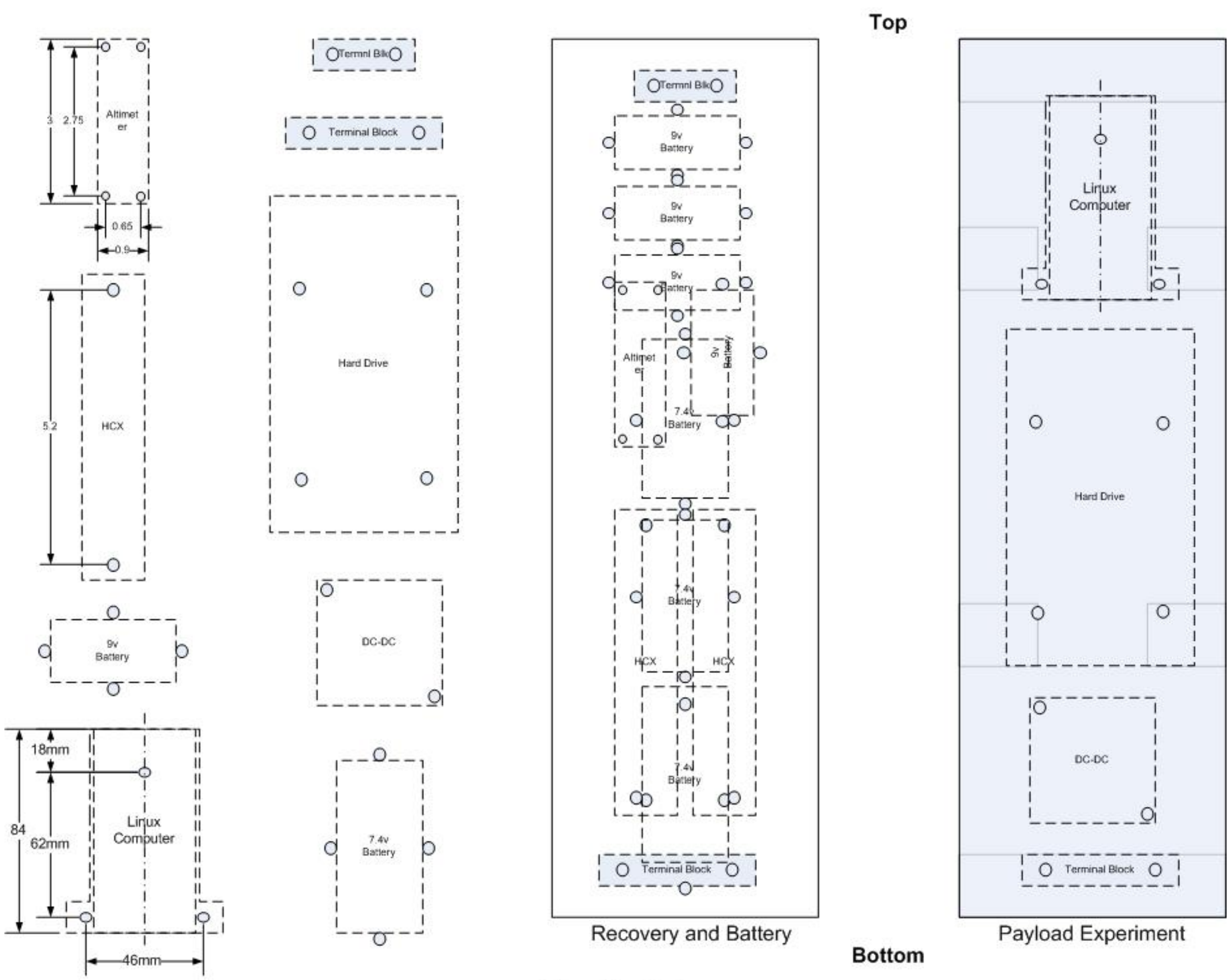
3.4.4. Stability margin and the actual CP and CG relationship and locations.

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.

3.5. Payload Integration

We positioned the rocket's main power source on the bottom of the recovery sled and the actual experiment (hardware) on the top of the payload sled. Only one component from the payload is placed with the recovery systems: the G-Wiz Partners HCX flight computer. Wooden support blocks will hold the payload and recovery sleds together; holes bored through the blocks allow for steel screws to pass through. The sled combination will slide into a G-10 fiberglass coupler. The steel screws, slightly longer than the coupler, will stick out when we seal off the coupler with fiberglass bulkheads. Butterfly bolts will be used to secure the steel screws.



Mounting Holes

3.6. Ease of integration

The payload, unlike recovery, has its own sled and a lot of room—most of its components are flat, making plenty of room for wiring. There is nothing mounted on the back side of the payload sled, so we do not have adjust where we have to drill the screw holes.

3.6.1. Integration plan

All the payload electronics will be mounted on balsa wood sleds. The batteries—3 9V alkaline batteries and 3 7.2V 2200mAh lithium ion batteries—are fixed to the underside of the recovery sled by plastic zip ties threaded through holes drilled through the wood. The Toshiba hard drive, the DC-DC power converter, and the plastic terminal blocks will be installed on the payload sled with screws. The simple net computer, however, will be slotted into a custom-made copper mount, before being screwed in next to the hard drive. This sled is screwed into six wooden support blocks—the recovery sled is glued to these blocks. Only the payload G-Wiz Partners HCX flight computer sits among the recovery electronics.

The payload, together with the recovery, lodges in a 16" G-10 fiberglass coupler. Two long steel screws will be threaded through the wooden support blocks and out through the bulkheads covering each end of the avionics bay. Each screw will be secured by butterfly bolts

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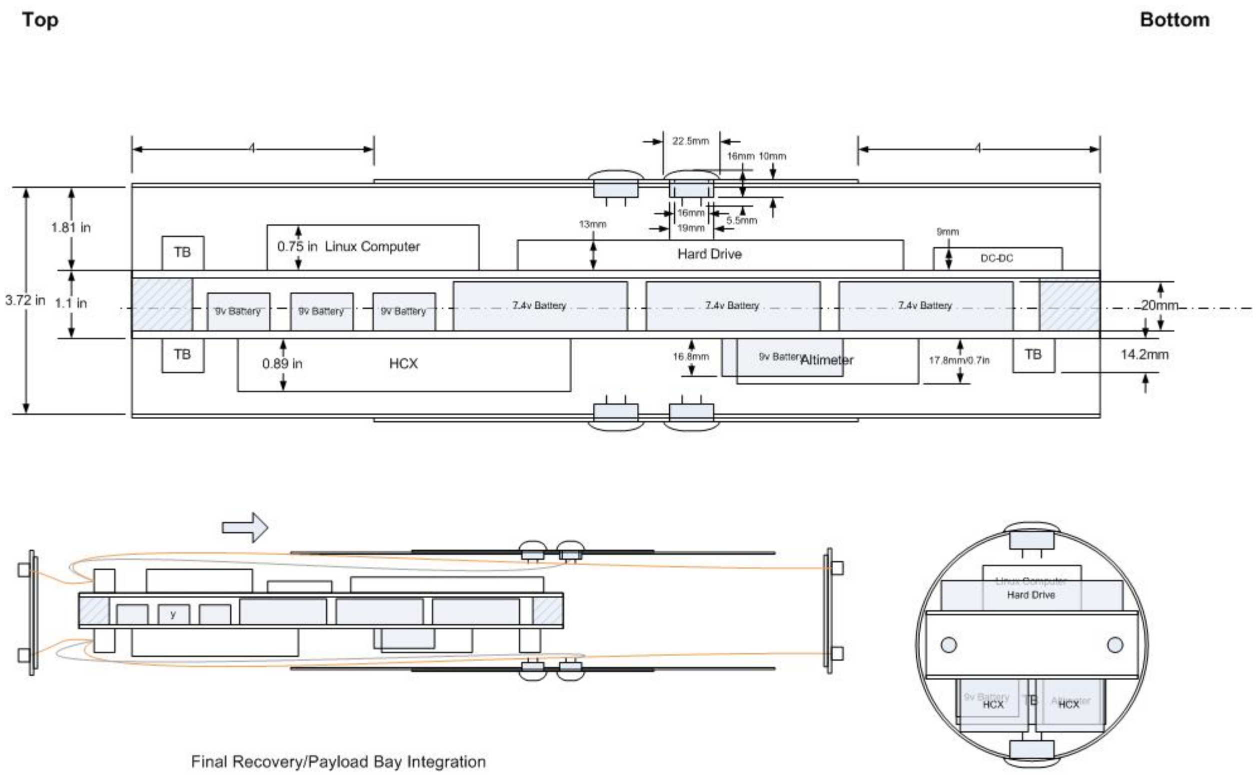
3.6.2. Installation and removal, interface dimensions, and precision fit

As described in Section 3.6, the power source is on the bottom of the recovery sled and the scientific payload, except the HCX flight computer, is on the top of the payload sled. We will first insert the batteries on the bottom of the recovery sled and then wire them to the terminal blocks. Next, we install the payload experiment. The payload sled is screwed onto the wooden blocks, and the sled combination is slides into the fiberglass coupler.

Removing or replacing any of the components in the payload is simple. The sled combination is made to slide in and out of the coupler without much friction—we sanded the edges of the sled. After the sleds are out of the coupler, we can deal with the payload electronics directly. To access the batteries, we can unscrew the payload sled from the wooden blocks.



Final Recovery/Payload Bay Integration

Assembling

- Balsa wood payload sled – 16” X 3.6”
- 3.72” fiberglass coupler – 16” long
- 2 Wooden support blocks (End block) – 0.98” X 3.6” X 0.87”
- 4 Wooden support blocks (Cube) – 0.98” X 0.73” X 0.87”
- Hard drive – 5.23” X 3” X 0.51”
- Simple net computer – 3.3” X 1.6” X 0.75”
- DC-DC power converter – 2” X 2” X 0.35”
- 3 7.2V 2200mAh Li-ion batteries – 2.76” X 1.5” X 7.9”
- 3 9V alkaline batteries – 2” X 1” X 0.5”
- G-Wiz Partners HCX flight computer – 5.5” X 1.1” X 0.89”

3.6.3. Compatibility of elements

Since the batteries took up too much space on the payload sled and the recovery sled, we decided to move them between the two sleds, and install them on the flipside of the payload sled. We also relocated the G-Wiz Partners HCX flight computer—originally on the payload sled—to the recovery section so we can free up a bit more room for terminal blocks. Wooden end blocks were added between the two sleds to make room for the protruding bulkhead bolts.

3.6.4. Simplicity of integration procedure

Originally, we had a 12” fiberglass coupler, and we were running low on space. We toyed with the idea of using three sleds, but stuck with elongating the coupler because three sleds were too cumbersome. We also tried replacing the Toshiba hard drive with a larger, more sensitive hard drive, but stuck to using the Toshiba hard drive because the ports were much more accessible.

3.7. Launch concerns and operation procedures

3.7.1. Draft of final assembly and launch procedures

See Flight Check List in Appendix D

3.7.2. 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
- Check both the drogue and main parachute in case of tangles within the shroud lines and shock cord
- Protect the parachutes from scorching with the use of a Kevlar shield.
- Secure the block powder in their designated areas

3.7.3. 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 makes sure the 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

3.7.4. 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

3.7.5. 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

3.7.6. 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.

3.7.7. Post flight inspection

The post flight inspection can be found in Appendix D

3.8. Safety and Environment (Vehicle)

3.8.1. Identify safety officer for your team

Our safety officers are Sjoen and Divya

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

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

3.8.3. Update the listing of personnel hazards and 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 to. 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. Our team is taking all safety precautions in every step of this project.

3.8.4. Discuss any environmental concerns.

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

4. *Payload Criteria*

In addition to the mission success criteria for our rocket:

- 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

The experiment must have the ability to achieve this:

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

- Experiment: Launching an active Toshiba hard drive
- Hypothesis: Hard drive latency will be greatly increased by g-forces caused by the launch of the rocket.

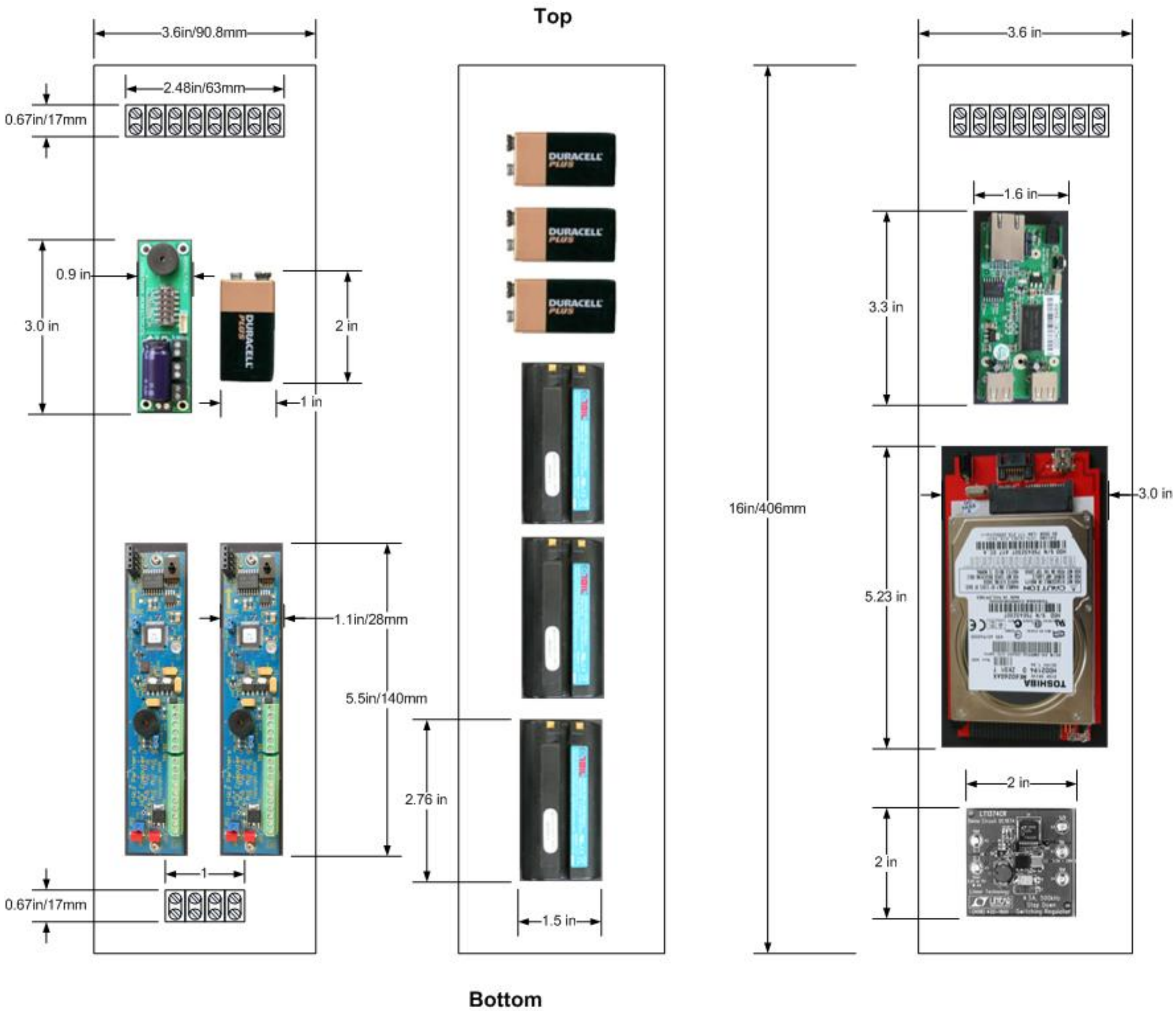
4.1. Testing and Design of Payload Experiment

Our experiment tests change in hard drive latency in comparison with the force of the rocket. We hooked a simple net computer to the hard drive; the computer will run a Linux script on the hard drive over and over again. The time it takes for the hard drive to run the script every time is captured by a flash drive inserted into the simple net computer.

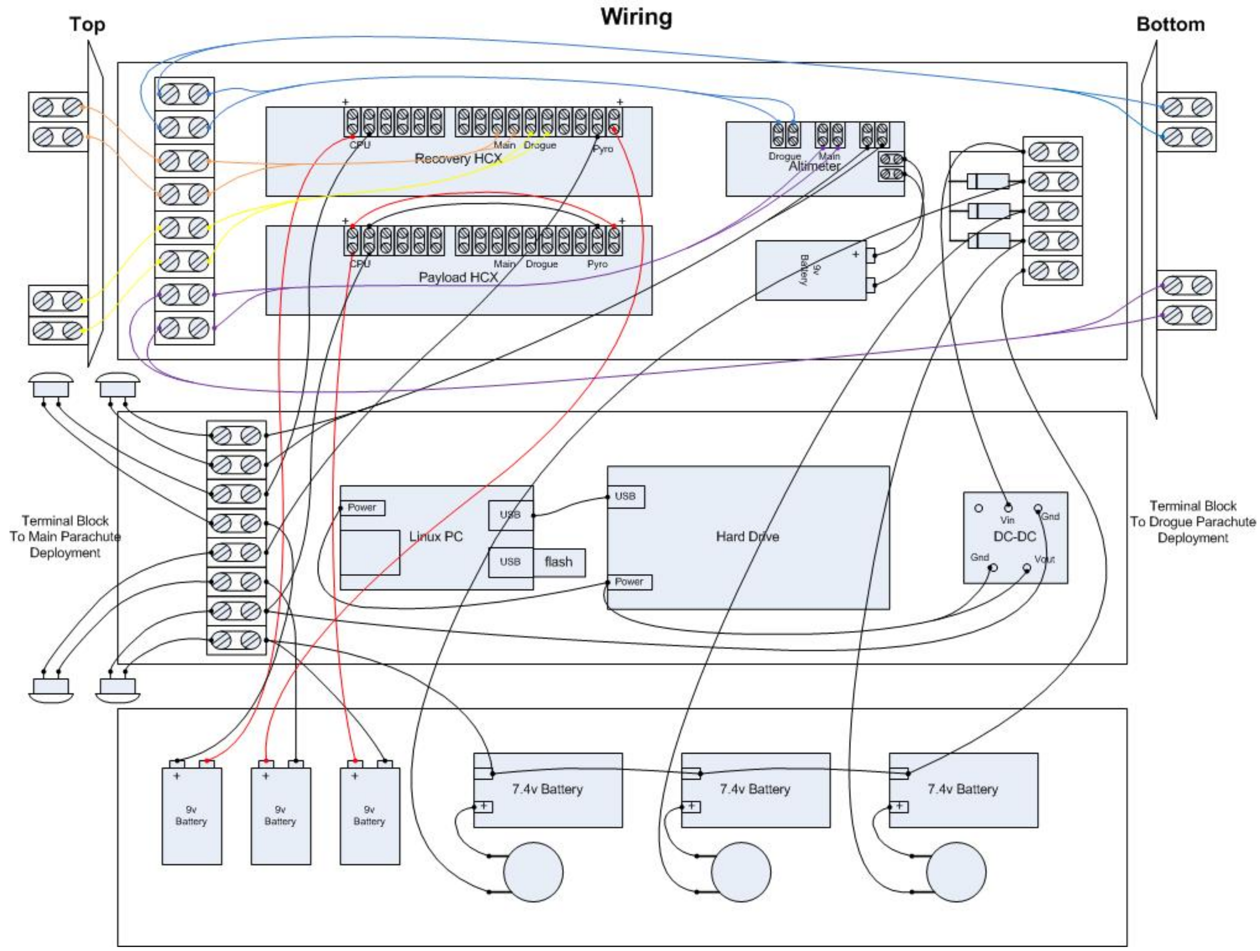
4.1.1. Review the design at a system level.

The hard drive, simple net computer, and the power converter will be located together. The simple net computer and the hard drive are wired in parallel, and get their power from the 3 7.2V lithium-ion batteries. The hard drive is connected to the simple net computer by a USB cable. The payload HCX flight computer will use one of the 9 V alkaline batteries from the battery sled.

4.1.1.1. Drawings and specifications



This Visio drawing of the avionics bay shows the dimensions of all the components that are to be secured onto the sleds. The right-most sled is the top of the payload sled, the middle sled is the bottom side of the recovery sled, and the left-most sled is the top side of the recovery sled.



This Visio drawing of the avionics bay shows the wiring going to all the components in the avionics bay. The top sled represents the top of the recovery sled, the middle sled represents the top of the payload sled, and the bottom sled is the bottom of the recovery sled

4.1.1.2. Analysis results

Launch data is stored onto the flash drive. The Linux script will create a .txt file in the flash drive; we will see a series of entries. Each entry lists three times: real, system, and user. The “real” time is the sum of the “system” and “user” times—essentially the hard drive latency. The “system” time is the time the computer takes to send the command to the hard drive, and the “user” time is the time the simple net computer takes to process commands sent by the user. We extract the “real” times and map them out on an Excel spreadsheet; we compare the hard drive latency with the acceleration data received from the payload HCX computer.

4.1.1.3. Test results

At first, we used an iPod to measure hard drive latency. We would run the Linux script, and shake the device to simulate a launch. Unfortunately, the iPod was too insensitive—the "real" time remained constant no matter how hard we shook it. We then experimented with a Toshiba hard drive. At rest, the hard drive had a "real" time of around 2 seconds. When we shook it, the "real" time jumped to 8 seconds—a notable increase. The difference prompted us to use a hard drive for testing.

4.1.1.4. Integrity of design

We use zip ties to secure the batteries. Each battery is strapped with 2 zip ties, and connections to the batteries are soldered on. All the electronics are screwed into the wood. Wires going in and out of the power converter, the hard drive, and the simple net computer are all soldered on to prevent them from falling out. The payload HCX computer has terminal blocks—the wires will be screwed down.

4.1.2. Design meets all system level functional requirements.

The hard drive and the simple net computer are fully capable of running on the 3 7.2V 2200mAh lithium-ion batteries. The power capacity of the batteries is approximately 47.52 Wh, while the simple net computer and the hard drive consume about 6 W, giving us a run time of about 7.92 hours.

4.1.3. Approach to workmanship as it relates to mission success.

Since the payload experiment and the recovery systems share the same space, cooperation is crucial. Most importantly, we must share power. Too little power on recovery and the rocket will crash. Too little power on payload and the experiment will not run properly. Not only must the experiment run, but the rocket must reach the ground safely. Both payload and recovery must work perfectly to reach success.

4.1.4. Planned component testing, functional testing, or static testing.

- We will test the battery life of the alkaline and lithium-ion batteries by hooking up the batteries to our components and letting the circuit run until all the batteries are spent.
- To see if the components are still functional when running on battery power, we will initialize the simple net computer with a PC.
- We will run the Linux script on the hard drive at rest to determine the optimal time it takes for the hard drive to run the script once.

4.1.5. Status and plans of remaining manufacturing and assembly.

We have manufactured the wooden support blocks on a CNC machine; the steel screws and wooden sleds were cut to length. The manufacturing is done, and we are currently assembling the avionics bay.

4.1.6. Integration plan

As described in Section 3.6.1, all the hardware will be screwed into the wood. The Toshiba hard drive will be connected to the simple net computer by a custom-made cable—this cable is soldered into the ports. The lithium-ion batteries are wired in parallel; they will supply power to the simple net computer and the hard drive. An alkaline battery will supply power to the payload HCX flight computer. Data from the experiment will be stored on a flash memory inserted in the simple net computer.

4.1.7. Precision of instrumentation and repeatability of measurement.

Because Toshiba hard drives are rated to withstand around 200 G's of force, we can be fairly confident about the precision of our instrumentation. The hard drive executes the Linux script as fast as it can; it finishes executing the script about every 0.1 seconds—plenty of chances for the flash drive to capture data during the crucial first seconds of launch. Finally, we store the data from the launch on the flash drive because it is more stable than the hard drive.

4.1.8. Safety and failure analysis

- 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 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.

4.2. Payload Concept Features and Definition

In the placement of the payload, we have separated the items in the payload from both the recovery electronics and the batteries. We placed the power converter, hard drive, and linux computer on one slide with the battery power on the opposite side of the slide allowing for the items to fit and space to be open. The HCX G-Wiz partners will be placed with the recovery's HCX G-Wiz partners, once again, allowing for space for all the electronics to be.

4.2.1. Creativity and originality

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

4.2.2. 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.

4.2.3. 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.

4.3. Science Value

4.3.1. Describe payload objectives

We are measuring the disc latency of the Linux computer and how the disc latency would increase with the addition of external forces. For instance, when launching, the upward thrust, air resistance, and other forces would add to the disc latency proving that our theory of increasing disc latency with the application of other forces.

4.3.2. State the payload success criteria.

When we retrieve the rocket after landing, if we can collect the data and interpret the data, we have completed our goal for the payload.

4.3.3. Describe the experimental logic, 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.

4.3.4. Describe test and measurement, 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.

4.3.5. Show relevance of expected data and accuracy/error analysis.

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.

4.3.6. Describe the 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.

4.4. Safety and Environment (Payload)

4.4.1. Safety officer for your team.

The safety office for our team is Sjoen and Divya.

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

Failure modes can be found in Appendix A.

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

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.

4.4.4. Environmental concerns.

The environmental hazard can be found in Appendix B

5. *Activity Plan*

5.1. Status of activities and schedule

The activity status can be found in appendix E.

5.1.1. 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.

5.1.2. Timeline

The complete time line is in Appendix G

5.1.3. 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.

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

5.1.3.2. 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.

5.1.3.3. **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 been asked to write an article for our neighborhood newspaper , “The Foothills Sentry” - after the PDR is done.

5.1.3.4. **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.

5.1.3.5. **Discovery Science Center**

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

5.1.3.6. ABC Unified School District Science Olympics

We are waiting to see if our team can help out at the Science Olympics and maybe give a presentation about what this program is and is about.

6. Conclusion

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

Appendix A

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

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

	gun powder and the E-match -We will check that all electronics are wired properly and will do what they are programmed to do in flight
The Drogue parachute deploys at the wrong altitude	-We will double check our recovery system before launch, once while assembling and once before it is placed on the launch pad -We will test how long a battery will last in the recovery system, in case there is a delay because of weather conditions or other such things that would prevent launching -We will program our electronics and test them to make sure they work properly -We will check that there is no air between the gun powder and the E-match
The Main parachute does not deploy	-We will double check our recovery system before launch, once while assembling it and once before it is placed on the launch pad -Before leaving the launch pad we will check that our Electronics bay is armed and ready to go -We will test how long a battery will last in the recovery system, in case there is a delay because of weather conditions or other such things that would prevent launching -We will use a electronics bay and tape in our batteries before launch -We will check that there is no air between the gun powder and the E-match -We will check that all electronics are wired properly and will do what they are programmed to do in flight
The Main parachute deploys at the wrong altitude	-We will double check our recovery system before launch, once while assembling and once before it is placed on the launch pad

	-We will test how long a battery will last in the recovery system, in case there is a delay because of weather conditions or other such things that would prevent launching -We will program our electronics and test them to make sure they work properly -We will check that there is no air between the gun powder and the E-match
The Rocket weather cocks	-Our rocket will be stable, not over stable -We won't have over sized fins -We might include a tail cone to reduce drag
The rocket folds upon itself	-We will use a engine that won't accelerate to that speed -We will use fiber glass material to construct our rocket
The altimeter(s) gets damaged	-we will use an electronics bay to hold all electronics -we will have rails with nuts to hold the sled in place so it will not shake and slide during launch -We will secure our electronics onto the sled securely so they will not come apart from it
The battery(s) of our electronics bay fall out	-We will tape in battery(s) so they will not fall out
The battery(s) 'die' during launch	-we will use fresh batteries for each launch, testing them to make sure there isn't any fault in their power (very low electricity output) -We will test how long a battery will last in the recovery system, in case there is a delay because of weather conditions or other such things that would prevent launching
The electric match doesn't ignite the black powder	-We will fresh e-Matches when launching our rocket, that made from a recommendable

	manufacturer -We will check that there is pyrogen at the end of the e-match and enough of it to be able to ignite the black powder
The altimeter isn't set to fire the drogue 'chute	- We will double check to make sure that the electronics bay is set up correctly and everything is programmed to do everything that it is supposed to
The altimeter isn't set to fire the drogue 'chute at correct height	-We will double check the programming of our altimeters is correct
The altimeter isn't set to fire the main 'chute	- We will double check to make sure that the electronics bay is set up correctly and everything is programmed to do everything that it is supposed to
The altimeter isn't set to fire the main 'chute at the correct height	-We will double check the programming of our altimeters is correct
Tracking device isn't accurate	-We will test our tracking device before using it in our vehicle -We will make sure that our tracking device is accurate so we may retrieve the rocket
Tracking device doesn't transmit radio waves	-We will check that our tracking device is set up properly and is functioning correctly before loading it into the electronics bay -We will make sure that the batteries are new and fresh to make sure that our tracking device can transmit radio waves
Tracking device is damaged in launch	- We will use an electronics bay to hold all electronics -we will have rails with nuts to hold the sled in place so it will not shake and slide during launch -We will secure our electronics onto the sled securely so they will not come apart from it

Appendix B

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

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

The payload in the high power rocket could be flammable, explosive, or cause harm.	-The rocket's electronics bay does not contain explosive material/ substances. The use of black powder is limited to how pressure is necessary to deploy the drogue 'chute or the main 'chute
Disposal:	
Batteries	-The team will dispose of this material at **Anaheim Disposal, Inc.** Customer Service (714) 238-2444 1131 North Blue Gum Street Anaheim CA 92806 or at Datamax-O'neil 8 Mason, Irvine, CA 92618-2705 (949)206-6810
Electrical Matches	-The team will dispose of this material at **Anaheim Disposal, Inc.** Customer Service (714) 238-2444 1131 North Blue Gum Street Anaheim CA 92806 or at Datamax-O'neil 8 Mason, Irvine, CA 92618-2705 (949)206-6810
Dead or Damaged Electronics	-The team will dispose of this material at **Anaheim Disposal, Inc.** Customer Service (714) 238-2444 1131 North Blue Gum Street Anaheim CA 92806 or at Datamax-O'neil 8 Mason, Irvine, CA 92618-2705 (949)206-6810
Fiberglass	-The team will dispose of this material at Higgins Environmental 311 Yorktown Huntington Beach, CA 92648 (714) 747-9850
Paint Materials	-The team will dispose of this material at Higgins Environmental 311 Yorktown

	Huntington Beach, CA 92648 (714) 747-9850
Spent Engines	-The team will dispose of this material at Higgins Environmental 311 Yorktown Huntington Beach, CA 92648 (714) 747-9850
Epoxy	-The team will dispose of this material at Higgins Environmental 311 Yorktown Huntington Beach, CA 92648 (714) 747-9850

Appendix C

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

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

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

Appendix C ‘Continued’

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

1 Parts are delivery damaged

2 Parts delivery is delayed

3 Large amounts of people leaving for the holidays

4 Having a lack of mentors

5 Wrong part is delivered

6 Not fulfilling our public outreach

7Not being recognized publicly by media response

8 Team members not being familiar with the project

9 Vehicle getting damaged

10 Members not completing written sections

11Vehicle receives damage traveling to launch site

12 school holidays not coinciding

13 Miscommunication between members

14 Not raising enough money to cover the costs

15 Electronics damaged during tests

16 Not raising enough money to cover travel fees

17 Not all members are readily availed to travel to Huntsville

18 Written Document not being completed on time

19 Suppliers not having our items in stock

20 Not following the schedule

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

Appendix D

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 alredy 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

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

☐ Briefly power on the payload power switch and verify power on beeps from the HCX accelerometer

HAZARDOUS OPERATION – SEE SAFTEY PLAN

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

- ☐ Measure the black powder for each **DROGUE** parachute ejection charges
- ☐ Cut off an end of a rubber glove finger and pour in the black powder
- ☐ Twist the wire ends of the e-match together
- ☐ Insert an e-match and into the glove finger with the black powder
- ☐ Compress the each glove finger and seal tightly with 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 SAFTEY PLAN

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

- ☐ Measure the black powder for each **MAIN** parachute ejection charges

☐ Cut off an end of a rubber glove finger and pour in the black powder

☐ Twist the wire ends of the e-match together

☐ Insert an e-match and into the glove finger with the black powder

☐ Compress the each glove finger and seal tightly with a 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 read body tube (with fins) followed by the parachute in the Nomex shield verifying the parachute is completely protected by the Nomex shield

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

Vehicle preparation - propulsion

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

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

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

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

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

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

☐ Secure the igniter to the outside of the vehicle

Final vehicle preparation for launch

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

☐ Side the vehicle onto the launch rail

☐ Arm the 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

<table>
<tr><td colspan="2">Flight Computer Status Codes Normal Status Code
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.</td></tr>
<tr><td>Low Battery
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.</td><td>SD Card is Unplugged
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.</td></tr>
<tr><td>Power-On Self-Test Failure (POST Failure)
1. Long warble.
2. Then a half second delay.
3. 1 – 7 high pitch beeps giving a failure code.
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.</td><td>Break Wire Error
1. Short warble.
2. A 1 second pause, and then the sequence repeats.

For Breakwire Flight
1. Power HCX off.
2. Correctly attach ends of break wire to TB2 pins3/4.

For Non-Breakwire Flight
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.</td></tr>
</table>

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
- × March 28, 2011 – FRR Presentation (Start)

- March 31, 2011 – FRR Presentation (Finish)
- 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:

AIAA SLI Project Timeline

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

Appendix H

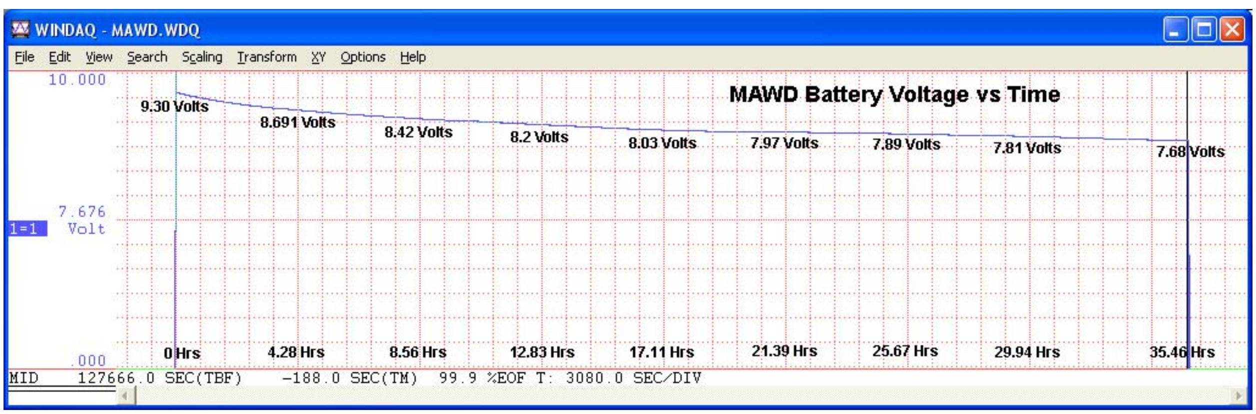
1. **Black Powder**
   a. **Equipment**
      i. Vehicle
      ii. Vise
      iii. Black Powder
      iv. Wire
      v. Nine Volt Battery
   b. **Procedure**
      i. Connect wire to a terminal block that is attached to either a drogue or main Terminal block and twish end of wire that is not attached 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

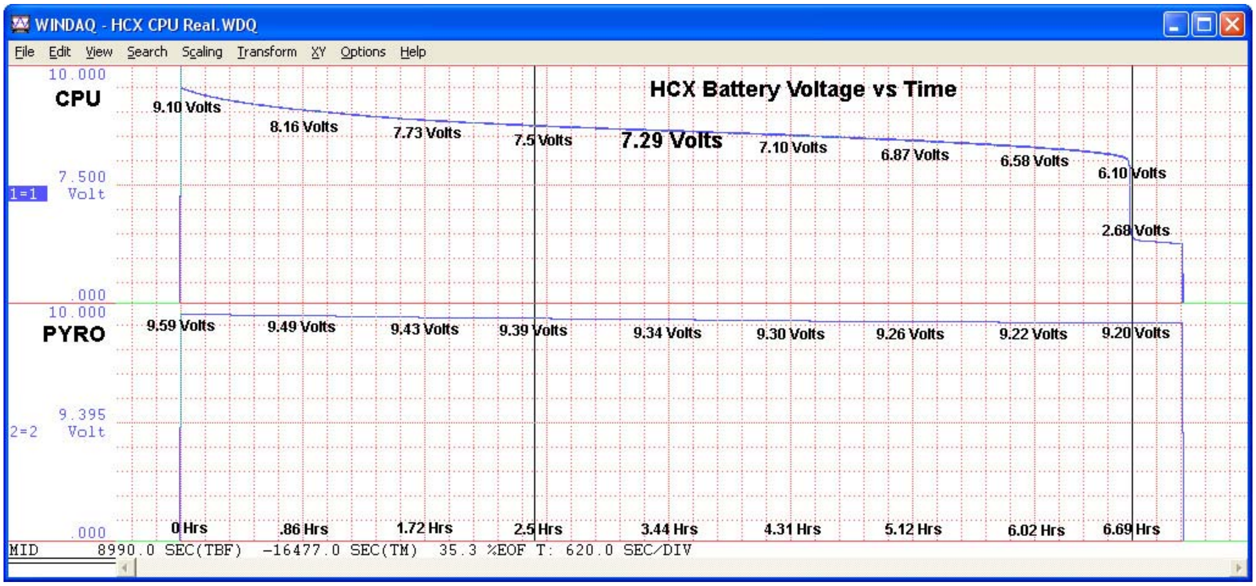


   c. **Observation**

   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 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 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.

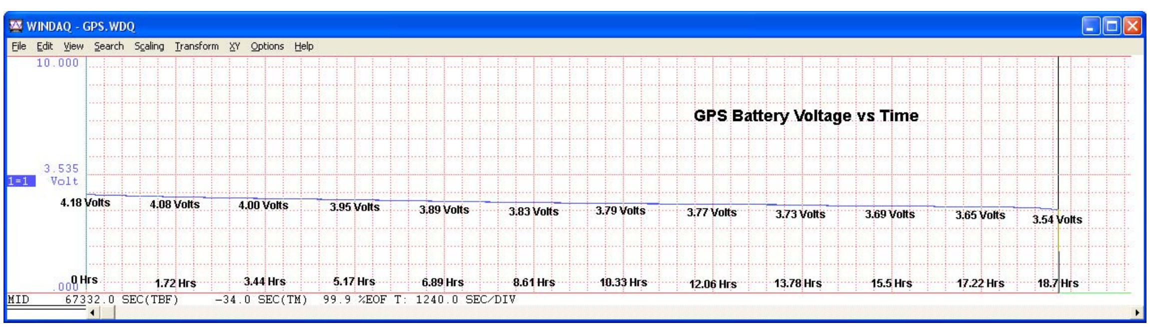
4. Battery Life – GPS

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**

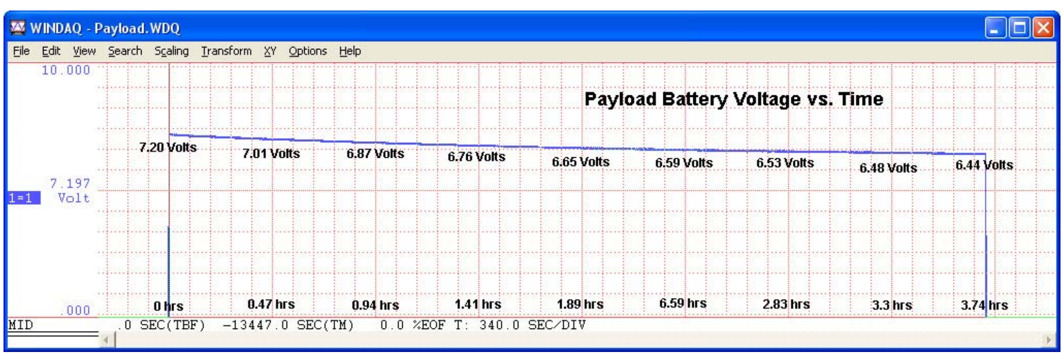
   One payload section containing
   - One small Linux computer
   - One hard disk drive and USB interface
   - One power regulator
   - One flash drive
   - Three rechargeable 2200mAh LiIon batteries connected in parallel
   - One router with network connection to the PC and the Linux computer
   - One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

   b. **Procedure**

   i. The LiIon 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 LiIon 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://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 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 Beep 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://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 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. Light Testing

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>.

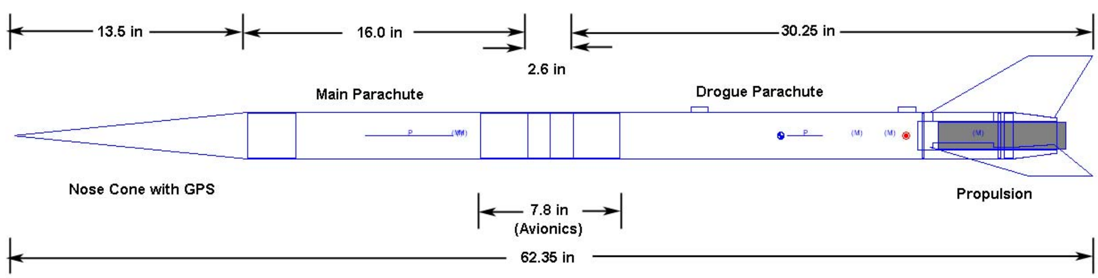
Appendix M

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 – ¼” 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://aiaaocrocketry.org/Videos/SLI2011/SLI%202011%20Scale%20Drogue%20Black%20Powder%20Test.wmv>

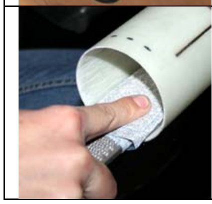
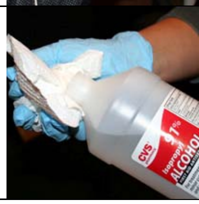
1.4. Motor Selection and simulation results

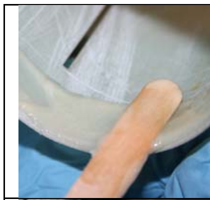
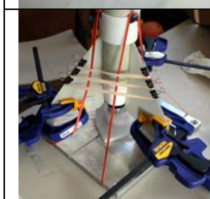
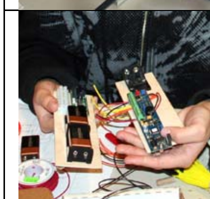
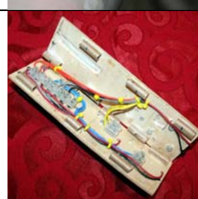
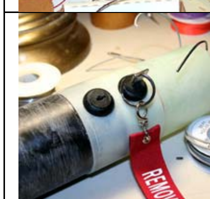
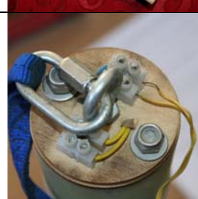
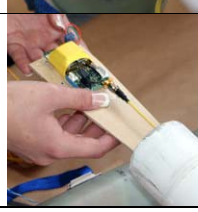
The motor selected for the flight was a Cesaroni 276H152 BlueStreak. We had done simulations based upon several "H" motors. This impulse range of motors was selected to make certain we could have the entire flight visible without going too high to see. We did all of the motors since we were unsure of 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://aiaaocrocketery.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	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: • Always use shear pins on heavier dual deploy rockets • Follow your design and don't let "experts" on site misguide you 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

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, 2011at 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://aiaaocrocketry.org/Videos/SLI2011/SLI%202011%20Scale%20Second%20Launch.wmv>