AIAA Orange County Section

Student Launch Initiative 2011-2012

Flight Readiness Review

Rocket Deployment of a Bendable Wing

Micro-UAV for Data Collection

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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	Reusable is defined as being able to be launched again on the same day without repairs or modifications.	
3.4.1.6	The launch vehicle shall stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee and a main parachute is deployed at a much lower altitude. Tumble recovery from apogee to main parachute deployment is permissible, provided that the kinetic energy is reasonable.	***21***
3.4.1.7	The recovery system electronics shall be shielded from all onboard transmitting devices, to avoid inadvertent excitation of the recovery system by the transmitting device(s).	***21***
3.4.1.8	Removable shear pins shall be used for both the main parachute compartment and the drogue parachute compartment.	***21***
3.4.1.9	The launch vehicle shall have a maximum of four (4) independent or tethered sections.	***21***
3.4.1.10	The launch vehicle shall be capable of being prepared for flight at the launch site within 2 hours, from the time the waiver opens.	***22***
3.4.1.11	The launch vehicle shall be capable of remaining in launch-ready configuration at the pad for a minimum of 1 hour without losing the functionality of any onboard component.	***22***
3.4.1.12	The launch vehicle shall be launched from a standard firing system (provided by the Range) using a standard 10-second countdown	***22***
3.4.1.13	The launch vehicle shall require no external circuitry or special ground support equipment to initiate the launch (other than what is provided by the Range).	***22***
3.4.1.14	Data from the science or engineering payload shall be collected, analyzed, and reported by the team following the scientific method.	***22***
3.4.1.15	An electronic tracking device shall be installed in each independent section of the launch vehicle and shall transmit the position of that independent section to a ground receiver. Audible beepers may be used in conjunction with an electronic, transmitting device, but shall not replace the transmitting tracking device.	***23***
3.4.1.16	The launch vehicle shall use a commercially available solid motor propulsion system using ammonium perchlorate composite propellant (APCP) which is approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA) and/or the Canadian Association of Rocketry (CAR).	***23***
3.4.1.17	The total impulse provided by the launch vehicle shall not exceed 2,560 Newton-seconds (K-class). This total impulse constraint is applicable to any combination of one or more motors.	***23***
3.4.1.18	All teams shall successfully launch and recover their full scale rocket prior to FRR in its final flight configuration.	***23***

1. Summary of FRR report

1.1. Team Summary

1.1.1. School name

The AIAA OC Section Student Launch Initiative team name is OC Rocketeers.

1.1.2. Location

The team location is:
20162 East Santiago Canyon Road
Orange, CA 92869

1.1.3. Team official/Mentors

The team officials and mentors are Bob Koepke, Jann Koepke, Michael Stoop, Andrea Earl, and Dr. Robert Davey.

1.2. Launch Vehicle Summary

1.2.1. Size

The total length of our Rocket will be 125 inches long, and the diameter of my rocket will be 5 inches.

1.2.2. Final motor choice

The motor we chose is the Aerotech K-1050. This motor will keep our rocket under the speed of sound, and propel it a mile high.

1.2.3. Recovery system

The recovery system consists of a total of four parachutes. The drogue and main parachute are located in the bottom section of the rocket. There will be another parachute located in the top section of the rocket. The final parachute will be on the UAV. The recovery electronics include the G-Wiz Partners and the Raven altimeter HCX, along with three nine volt batteries, associated wiring and safety interlock switches. They are located in the electronics bay along with the payload. There is more information on this in the recovery subsystem of the Critical Design Review.

1.2.4. Rail size

We will be using a ten foot long, one inch rail for our test flights in California. We acknowledge that we will be using an eight foot long one inch rail in Huntsville, Alabama.

1.3. Payload Summary

1.3.1. Summarize experiment

The payload of our rocket is an unmanned Arial vehicle (UAV). The experiment will begin once the UAV has been released from the sabot. It will be manually controlled by one of our team members until about 400 feet, where pre-determined commands will take over. Once deployed from the sabot, the UAV will use a telemetry kit to collect data. The telemetry kit will collect airspeed, altitude, compass heading, and artificial horizon through a 3 axis magnetometer. The UAV will also have a video feed in real time.

2. Changes made since CDR

2.1. Changes made to vehicle criteria

The vehicle criteria has not changed since the CDR.

2.2. Changes made to payload criteria

The payload criteria has changed. We are no longer using the ardupilot mega, the xbee. We will be only collecting real time video data.

2.3. Changes made to activity plan

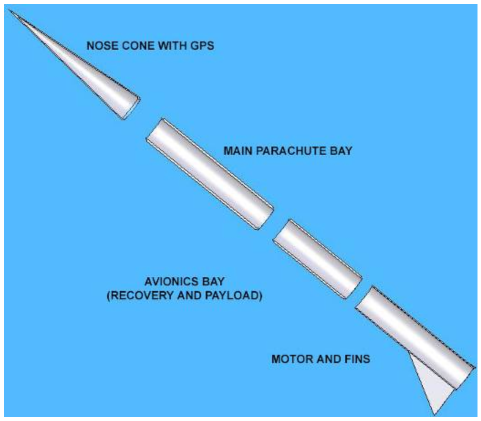
There has been no change to the activity plan since the CDR.

3. Vehicle Criteria

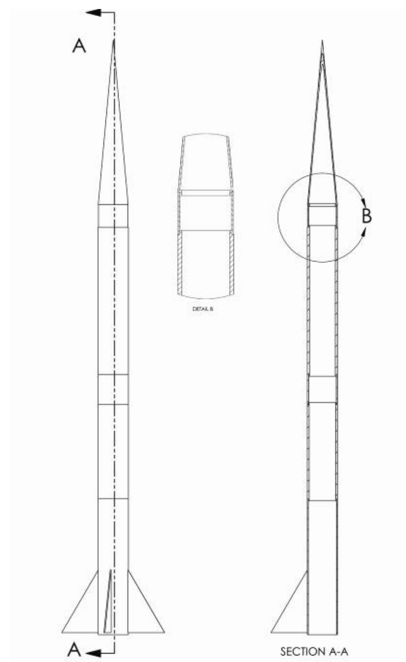
3.1. Design and Construction of Vehicle

3.1.1. Describe the design and construction of the launch vehicle, with special attention to the features that will enable the vehicle to be launched and recovered safely.

3.1.1.1. Structural elements (such as airframe, fins, bulkheads, attachment hardware, etc.)



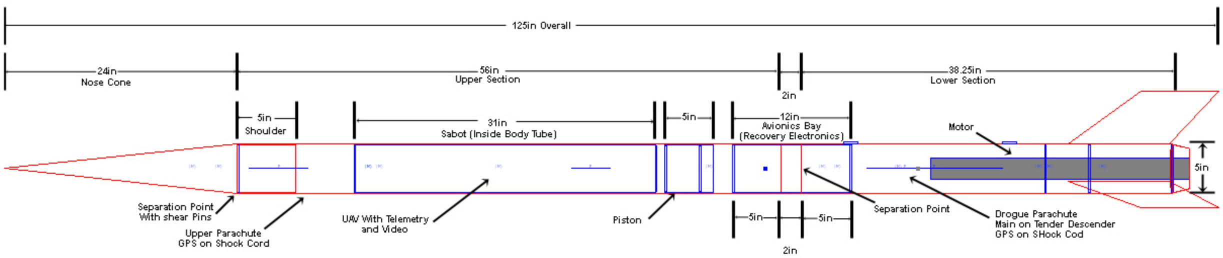
The Rocket was designed using Rocksim and is made up of 4 main parts. First there is the 24 inch long conic nose cone with a 6 inch long shoulder. There is a ½ inch thick plywood bulkhead (laminated with 1/8 inch thick G10 fiberglass on the lower end for added strength) at the top of the nosecone shoulder. This is where the shock cord attaches to. The nosecone is attached to the upper section via 3 #2 sheer pins. Next is the 56 inch upper section that holds our 32 inch sabot, 5 inch piston and 36 inch upper section parachute. The Sabot is 32 inches long and split along the longer axis pivoting from the bottom end. It will contain our UAV and the UAV parachute before they are deployed. There is a large U bolt on the top side of the sabot to force the sabot open when deployed. There is a shock cord that attaches to the nose cone bulkhead and the top of the sabot. Both the upper section parachute and a GPS unit are attached to this shock cord. Next is the avionics bay. It is a 12 inch section that houses all of the recovery electronics. It overlaps 5 inches into both the upper bay and the lower bay with a 2 inch long coupler around the middle. Last is the 38.25 inch lower bay. This houses the motor mount, motor, drogue parachute, main parachute, tender descenders, GPS and the nylon shock cord that the GPS and the drogue and main parachutes are all attached to. All of the outer body tubes and the coupler around the middle of the payload bay have a 5 inch outside diameter. The inside diameter of all body tubes and the outside diameter of the payload bay is 4.9920 inches. The outside diameter of the shoulder on the nosecone is 4.875 inches. Since we will be using a single use motor, our motor will use friction retention. There will be three fins equally placed around the outside of the lower bay an inch up from the bottom of the lower bay. The fins will have a root chord length of 14.325 inches, tip chord length of 5.25 inches, a sweep length of 14 inches, a semi span of 7 inches, and they will be 0.1875 inches thick. The fins are made entirely out of G10 fiberglass.



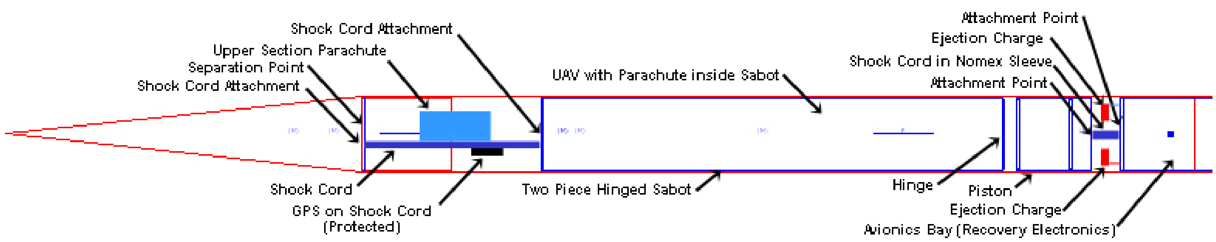
3.1.1.2. Electrical elements (wiring, switches, battery retention, retention of avionics boards, etc.)

All of our avionics equipment is housed within the avionics bay and are all contained on a 1/8 inch thick plywood sled. All of our terminal blocks and altimeters are secured to the sled using bolts and nuts to ensure that they will not move. Our batteries have also been secured with zip ties in both directions ensuring their security. All switches and pyros are wired through terminal blocks inside of the avionics bay for easy connection and disconnection. The pyros are also connected to terminal blocks on the upper and lower bulkheads of the avionics bay (depending on which pyro) so that we can easily connect the balck powder charges.

3.1.1.3. Drawings and schematics to describe the assembly of the vehicle.

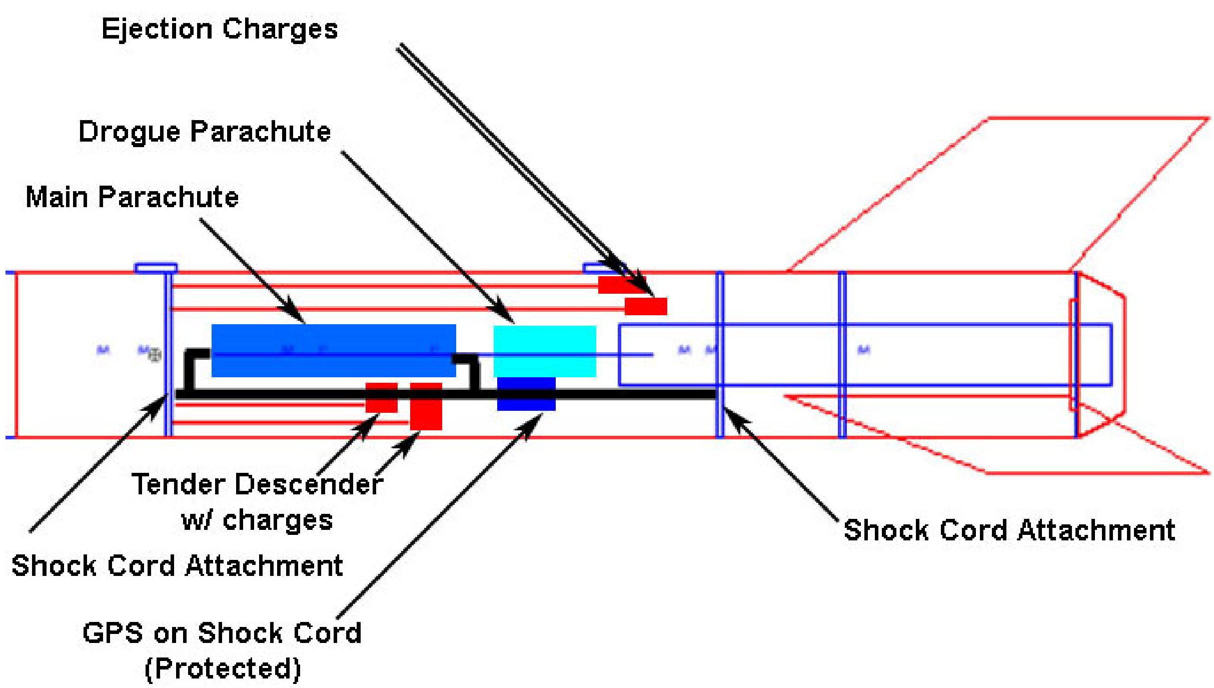


Parameter	Details
Length/Diameter	125 inches / 5 inches
Material	Carbon Fiber
Shock Cord	1" Tubular Nylon
Center of Pressure/Center of Gravity	94"/78.3"behind nose tip
Stability Margin	3.14

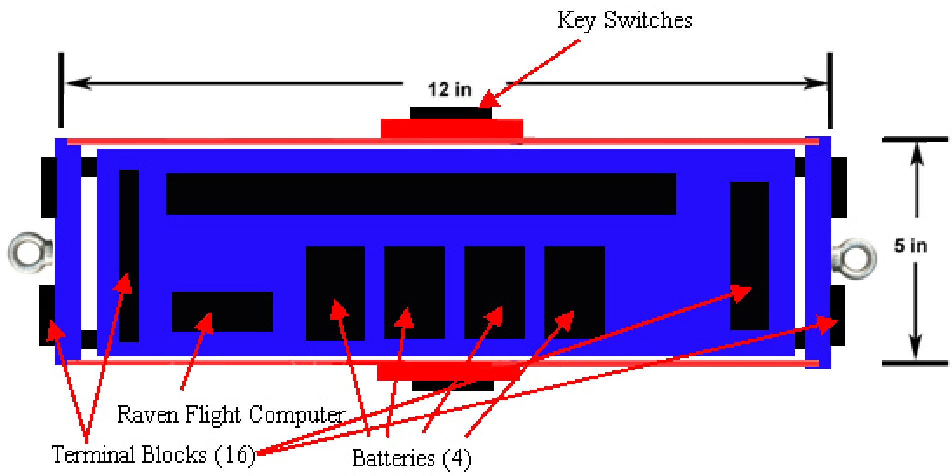


Parameter	Details
Nose Cone	Carbon Fiber 24" long
Body Tube	Carbon fiber 5" diameter x 56" long
Bulkhead	½" plywood with fiberglass on bottom face with "U" bolt for shock cord attachment
Shock Cord	1" Tubular Nylon x 20 ft + 4 ft (Piston)
Sabot	Carbon Fiber coupler, split lengthwise, hinged

Forward Cavity	10" x 5" diameter for ejection charge, shock cord, GPS, and forward section parachute (56" – 5" for avionics bay – 5" for nose cone – 31" for sabot – 5" for piston)
Ejection Charge	2.0 grams (250 lbs – 13psi)



Parameter	**Details**
Body Tube	Carbon fiber 5" diameter x 38.75" long
Centering Rings	2ply x 3/32" = 3/16" fiberglass with "U" bolt for shock cord
Shock Cord	1" Tubular Nylon x 15 ft + 15 ft
Rear Cavity	12.75" x 5" diameter for ejection charge, shock cord, GPS, and forward section parachute
Ejection Charge	2.0 grams (250lbs – 13psi)
Tender Descender	.2 grams (per the data sheet)



Parameter	Details
Bay Material	Carbon Fiber tubing 12” long – coupler for 5” body tube
Body Tube	Carbon fiber 5” diameter x 2” long
Bulkhead	½” plywood with fiberglass on both faces with U bolt for shock cord attachment
Sled	1/8” plywood with ¼” threaded rods the entire length
Electronics	HCX and Raven flight computers, Batteries
Terminal Blocks (for ejection chg)	Aft: Drogue primary and backup, Main primary and backup Forward: UAV deploy primary and backup

3.1.2. Discuss flight reliability confidence. Demonstrate that the design can meet mission success criteria.

Our vehicle is fully able to meet the mission success criteria as shown by our numerous Rocksim simulations and our fully successful scale model flight. It has shown that both our piston and sabot function as predicted and that the tender descenders work in series as well.

3.1.3. Discuss analysis, and component, functional, or static testing.

Most of the conceptual testing was completed during the scale model were the design concept was refined through test failures and subsequent design refinement. The part that we had the most trouble was with deploying the sabot. We concluded that we needed to use a piston and a strong sabot. The balance of the testing such as range testing and black powder testing yielded acceptable results that were in line with the design requirements.

3.1.4. **Present test data and discuss analysis, and component, functional, or static testing of components and subsystems.**

Calculated black powder charges were validated through ground testing. Other test results can be found in section 3.4.3.

3.1.5. **Describe the workmanship that will enable mission success.**

The rocket has been well assembled so that it can survive the flight and be flown again. We used West System Epoxy to construct the rocket and we also used fiberglass glass. All the connections for the recovery system and for the payload, the UAV, have to work and be secure; we will check connections before flight. We will always check to make sure our rocket will never reach mach1 and that our rocket will recover safely, the parachute will be large enough to recover the rocket safely.

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

Failure modes, causes and effects can be found in appendix A, and risk mitigations can be found in appendix C.

3.1.7. **Discuss full-scale launch test results. Present and discuss actual flight data. Compare and contrast flight data to the predictions from analysis and simulations.**

Our full scale rocket is scheduled to be launched on 3/31/12 at plaster city before the FRR WebEx.

3.1.8. **Provide a Mass Report and the basis for the reported masses.**

The mass statement can be found in appendix L. All masses are obtained by either self-measurements or through manufacturer advertised masses.

3.2. **Recovery Subsystem**

3.2.1. **Describe and defend the robustness of as-built and as-tested recovery system.**

Our recovery system is dual deploy dual redundant. The two altimeters we are using are the GWIZ Partners HCX and a Featherweight Raven. The HCX determines height by using barometric pressure or acceleration while the Raven determines height by using barometric pressure. The HCX will be our Main altimeter and the Raven will be the back up altimeter. The electronics are mounted to a piece of plywood with standoffs and screws. All wires have ferrules on the end of them to ensure a good connection. The recovery system has proven itself in the scale model test flight and will prove itself in the full scale test flight.

3.2.1.1. **Structural elements (such as bulkheads, harnesses, attachment hardware, etc.)**

We will be using 1 inch Kevlar for the shock cord material. The centering ring attachment point is a composite construction of two 3/16th inch fiberglass sandwiching 1/8th inch honey comb. The other bulkheads are a composite construction of 9 ply plywood and 3/16th fiberglass. All the attachment points are U bolts and the attachment hardware that is used are quick links.

3.2.1.2. **Electrical elements (such as altimeters/computers, switches, connectors).**

We will be using two altimeters the G-Wiz Partners HCX as the main altimeter and a Featherweight Raven Altimeter as the backup altimeter. These altimeters will work together by providing two black powder charges for each event and by giving two sets of flight data so that we can compare the data to get more accurate flight results. The first black powder charge from the G-Wiz

Partners HCX will hopefully sheer the shear pins and deploy the parachute, but if the first black powder charge does not then the second black powder charge with fifty percent more black powder than the first black powder charge from the Featherweight Raven will shear the shear pins and deploy the parachute. The terminal blocks will connect the altimeters to the batteries, the HCX has two nine volt batteries and the Raven has one nine volt battery, and the terminals also connect the altimeters to the electrical match outside of the avionics bay. Wires connect the altimeters to the terminal blocks, on each end of the wire there will be ferrules to ensure a good connection.

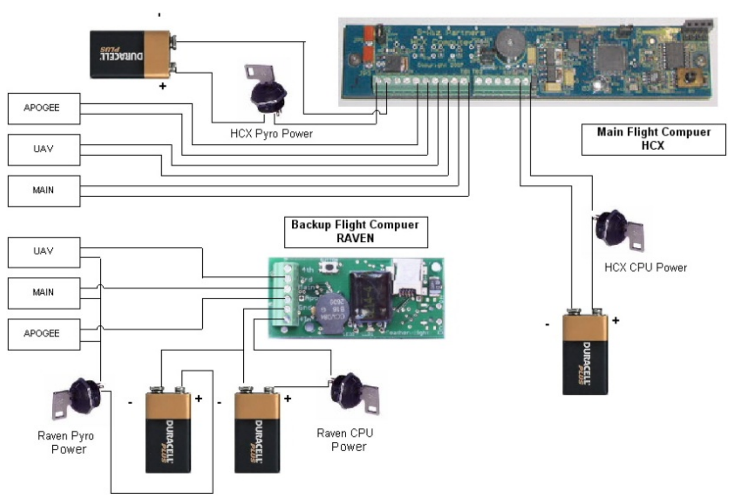
3.2.1.3. Redundancy features

Our rocket will have dual redundant dual deploy altimeters. The G-Wiz Partners HCX will be our main altimeter and the Featherweight Raven will be our back up altimeter. The HCX can use barometric pressure or acceleration to determine its altitude, while the raven only has and uses barometric pressure to determine altitude. We will program the HCX to use barometric pressure.

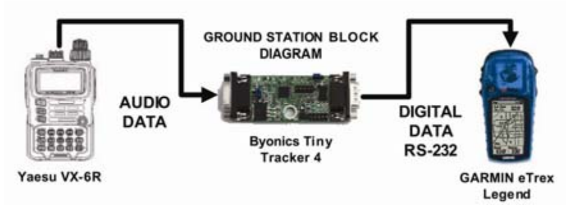
3.2.1.4. Parachute sizes and descent rates

The parachute sizes are as follows Drogue 24 inch parachute, Main 84 inch parachute, Nose cone and sabot 36 inch parachute and UAV 24 inch parachute. The first event will be the drogue parachute at apogee, the 24 inch drogue parachute will give us a 81.65 feet per second descent rate. The second event will be the main parachute at 950 feet; the 84 inch parachute will give us a descent rate of 23.33 feet per second and after the third event the descent rate will be 21.23 feet per second. The third event will be at 800 feet, the nose cone and sabot will have a descent rate of 19.55 feet per second and the UAV will have a descent rate of 18.42 feet per second.

3.2.1.5. Drawings and schematics of the electrical and structural assemblies



The flight computers shown above in the schematic are powered by Duracell 9VDC batteries. This design includes four safety switches: the Raven Flight Computer Power (normally open), the HCX Flight Computer CPU Power (normally open), the HCX Pyro Power (normally open), and the HCX Pyro Shunt (normally closed and the last to be switched).



The above schematic's receiver is a Yaesu VX-6R, its TNC is a Byonics Tiny Track 4, and its GPS is a Garmin eTrex Legend.

3.2.1.6. **Rocket-locating transmitters with a discussion of frequency, wattage, and range.**

We will be using two Big Red Bee Beeline GPS transmitters. They will be encased in foam and placed on the one inch Kevlar shock cord because our rocket is carbon fiber. The range of frequencies that the Big Red Bee Beeline has is 420-450MHz, we will be using 433.92 MHz and 434.92 MHz for the frequencies. The maximum output that the Big Red Bee Beeline has is approximately 16 milli-watts. The range in the air is more than twenty miles. In our ground tests we have found that the range is more than three miles.

3.2.1.7. **Discuss the sensitivity of the recovery system to onboard devices that generate electromagnetic fields (such as transmitters). This topic should also be included in the Safety and Failure Analysis section.**

The electronics that would be affected by electromagnetic fields are the altimeters and the big red bee beeline GPS. Our rocket is made out of carbon fiber so it should minimize any frequencies and electromagnetic fields that are generated through electronic devices. We will also spray our avionics bay and end plates with MG Chemicals Super Shield to further eliminate interference.

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

We will be using a 24 inch parachute as our Drogue, a 84 inch parachute as our main, a 36 inch parachute for our upper section, and a 24 inch parachute for our UAV. The first attachment point is on the centering ring on the motor tube. The centering ring is a composite construction of 1/8th inch honey comb centering ring sandwiched between two 3/16th fiberglass centering rings. The attachment point is a steel U bolt. A quick link will attach the Kevlar shock cord to the U bolt. The second attachment point will be on the bottom end of the Avionics Bay. The Avionics bay's bulk head will be a composite construction of 3/16th fiberglass and 9 ply plywood that is stepped. The attachment point will be a steel U bolt and a quick link will attach the Kevlar shock cord to the U bolt. The third attachment point will be on the upper end of the Anionic Bay. The Avionics bay's bulk head will be a composite construction of 3/16th fiberglass and 9 ply plywood that is stepped. The attachment point will be a steel U bolt and a quick link will attach the Kevlar shock cord to the U bolt. The fourth attachment point is a U bolt on the piston. The bulkhead will be composited of 9 ply plywood and 3/16th fiberglass and a quick link will attach the Kevlar shock cord to the U bolt. The fifth attachment point will be a U bolt on the sabot. The sabots bulkhead is a composite construction of 9 ply plywood and 3/16th fiberglass bulkheads, a quick link will attach the Kevlar shock cord to the U bolt. The sixth attachment point will be a U bolt in a bulkhead in the nose cone. The bulkhead is a composite construction of 9 ply plywood and 3/16th plywood, a quick link will attach the Kevlar shock cord to the U bolt.

We have planned our black powder test for a nonrainy day.

Upper section black powder charge amount:

175lbs = 1.3g
200lbs = 1.5g
225lbs = 1.6g
250lbs = 1.8g
275lbs = 2.0g
300lbs = 2.2g

Sustainer section black powder charge amount:

175lbs = 2.25g
200lbs = 2.6g
225lbs = 2.9g
250lbs = 3.25g
275lbs = 3.5g
300lbs = 3.9g

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

Appendix A has failure modes, causes and effects and Appendix C has risk migrations.

3.3. Mission Performance Predictions

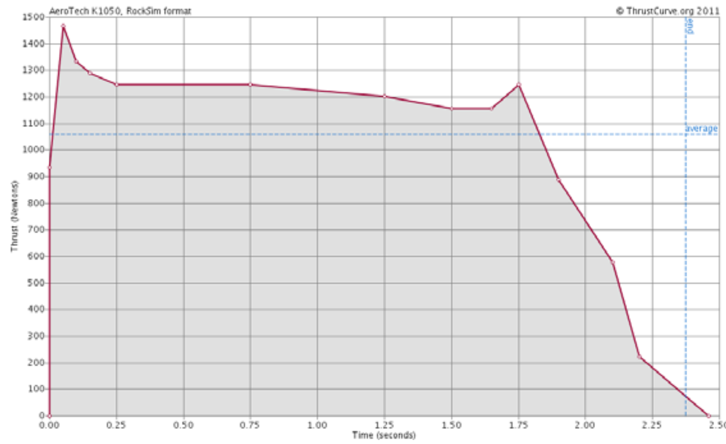
3.3.1. State mission performance criteria

Our team's rocket has been designed and built by the team. The rocket will be flown and reach a mile high. The recovery system will use dual deployment and will work successfully. The payload will be launched from the sabot at the second event and will be able to transmit the GPS location, video in real time and will be able to be flown via RC. The rocket will not exceed mach1, pose as a safety threat and won't travel outside of the 2,500 feet range from the launch pad. It will be a success if it meets these criteria, gathers useful data, and can be flown again without major repair.

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

	Simulation	Results	Engines loaded	Max. altitude Feet	Max. velocity Feet / Sec	Max. acceleration Feet/sec/sec	Time to apogee	Velocity at deploym Feet / Sec	Altitude at deploym Feet
44	43		[K1050W-None]	4960.63	664.62	390.31	16.98	0.02	4960.61
45	44		[K250W-None]	4693.60	443.80	93.20	19.64	0.01	4693.61
46	45		[K300-CL-None]	4747.41	464.56	127.74	18.99	0.01	4747.41
47	46		[K750W-None]	4798.43	602.67	304.49	17.20	0.01	4798.42
48	47		[K350-LW-None]	4653.25	468.57	349.03	18.48	0.03	4653.24
49	48		[K1185GT-None]	4719.36	652.56	374.45	16.74	0.00	4719.37
50	49		[K1750R-None]	4716.77	679.33	609.80	16.38	0.01	4716.75
51	50		[K975WW-None]	4604.27	624.63	344.07	16.70	0.03	4604.25
52	51		[K470WC-None]	4669.69	519.05	279.93	17.47	0.00	4669.69
53	52		[K660-Classic-None]	4800.95	594.60	294.43	17.26	0.04	4800.96
54	53		[K1050W-None]	4960.63	664.62	390.31	16.98	0.02	4960.61

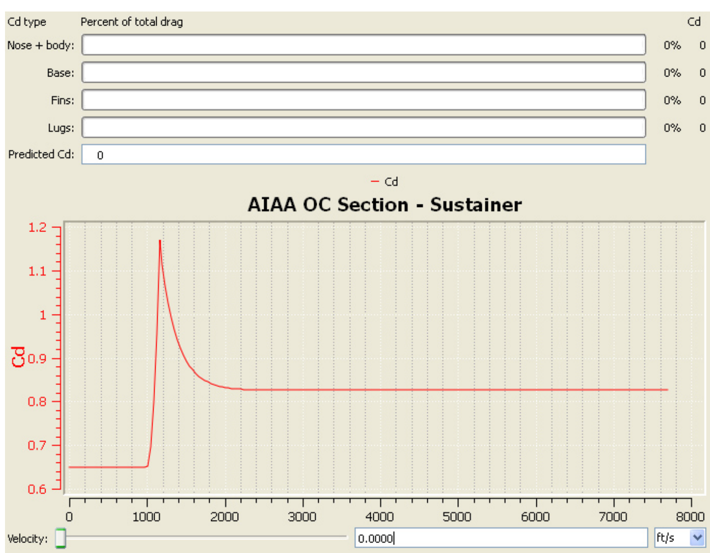
Though we are a little sensitive towards altitude and temperatures below 45F, we have very minimal variation in altitude with changes in humidity and wind speeds (witch we find would be the most prominent variables in launch).



This thrust curve for the Aerotech k1050 shows an almost optimal burn pattern for how heavy our rocket is. It gives a nice fast boost off the pad, and then holds a steady burn until it gives one last bump of power at the end for a nice stead flight and a smooth arch at apogee.

3.3.3. Thoroughness and validity of analysis, drag assessment, and scale modeling results. Compare analyses and simulations to measured values from ground and/or flight tests. Discuss how the predictive analyses and simulation have been made more accurate by test and flight data.

The scale model had a very successful flight and proved the integrity of our basic design. We also have run this same scaled up design through several rocksim simulations to prove its reliability. Though our altitude was higher than predicted, all other predicted values were within a small margin of error. These predictions could have been more accurate if we had used the actual weather data for our simulations instead of using the preset rocksim values.



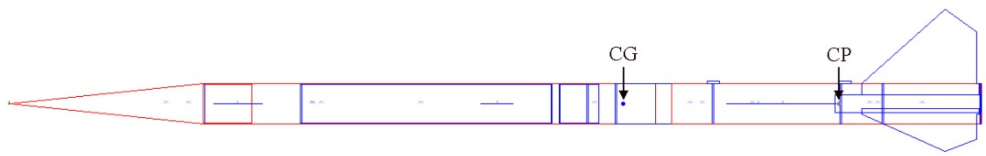
This is a graph that shows our CD compared against velocity (in ft/s). Up until Mach we have a low CD of around .65. We found this value very suitable, as it is an average value, and possibly slightly low for a 5 inch diameter rocket. We were not concerned at the jump in the CD at Mach as our current motor is un capable of propelling our vehicle at such speeds.

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

The CG, center of gravity, is located 82.0142 inches from the tip of the nose cone and the CP, center of pressure, is located 102.6403 inches from the tip of the nose cone. This gives us a stability margin of 4.13. Below is the rocket with the locations of the CG and CP.

The sensitivities include:

- added weight in the nose, increases stability
- Added weight in the rear, decreases stability
- Larger fins, increases stability



3.3.5. Discuss the management of kinetic energy through the various phases of the mission, with special attention to landing.

We are controlling the kinetic energy by controlling the descent rate, The rocket has a fixed weight by which we are using parachutes to control the descent rate which is listed in the section below.

Kinetic Energy is as follows:

- Lower section tethered to avionics bay which is attached to the Upper body tube (84 in Parachute) K.E. = 56.50
- Nose cone tethered to the sabot (36 in Parachute) K.E. = 7.39
- UAV (24 in Parachute) K.E. = 2.59
- Lower section tethered to avionics bay and Upper section with Nose cone and sabot attached (DROGUE ONLY – 24 in Parachute)
- Lower section tethered to avionics bay and Upper section with Nose cone and sabot attached (MAIN ONLY – 84 in Parachute) K.E. = 81.58

3.3.6. Discuss the altitude of the launch vehicle and the drift of each independent section of the launch vehicle for winds of 0-, 5-, 10-, 15-, and 20-mph.

Drogue (5280ft-950ft)

Weight (Oz.)	Parachute size (in)	Velocity (ft/s)	Wind Speed (MPH)	Drift (ft)
314.28	24	81.65	5	338.90
314.28	24	81.65	10	777.80
314.28	24	81.65	15	1166.69
314.28	24	81.65	20	1155.59

Main (950ft-800ft)

Weight (Oz.)	Parachute size (in)	Velocity (ft/s)	Wind Speed (MPH)	Drift (ft)
314.28	84	23.33	5	47.15
314.28	84	23.33	10	94.30
314.28	84	23.33	15	141.45
314.28	84	23.33	20	188.60

Main (800ft-0ft)

Weight (Oz.)	Parachute size (in)	Velocity (ft/s)	Wind Speed (MPH)	Drift (ft)
260.41	84	21.23	5	275.04
260.41	84	21.23	10	550.09
260.41	84	21.23	15	825.13
260.41	84	21.23	20	1100.18

UAV (800ft-0ft)

Weight (Oz.)	Parachute size (in)	Velocity (ft/s)	Wind Speed (MPH)	Drift (ft)
16.00	24	18.42	5	318.50
16.00	24	18.42	10	637.00
16.00	24	18.42	15	955.48
16.00	24	18.42	20	1273.98

Nosecone and Sabot (800ft-0ft)

Weight (Oz.)	Parachute size (in)	Velocity (ft/s)	Wind Speed (MPH)	Drift (ft)
40.47	36	19.55	5	300.09
40.47	36	19.55	10	600.17
40.47	36	19.55	15	900.26
40.47	36	19.55	20	1200.34

Total Distance traveled Sustainer

Wind Speed (MPH)	Total distance traveled (ft)
5	711.09
10	1422.18
15	2133.26
20	2844.35

Total Distance traveled Sabot and Nosecone

Wind Speed (MPH)	Total distance traveled (ft)
5	736.13

10	1472.26
15	2208.39
20	2944.52

Total Distance traveled UAV

Wind Speed (MPH)	Total distance traveled (ft)
5	754.54
10	1509.08
15	2263.62
20	3018.16

3.4. Verification (Vehicle)

_3.4.1._ For each requirement (Pages 5, 6, and 7), describe how that requirement has been satisfied and by what method the requirement was verified. Note: Requirements are often satisfied by design features of a product, and requirements are usually verified by one or more of the following methods: analysis, inspection, and test.

3.4.1.1. The launch vehicle shall carry a science or engineering payload of the team's discretion.

Our rocket will carry a UAV up and deploy it via sabot. The UAV will record and transmit live telemetry and video while being flown via RC. The entire payload has been reviewed and approved by NASA.

3.4.1.2. The launch vehicle shall deliver the science or engineering payload to, but not exceeding, an altitude of 5,280 feet. above ground level (AGL).

Our rocket is designed to attain an altitude of 5280 feet wile not exceeding, and since out paylod will be deployed after more than 4000ft of decent from apogee and we have a flight celeing of 400 feet, there is no chance for our payload exceeding 5280 feet.

3.4.1.3. The recovery system electronics shall have the following characteristics:

3.4.1.3.1. The recovery system shall contain redundant altimeters. The term "altimeters" includes both simple altimeters and more sophisticated flight computers.

We are using both the Gwiz HXC and the Feather Weight Raven flight computers. The HCX will be our main altimeter and control our first set of pyros. The Raven will then be used for our backup pyro charges and as a second altimeter for verification.

3.4.1.3.2. Each altimeter shall be armed by a dedicated arming switch.

Our avionics bay is built with 4 independent switches for each the HCX CPU, HCX Pyros, Raven CPU, and Raven Pyros respectively

3.4.1.3.3. Each arming switch shall be accessible from the exterior of the rocket airframe.

These arming switches will be located on the cuff in the middle of the avionics bay, which will be on the very exterior of our vehicle.

3.4.1.3.4. Each arming switch shall be capable of being locked in the ON position for launch.

The keys on the switches we have used may only be removed when the switch is in the “on” position, locking it in place for the duration of the launch.

3.4.1.3.5. The recovery system shall be designed to be armed on the pad.

These switches will only be moved to the “on” position once the rocket is loaded onto the launch pad, thus leaving the recovery system disarmed until we are ready to launch.

3.4.1.3.6. The recovery system electronics shall be completely independent of the payload electronics.

All of our payload will be housed in the UAV witch will be located in the sabot (entirely separate from the avionics bay) during launch until deployment. It will use separate batteries, and have its own GPS unit, thus making it an entirely autonomous sub-system of our vehicle.

3.4.1.3.7. Each altimeter shall have a dedicated battery.

Each altimeter is powered by its own battery along with another battery for each set of independent pyros.

3.4.1.3.8. Each arming switch shall be a maximum of six (6) feet above the base of the launch vehicle.

Our switches will be 54 inches up from the base of our launch vehicle, well under the 72 inch maximum.

3.4.1.4. The launch vehicle and science or engineering payload shall remain subsonic from launch until landing.

The K1050 Aerotech motor will give us a max velocity of roughly 750 ft/s well beneath the sound barrier.

3.4.1.5. The launch vehicle and science or engineering payload shall be designed to be recoverable and reusable. Reusable is defined as being able to be launched again on the same day without repairs or modifications.

Our vehicle and payload have been designed to be recoverable and reusable.

3.4.1.6. The launch vehicle shall stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee and a main parachute is deployed at a much lower altitude. Tumble recovery from apogee to main parachute deployment is permissible, provided that the kinetic energy is reasonable.

Our recovery system has been designed to deploy a drogue parachute at apogee and to deploy a main at a much lower altitude.

3.4.1.7. The recovery system electronics shall be shielded from all onboard transmitting devices, to avoid inadvertent excitation of the recovery system by the transmitting device(s).

Our rocket is made almost solely out of carbon fiber witch has natural RF blocking properties, and then we coated the inside of our avionics bay with MG Chemicals Supper Shield for some added protection.

3.4.1.8. Removable shear pins shall be used for both the main parachute compartment and the drogue parachute compartment.

We will use 3 #2 sheer pins at every separation point on our vehicle.

3.4.1.9. The launch vehicle shall have a maximum of four (4) independent or tethered sections.

Our vehicle has been designed to have three independent tethered sections. The first is our lower and upper sections, second is our sabot and nosecone, and lastly is our UAV under its own parachute.

3.4.1.9.1. At landing, each independent or tethered sections of the launch vehicle shall have a maximum kinetic energy of 75 ft-lbf.

The independent tethered sections of our vehicle have less than 75 ft-lbf at landing. The sustainer, avionics bay and upper body tube at landing will have a kinetic energy of 56.50 ft-lbf. The nose cone and sabot at landing will have a kinetic energy of 7.39 ft-lbf. The UAV on parachute will have a kinetic energy of 2.59 ft-lbf.

3.4.1.9.2. All independent or tethered sections of the launch vehicle shall be designed to recover with 2,500 feet of the launch pad, assuming a 15 mph wind.

All independent tethered sections of our launch vehicle are designed to be recovered within 2,500 feet of the launch pad in 15 mile an hour wind. The sustainer tethered to the avionics bay which is attached to the upper body tube will travel a total distance of 2133.26 feet from the launch pad in 15 mile per hour wind. The sabot tethered to the nose cone will travel a total distance of 2208.39 feet in 15 mile per hour wind. The UAV under parachute will travel a total distance of 2263.62 feet in 15 mile per hour wind.

3.4.1.10. The launch vehicle shall be capable of being prepared for flight at the launch site within 2 hours, from the time the waiver opens.

Our team is capable of being prepared for launch at the launch site within 2 hours.

3.4.1.11. The launch vehicle shall be capable of remaining in launch-ready configuration at the pad for a minimum of 1 hour without losing the functionality of any onboard component.

Our launch vehicle is capable of remaining in launch ready configuration at the pad for a minimum of one hour without losing functionality. Through our electronic life testing we have concluded that the HCX can run for 3 hours, the Raven and the Big red bee beeline GPS can run for a minimum of 10 hours on new 9 volt batteries. The payload has switches, once it is deployed from the sabot the UAV will turn on.

3.4.1.12. The launch vehicle shall be launched from a standard firing system (provided by the Range) using a standard 10-second countdown

Our launch vehicle will be launched from a standard firing system provided by the range using a standard 10-second countdown. Standard firing system is 10 foot rail using a safety interlock launch controller.

3.4.1.13. The launch vehicle shall require no external circuitry or special ground support equipment to initiate the launch (other than what is provided by the Range).

Our launch vehicle does not require external circuitry or special ground support equipment to initiate the launch other than what is provided by the range. The Launch vehicle only requires the two alligator clips for the igniter which is provided by the range.

3.4.1.14. Data from the science or engineering payload shall be collected, analyzed, and reported by the team following the scientific method.

Our payload is more of an engineering payload than a scientific payload. Our hypothesis is that our plane will have a stable flight and will transmit video in real time to our ground station which will be recorded

3.4.1.15. An electronic tracking device shall be installed in each independent section of the launch vehicle and shall transmit the position of that independent section to a ground receiver. Audible beepers may be used in conjunction with an electronic, transmitting device, but shall not replace the transmitting tracking device.

Each independent section of our rocket will be equipped with a Big Red Beeline GPS unit to help aid with location of the vehicle.

3.4.1.16. The launch vehicle shall use a commercially available solid motor propulsion system using ammonium perchlorate composite propellant (APCP) which is approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA) and/or the Canadian Association of Rocketry (CAR).

We will be using a NAR certified APCP Aerotech k-1050 motor.

3.4.1.17. The total impulse provided by the launch vehicle shall not exceed 2,560 Newton-seconds (K-class). This total impulse constraint is applicable to any combination of one or more motors.

The motor we will be using has a total impulse of 2,530 Ns.

3.4.1.18. All teams shall successfully launch and recover their full scale rocket prior to FRR in its final flight configuration.

We have our final flight scheduled before the FRR WebEx which will occur on April 9th, 2012.

3.4.1.18.1. The purpose of the full scale demonstration flight is to demonstrate the launch vehicle's stability, structural integrity, recovery systems, and the team's ability to prepare the launch vehicle for flight.

This is the goal of our flight, the data will be provided in the FRR WebEx.

3.4.1.18.2. The vehicle and recovery system shall have functioned as designed.

This is the goal of our recovery system, the data will be provided in the FRR WebEx.

3.4.1.18.3. The payload does not have to be flown during the full-scale test flight.

3.4.1.18.3.1. If the payload is not flown, mass simulators shall be used to simulate the payload mass.

We will use a weight system attached to a parachute during our scale test launch to simulate our UAV.

3.4.1.18.3.2. If the payload changes the external surfaces of the launch vehicle (such as with camera housings and/or external probes), those devices must be flown during the full scale demonstration flight.

We have no such devises.

3.4.1.18.4. The full scale motor does not have to be flown during the full scale test flight. However, it is recommended that the full scale motor be used to demonstrate full flight readiness and altitude verification.

The full scale motor will not be used for economic reasons, however a motor with the same relative burn time and nearly identical thrust curve will be.

3.4.1.18.5. The success of the full scale demonstration flight shall be documented on the flight certification form, by a Level 2 NAR/TRA observer.

This will be provided after the flight.

3.4.1.18.6. After successfully completing the full-scale demonstration flight, the launch vehicle or any of its components shall not be modified without the concurrence of the NASA Range Safety Officer.

We will comply.

3.4.1.19. The following items are prohibited from use in the launch vehicle:

3.4.1.19.1. Flashbulbs. The recovery system must use commercially available low-current electric matches.

Our recovery system is designed based off of the use of low-current e-matches with black powder charges.

3.4.1.19.2. Forward canards.

Our vehicle has been designed with no forward canards.

3.4.1.19.3. Forward firing motors.

Our only motor is our main motor witch will fire down, so there will be no forward firing motors.

3.4.1.19.4. Rear ejection parachute designs.

Our rocket has be designed to deploy parachutes between the lower section and the avionics bay and between the upper section and the nose cone, so there will be no rear ejection in our design.

3.4.1.19.5. Motors which expel titanium sponges (Sparky, Skidmark, MetalStorm, etc.)

Both the Aerotech K-1050 that we plan to use and our back up Ceseroni K-600 do not contain any form of titanium sponge.

3.4.1.20. Each team shall use a launch and safety checklist. The final checklist shall be included in the FRR report and used during the flight hardware and safety inspection and launch day.

Our launch and safety checklist can be found in Appendix D.

3.4.1.21. Students on the team shall do 100% of the work on the project, including design, construction, written reports, presentations, and flight preparation with the exception of assembling the motors and handling black powder charges.

All work and been and will be done by team members.

3.4.1.22. The rocketry mentor supporting the team shall have been certified by NAR or TRA for the motor impulse of the launch vehicle, and the rocketeer shall have flown and successfully recovered (using electronic, staged recovery) a minimum of 15 flights in this or a higher impulse class, prior to PDR.

Many of our Mentors have Level 2 NAR certifications and two in particular (Mike Stoop and Mr. Koepke) have had over 15 flights in the K-class and above.

3.4.2. **The verification statement for each requirement should include results of the analysis, inspection, and/or test which prove that the requirement has been properly verified.**

This will be provided. Some testing can be found with component and functional and static testing.

3.4.3. **Present test data and discuss analysis, and component, functional, or static testing of components and subsystems.**

Battery life
Procedure can be found in Appendix I

Electronics	Life time (hours)	Successful
HCX G-Wiz Partners	2.5	Yes
Raven Flight Computer	11.8 (and still going)	Yes
Big Red Bee Beeline GPS	18.7 (and still going)	Yes

GPS Range
Procedure can be found in Appendix J

Transceiver Location	Range	Successful
On the ground	3.05 miles	Yes

3.4.4. **Describe the workmanship that will enable mission success.**
The rocket had to be well assembled so that it can survive the flight and be flown again. We used West System Epoxy to construct the rocket and we also used fiberglass glass tape. All the connections for the recovery system and for the payload, the UAV, work and are secured well; we will check connections before flight. We will always check to make sure our rocket will never reach mach1 and that our rocket will recover safely, the parachute is large enough to recover the rocket safely.

3.4.5. **Provide a safety and failure analysis, including a table with failure modes, causes, effects, and risk mitigations.**
Failure modes causes and effects are in appendix A. Our Risk mitigations are in Appendix C.

3.4.6. **Discuss full-scale launch test results. Present and discuss actual flight data. Compare and contrast flight data to the predictions from analysis and simulations.**
This will be provided in the WebEx.

3.4.7. **Provide a Mass Report and the basis for the reported masses.**
The mass statement can be found in appendix L. All masses are obtained by either self-measurements or through manufacturer advertised masses.

3.5. Safety and Environment (Vehicle)

3.5.1. **Provide a safety and mission assurance analysis. Provide a Failure Modes and Effects Analysis (which can be as simple as a table of failure modes, causes, effects, and mitigations/controls put in place to minimize the occurrence or effect of the hazard or failure). Discuss likelihood and potential consequences for the top 5 to 10 failures (most likely to occur and/or worst consequences).**
The mitigation table can be found in Appendix C.
The most severe failure is that the batteries of the electronics bay become disconnected. We plan on using zip ties to attach the batteries to the board and we will also double check the connectors are all the way on the batteries. Our second most severe failure is that our recovery system fails. We plan on double-checking our rocket to ensure that it is set up correctly and that all electronics are working properly along with ejection charges.
Our third most severe failure is loss in signal via controller. We are going to use a 2.4 GHz radio for long range and less interferences. Our fourth most sever failure is the black powder is not the correct amount. We plan on checking the amount of black powder before we measure it out, the amount that is determined will come

from the black powder charge testing. Igniter doesn't ignite black powder charge is our fifth most sever Failure. We plan on double checking the electrical match is well connected to the terminal blocks and when packing the black powder charge to make sure that there is no air surrounding the match.

3.5.2. **As the program is moving into the operational phase of the Life Cycle, update the listing of personnel hazards, including data demonstrating that safety hazards will still exist after FRR. Include a table which discusses the remaining hazards and the controls that have been put in place to minimize those safety hazards to the greatest extent possible.**

The table that discusses safety hazards are in Appendix A and B.

3.5.3. **Discuss any environmental concerns that remain as the project moves into the operational phase of the life cycle.**

Any environmental concerns are addressed and can be found in Appendix B of this review.

3.6. Payload Integration

3.6.1. **Describe the integration of the payload into the launch vehicle.**

The payload, the UAV, will be in sabot until the upper section ejection charge is fired. The sabot will have a hinge on the side that faces the avionics bay and one closed eye bolt on the side that faces the nose cone. The UAV will fit inside the sabot, the bendable wings will be wrapped around the fuselage. The UAV will remain off until it is released from the sabot via a micro switch. When the upper ejection charge fires the piston will push out the sabot, on ethe sabot is deployed from the upper body tube the sabot will hinge open releasing the sabot. At this time the micro switch will close powering the system. The UAV will now be under a parachute.

3.6.2. **Demonstrate compatibility of elements and show fit at interface dimensions.**

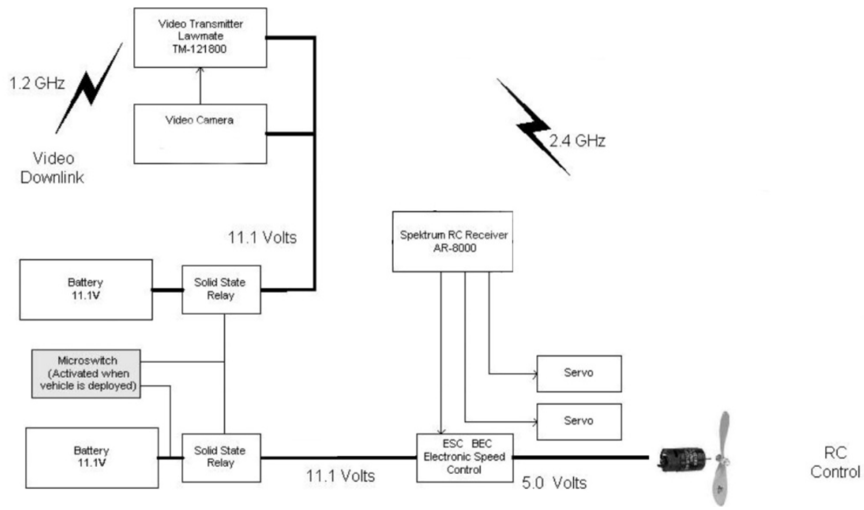
We will be using a carbon fiber body tube and a Carbon Fiber sabot. We are using a Carbon Fiber coupler body tube because of the added strength, it weights less than fiberglass and it is easier to change the diameter of it. In our black powder testing on the scale model rocket we learned that we need a stronger sabot because during the testing the phenolic body tube that made up the piston broke in many areas.

3.6.3. **Describe and justify payload-housing integrity.**

The payload will be housed in a sabot. The sabot is comprised of carbon fiber coupler with bulkheads composited of nine ply plywood and 3/16th fiberglass, the bulkheads are glued on after the coupler was cut in half length wise and then the bulkheads were cut after they were glued in. A hinge was attached to the two sides so that the sabot hinges open to release the payload.

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

When the UAV plane is placed in the sabot the UAV plane would be checked for proper connection of the electronics and micro switch, then it must have the parachute attached then checked for proper deployment. Then the propellor would be folded back leaving the the foldable wing which would be screwed to the top of the fuselage then folded and placed in the sabot securely. The sabot would then be placed in the payload section of the rocket and checked that it is securely attached to the parachute.



4. *Payload Criteria*

4.1. Experiment Concept

4.1.1. Creativity and originality

While deployment of a UAV during a rocket launch has been done before, the concept of a bendable wing UAV is still new. There are many innovative features of our payload, such as deploying said UAV from a rocket, then flying it to 400 feet, and using autopilot to return it to ground level

4.1.2. Uniqueness or significance

The UAV we will deploy has a unique bendable wing design. The bendable UAV wings will be significant because it will allow our project to test the versatility and stability of bendable wings, especially at a variety of altitudes

4.2. Science Value

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

Our UAV payload will eject from the rocket in its sabot at (altitude) by the force of a piston with a black powder charge set off by one of our black powder charges. Upon exiting from the rocket, the sabot will open with the natural outward force of the bendable wing. The sabot will come down on a (36in?) parachute with the nosecone and the UAV will have its own parachute that will have a servo – controlled release mechanism for safety. The UAV will fly autonomously when we command it to from the ground station, flying to GPS waypoints that we will set at the launch site the day before, or simply by the directional commands we preset (i.e. Fly 50m west. Turn left and fly south 80m and drop 25m in altitude.) The UAV will be landed manually for safety reasons

4.2.2. State the mission success criteria.

The Success criteria for out payload is as follows

- The UAV exits the sabot
- The Parachute attached to the UAV opens and the wings on the UAV unfolds
- The UAV detaches from the parachute
- All the Subsystems work by itself and in the system
- The UAV reacts to the Spectrum transmitter during flight.

- The UAV is able to fly and can be switched from autopilot to manual control at 400ft
- The video footage is captured and sent to the ground station.
- The ground stations shows the video footage
- The MediaTek GPS system works and can accurately report where the UAV is located
- The ground station for the GPS unit on the UAV can accurately display where the MediaTek GPS says it is located.
- The UAV is able to fly autonomously and safely.

The UAV lands and all on board equipment is reusable/not damaged.

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

Our logic in determining our payload and its scientific value began with the realization that major universities like MIT had tried a very similar experiment with minimal success. Since we knew that we needed to choose a more difficult experiment, this payload option stood out to us, especially because the UAV could have important real-life (Military) application. We first decided that our payload would be a UAV. The next step was determining the UAV's on-board equipment, mainly the ArduPilot Mega and the camera. Then part of our team designed the rocket that would carry this payload. Then we found out how we were going to make the wings. This process involves making a mold in a CNC machine for our wing based on a 24" bendable wing given to us by graduate students studying similar concepts at the University of Florida in Gainsville. Using that mold, we will make 3 ply carbon fiber wings by putting carbon fiber material in the mold and cooking it in an oven while the carbon fiber and the mold are sealed and compressed by a vacuum pump We are going to investigate the success of the payload by flying the electronics in another RC plane.

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

Our tests will be meaningful mainly because the area conjoining the use of rockets and UAVs is not one that is often tested. Our measurement of a successful flight will be based on the mission criteria, but at first the main focus will be on ability to manually control the UAV in flight safely. Only then can we move on to further mission success criteria, which we will hopefully meet in rapid succession. Variables consist mainly of the steps for electronics integration once we have a control test flight determining flightworthiness. By this we mean that we will first achieve a successful flight with only the necessary electronics like the servos for the rudder and elevator and the motor/ESC. Then our variables will be attachment of a camera, telemetry and the Ardu Pilot, and the other components of the final product. Controls consist of everything else that will stay the same from flight to flight.

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

To begin with, the most relevant data will be taken from our control test, where we will determine our ability to control the UAV in flight with its structural modifications. If we are not able to, then we will continue to modify the UAV until it is flight worthy. Then, in order of importance, we will integrate the following onto our UAV

- Camera with transmitter
- Parachute release mechanism

- Telemetry unit with the Ardupilot(which we must first ground test in an "in the loop" hardware test to make sure all systems function compatibly
  At that point we should be ready to fly the UAV from the rocket.

Accuracy/error analysis will be based on simple success or failure of variables as we integrate them, from which we will determine what is right and wrong and make modifications before carrying on if there are problems. For example, if the camera is not transmitting properly, we will try adjusting our channels or fix any wiring problems with the transmitter to get it working before we move on, ensuring a minimum of complications in our flight analysis at any one time.

4.2.6. Provide detailed experiment process procedures.

The experiment process procedures are as follows:

- Attach carbon fiber wing to the Rifle airframe with long screws and balsa
- Verify security of the wing by feeling for structural integrity of the design with elevated wing.
- Finish building the rudder, elevator, their servo controls
- Try to control the servos and motor by RC control before attempting to fly
- Test fly the UAV
- Add the camera to the bottom of the plane, ensuring a secure attachment as well as the transmitter
- Test before flight that the transmitter's video is being received by our receiver
- Test fly
- Add the parachute release mechanism to the top of the UAV and test that it works
- Do ground testing of Ardupilot system compatibility, just to be sure that it works as it should.
- Fly plane with Ardupilot on board to test again for stability with the added weight
- Add GPS waypoints to the Ardupilot
- Test fly the UAV to make sure the autopilot works as well as our Xbee telemetry system sending us live barometer, artificial horizon, and servo control information simultaneously with our video feed, and the Media Tek GPS System tells us the UAV's location
- When all systems work properly, we launch the UAV from the Rocket, at first under the attached parachute

4.3. Payload Design

4.3.1. Describe the design and construction of the payload and demonstrate that the design meets all mission requirements.

The payload is made with the Rifle's airframe with a balsawood riser to lift the wings to the height where the plane's T- tail went originally. This is a special design to allow the wing of the UAV to use up a maximum circumference in the sabot. This piece of balsa will sit in the body of the plane where the electronics were originally, and electronics will be placed beneath the plane inside of a partial piece of body tube secured to the air frame. We are not yet worried about speed issues or control because our plane will likely be slowed by this feature. The bendable wings will not have control surfaces on them, so we plan to have a rudder and elevator on the back of the plane. Our best option seems to be a cruciform tail that is structurally sound, and made with a servo attachment and a rudder that has a hinge connecting the back of the plane as it came to a 1/8th in. plywood piece.

Our cruciform tail would be cut to fit over the existing upright part of the tail, sticking out in front of the back tail by about an inch. The increased depth of the horizontal stabilizer/ rudder is a modification we are making so that the tail would be one solid piece and have increased surface area, which, while not as responsive as a wider tail and control surfaces, will give us somewhat more control over the UAV in flight.

4.3.1.1. **Structural Elements (such as airframe, bulkheads, attachment hardware, etc.)**

Structural Elements include:

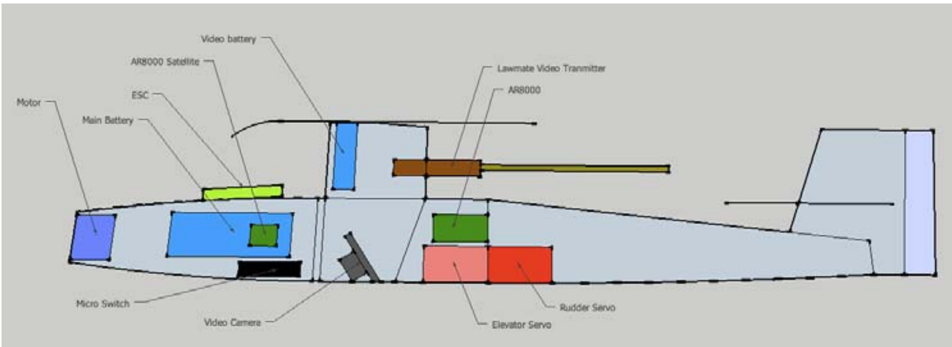
- Rifle airframe
- Carbon fiber wing
- Balsa wood riser for main wing
- 2 long screws for securing the airframe to the balsawood riser and the wing
- 1/8th in. plywood horizontal stabilizer
- Hinges and servo attachments for control surfaces of horizontal stabilizer
- 1/8th in. plywood piece for rudder
- Hinges and servo attachments for rudder
- Body tube cut lengthwise for components under the plane’s main airframe
- Partial balsawood nosecone to cover the front of this body tube
- Servo attachment and eye bolts for the parachute- release mechanism

4.3.1.2. **Electrical Elements (wiring, switches, battery retention, retention of avionics boards, etc.)**

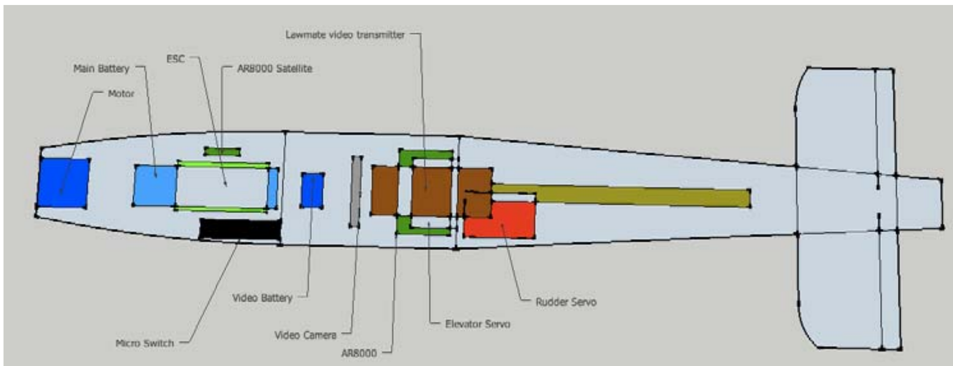
Working from the front to the back of the plane, the Brushless Motor Is secured with 4 screws attaching to the front of the motor to the front of the plane while being placed inside the plane. The Main Battery by velcro and a zip tie around the battery ensuring that the battery does not move around. Behind the battery there is a micro-switch which connects to the video control system and the ESC for the main electronics and the video system. Then the housing unit for the video system lies where the original wing was placed. The housing unit includes the battery for the video system, lawmate transmitter, and video camera. Within the housing unit the video camera is placed on the on the bottom where there is slot open for the camera viewing area. The housing unit for the for the video system has moved the placement of the wing upward in the y direction this overall helps the stability of the plane as it changes the pivot point for the plane higher up therefore creating greater stability. Behind the video unit the lies the elevator servo and the AR8000 receiver, then the rudder servo is behind that next to the Satellite for the AR8000.

4.3.1.3. **Drawings and schematics to describe the design and assembly of the payload**

Side Image



Top Image



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

The AR8000 maintains accuracy down to 3.5V and therefore provides a greater accuracy overall for the project intended. The castle creations ESC provides a 1:1 accuracy that measures every revolution of the motor speed therefore creating a high repeatability measure and comes with a preset calibration from the manufacturer to ensure a high efficiency rating. The servos have a manual calibration for the set value needed as well as a remote software calibration to the greater the zero degree value. The lawmate transmitter offers a 300 to 1100 hPa accuracy.

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

After the Sabot is deployed the UAV becomes active and the batteries are switched on via the micro switch. The UAV ejects the sabot and glides down on its own parachute until 900 feet where the UAV will release the parachute and be controlled via human input if seen safe to fly by the onsite safety advisor. If seen safe the UAV will fly down at a controlled descent until 400 feet where if seen safe by the safety advisor then will be flown at a controlled descent autonomously.

4.3.4. **Specify approach to workmanship as it relates to mission success.**

Each component during the build process was thoroughly check and test for full functionality before flight and test flights, before sent for a real flight. The electronics have been checked before the installation process as well as after the installation to ensure no faulty issues occurred during the shipping process as well as installation process. Every component goes through a full operation check before performing action and flight to ensure that every flight is a successful flight, while learning after every flight. After each performing action and flight the UAV goes through inspection to ensure that there is no damaged parts or faulty retentions that need attention before the next flight and action.

4.3.5. **Discuss the test and verification program.**

The overall purpose of the payload is to safely eject out of the rocket the sabot and be released from its parachute when seen safe. Then the plane would fly down using human input where it would gather data via video feed and relay it back to the ground station live where it can be analyzed.

4.4. Verification

4.4.1. **For each payload requirement, describe how that requirement has been satisfied, and by what method the requirement was verified. Note: Requirements are often satisfied by design features, and requirements are usually verified by one or more of the following methods: analysis, inspection, and test.**

Requirements that the payload must fulfill include: prompt deployment while maintaining accuracy and safety, stable flight to ensure proper video feed and controlled decent and live video for our data gathering. RC input allowing direct feedback to the plane, reusability while having a safe recovery, and design constraints upon the payload must also be taken into account.

4.4.2. **The verification statement for each payload requirement should include results of the analysis, inspection, and/or test which prove that the requirement has been properly verified.**

Payload requirements:

- Quick deployment
  We tested accurate deployment of the payload section by deploying the sabot with an item of similar weight (scale Barbie and lead weights.) We also attached a parachute to Barbie and verified that the sabot worked properly while still being safe.
- Stable flight
  We flew the Wild Hawk with onboard electronics. Also, we changed the Rifle design so that the wing is higher up, which makes the plane more stable.
- Live Video
  Tested live video feed to the ground station
- Human/RC control
  We flew the electronics on the Wild Hawk for verification of proper function. After that, we transferred the electronics to the Rifle.
- The reusability and the safety of the plane include the ability to recover the plane safely to the ground with either flying or by parachute in order to reuse the plane and be able to place the plane back into the rocket and be ready for reuse.
- Design constraints
  Our rocket imposes specific constraints upon the UAV, regarding weight and size of the design. The carbon fiber wing, which bends around the fuselage, had to be scaled up to 30 inches. The weight of the UAV is under 700g.

Item	Weight (g)
Body with Battery	325
Release Mechanism	28
Video Feed + Mounting	185
Wing	135

TOTAL	673

4.5. **Safety and Environment (Payload) (This will describe all concerns, research, and solutions to safety issues related to the payload.)**
For more information relate to safety Appendix C and B. All testing has been accomplished at a safe location where it is free from grass and trees in the surrounding area.

4.6. **Provide a safety and mission assurance analysis. Provide a Failure Modes and Effects Analysis (which can be as simple as a table of failure modes, causes, effects, and mitigations/controls put in place to minimize the occurrence or effect of the hazard or failure). Discuss likelihood and potential consequences for the top 5 to 10 failures (most likely to occur and/or worst consequences).**
Failure modes and effects as well as the mitigations can be found in Appendix C.

4.7. **As the program is moving into the operational phase of the Life Cycle, update the listing of personnel hazards, including data demonstrating that safety hazards that will still exist after FRR. Include a table which discusses the remaining hazards and the controls that have been put in place to minimize those safety hazards to the greatest extent possible.**
Information can be found in Appendix A and C.

4.8. **Discuss any environmental concerns that still exist.**
Any and all environmental concerns related to the payload can be found in Appendix B.

5. Launch Operations Procedures

5.1. Checklist (Provide detailed procedure and check lists for the following (as a minimum).

5.1.1. Recovery preparation

- Make sure the mechanics within the avionics bay are locked into their designated spots
- Replace the used batteries with brand new 9volt Duracell
- Turn the key switch on and once again, make certain that everything is functioning correctly
- Fold the Drogue, main, Upper and UAV parachutes and check the shroud lines and the shock cords.
- Check the deployment bag for the main parachute and the tender descenders.
- Protect drogue and upper parachute from scorching with the use of a Kevlar shield.
- Secure the black powder in their designated areas

5.1.2. Motor preparation

- You must first make sure that your hands are clean and your working station in order to keep unwanted debris out of the engine
- Remove the engine from the packaging material
- Check to 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

5.1.3. Igniter installation

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

5.1.4. Setup on launcher

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

5.1.5. Launch procedure

Our launch procedure can be found in appendix D

5.1.6. Troubleshooting

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

5.1.7. Post flight inspection

The post flight inspection is as follows:

- Check the rocket for damage
  - Fins, fin joint, zipper (probably not in carbon fiber), cracks in body tube and nose cone
- Check the Recovery system for damage
  - Avionics bay electronics – visual inspection for apparent damage
  - parachutes – Burn marks and holes
  - shock cords – burn marks and holes
  - Nomex shields – severe burn marks and holes
  - attachment hardware – stress on hardware and loose components
- Collect Recovery Data
  - Download altimeter data from altimeters (This is a good sign that the electronics still works)

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

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

Our team has made mitigation tables and has taken in considerations all risks. Each team member has signed that they know and will act out all safety concerns. We have a check list to ensure we do not forget anything.

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

Our team has devised a series of tables and lists that discuss the possible risks associated with our launch. The tables and lists can all be found in Appendix C of the Flight Readiness Review. We have also proposed our means for mitigating the possible risks. The tables have been color coded to describe the severity of each risk discussed. Further analysis of risks and mitigations involved in this launch can be found in Appendix C.

5.2.3. Discuss environmental concerns.

All environmental concerns can be found in Appendix B of the Flight Readiness Review. The Appendix contains a table that discusses possible environmental hazards that our rocket may pose and how we plan to mitigate all of those problems.

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

The individuals on the team that are responsible for maintaining the safety, quality and procedures checklists for the rocket are Sjoen and Divya. Our safety officers will follow the Flight Checklist that can be found in Appendix D of this review.

*6. Activity Plan (*Show status of activities and schedule)

6.1. Budget plan (in as much detail as possible)

Our budget is in Appendix G. To pay for this, we are going to target fundraising there are 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 campaign asking for donations. The AIAA Orange County section is also helping us with a grant from Boeing, since they have inside contacts. When we write the articles for the newspapers we will ask for donation as well if we are allowed. We have sold see's candy in the winter and spring seasons.

6.2. Timeline (in as much detail as possible).

The timeline for this year's rocket can be found in Appendix G of this review.

6.3. Educational engagement

- The SLI team was apart of the AIAA booth at Education Alley, which is a part of the AIAA Space 2011 Conference and Exposition. From September 27 through September 29th, hundreds of school classes visit Education Alley on a field trip to learn about space and even hear astronauts speak.
- The SLI team has taken part ROCtober with the Rocketry Organization of California (ROC) on October 8-9, 2011. ROCtober is a youth launch sponsored by the ROC where scouts, 4H, and any youth are invited to Lucerne Dry Lake to learn about and launch rockets. Saturday is "Meet the Mentors and Teams" day where team members will be present in a booth all day to meet younger rocketeers and talk about rocketry, TARC, and SLI. On Sunday team members will be present in a booth to help these younger rocketeers build and prepare to fly their rockets. We did this last year and it was very successful.
- The SLI team has helped Girl Scouts in the Marina Del Ray area build rockets at a large meeting on October 22, 2011 and another build meeting in Long beach

on November 5, 2011. The younger scouts will be at the Marina Del Ray build meeting, while the older scouts will be at the Long Beach build meeting. We did this last year and it was very successful.

- The SLI team has helped at the Girl Scout rocket launch in San Gabriel on November 20, 2011. They will promote rocketry, TARC, and SLI and help with preparation and the launch. This is the launch not only for the girl scouts that attended build meetings above but also for several other rocketry build sessions for the Girl Scouts in other cities. We did this last year and it was very successful
- The SLI team has given a presentation to St. Norbert School on January 5, 2012. St. Norbert School has grades Kindergarten through eight. The team gave a presentation to promote rocketry, TARC, and SLI.
- The SLI team has given a presentation to Montessori School on January 6, 2012. Montessori School has grades first through sixth. The team gave a presentation to promote rocketry, TARC, and SLI.
- The SLI team will have a booth at Youth Expo sometime in April (the dates have yet to be decided for this event). The team members will be promoting TARC, SLI, NAR, AIAA and aerospace at this event. We did this last year and were able to reach a lot of teachers and students.

7. *Conclusion*

The AIAA Orange County section SLI team is very excited to be a part of the Student Launch Initiative program for another year. As the year is coming to an end we hope to see you in Huntsville. Though we had to modify our original payload a little bit we are just as excited about it. This project has helped all the team members develop new and very important skills. These skills will help each team member grow and become better leaders and better workers.

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 Upper Section 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 Upper Section 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 UAV is damaged during the launch	-We will protect the UAV from the launch and from the ejection charge
Electronics in the UAV Fail	-We will test the electronics individually and together in the system before launch.
The Sabot does not Exit the Upper Section Body Tube	-We will use black powder tests to test the sabot to make sure it does deploy. -We will have a backup charge to make sure the sabot (and parachute) exits the upper section body tube.
The UAV does not deploy	-We will test the deployment of the UAV from the sabot this includes ground tests -We will have the backup charge to ensure that the sabot exits the Upper Section.
The UAV deploys at the wrong altitude	We will test the deployment of the UAV from the sabot this includes ground tests -We will have the backup charge to ensure that the sabot exits the Upper Section.
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 devices isn't accurate	-We will test our tracking devices before using it in our vehicle -We will make sure that our tracking devices is accurate so we may retrieve the rocket
Tracking devices doesn't transmit radio waves	-We will check that our tracking devices 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 devices can transmit radio waves
Tracking devices are damaged in launch	- We will place the GPS on the vehicle in Styrofoam which will protect them during launch. The GPS in the Styrofoam will be securely attached to the nylon shock cord. - The GPS on the UAV will be on the UAV in the Sabbot. The sabot will protect the UAV and all the electronics on the UAV during launch.

Appendix B

The table below displays the environmental hazards and how we plan to fix the threat. It also shows the waste materials from our project and how and where we will dispose of them.

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

Appendix C contains the a Table displaying the risks and the probability that it will happen and how much damage it would 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.

5 Risk: The rocket weather cocks Mitigation: the design is not over stable	10 Risk: The Rocket lands in mud Mitigation:Make sure launch site is dry	15 Risk: A parachute misfires Mitigation: double check programming on the altimeter is correct	20 Risk: The tracking device isn't accurate Mitigation: Make sure tracking device works	25 Risk: The UAV hits an object Mitigation: UAV can be switched from autopilot to manual mode Each member in the payload subsection will know how to fly the UAV	30 Risk: The battery(s) of our electronics bay fall out Mitigation: zip tie batteries and double check connection
4 Risk: The engine "chuffs" Mitigation: make sure igniter is all the way in the engine	9 Risk: The rocket lands in a dangerous area mitigation: Launch site is clear of all hazardous materials	14 Risk: electrical matches for the upper section don't have a route to properly fit and get down to the bulkhead near the nosecone Mitigation: Use either groves or a	19 Risk: A servo cable on the UAV catches Mitigation: test the cables before flight and have a large enough opening	24 Risk: A part or battery disconnects Mitigation: use strong connectors and zip ties to secure wires	29 Risk: No recovery system Mitigation: Double-check our rocket is set up correctly

		half moon design			
3 Risk: the rocket struggles off the launch pad Mitigation: use the correct size launch rod	8 Risk: Interference of the lawmate video transmitter and xbee telemetry Mitigation: Make sure that the frequencies do not interfere with one another	13 Risk: a parachute fires at the wrong alititude Mitigation: double check programming on the altimeter is correct	18 Risk: The electronics in the UAV over heat Mitigation: Air vents will be placed for the entering and exiting of air – this will provide enough ventilation	23 Risk: Sheer pins aren't put in place Mitigation: double check the rocket before placing on the launch pad	28 Risk: Loss in signal via controller Mitigation: using a 2.4GHZ radio for long range and less interferences
2 Risk: The rocket folds upon itself Mitigation: body tube and nose cone are fiberglass	7 Risk: The parachute tangles around the UAV Mitigation: Make sure the parachute is correctly folded	12 Risk: The engine explodes Mitigation: make sure there is no defects in engine	17 Risk: The UAV Motor propeller breaks during sabot release Mitigation: A folding propeller will be used – this opens up when the motor powers on.	22 Risk: Tracking device is damaged in launch Mitigation: Make sure Tracking device is secure and is fully encased in the styrofoam	27 Risk: The black powder isnt the correct amount Mitigation: have a backup charge to either "blow it out or blow it up"
1 Risk: rocket misfires Mitigation: check continuity	6 Risk: The Parachute doesn't detach from the UAV Mitigation: Check harnesses and linkages	11 Risk: The Rocket's fins break Mitigation: Use in wall fins	16 Risk: The altimeters aren't set to fire the parachutes Mitigation: double check programming on the altimeter is correct	21 Risk: Tracking device doesn't transmit radio waves Mitigation: double check tracking device is on	26 Risk: The electric match doesn't ignite the black powder Mitigation: 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 severer

4 Risk: Lack of mentors and knowledge Mitigation: Our team has a large group of mentors that are skilled in rocketry, UAVs and Composite Martials	8 Risk: Team members not being familiar with the project Mitigation: our team will give presentations on their sections. We will also review vital information	12 Risk: school holidays not coinciding Mitigation: A large sum of our team have the same holiday schedule	16 Risk: Not raising enough money to cover travel fees Mitigation: Our team plans on holding many fundraising events	20 Risk: Not following the schedule Mitigation: The team will be constantly reminded of the schedule
3 Risk: Large number of team members leave for the holidays Mitigation: Most people are not leaving or if they are it is for a short period of time	7 Risk: Not being recognized publically by media response Mitigation: Local media already has interest in our team	11 Risk: Vehicle receives damage traveling to launch site Mitigation: The vehicle will travel safely inside the car.	15 Risk: Electronics damaged during tests Mitigation: Our team will be precautious during testing	19 Risk: Suppliers not having our items in stock Mitigation:The team will have a backup supplier
2 Risk: Parts are delayed Risk: Bob will pick up parts or order well in advanced	6 Risk: Not completing the educational engagement Mitigation: our team is ready and willing to help the community	10 Risk: Members not completing written sections Mitigation: The team will have many meetings to finished written sections	14 Risk: Not raising enough money to cover the costs Mitigation: Our team plans on holding many fundraising events	18 Risk: Written Document not being completed on time Mitigation: The team will push themselves to finish the written document
1 Risk: Parts are damaged while being delivered Mitigation: Bob will pick up parts or will hope for the best	5 Risk: The wrong part(s) is delivered Mitigation: we will email the vendor to double check our order or Bob will pick up parts	9 Risk: Vehicle getting damaged Mitigation: Vehicle will be stored safely	13 Risk: Miscommunication between members Mitigation: Our team will have frequent meetings throughout the project	17 Risk: Not all members are readily availed to travel to Huntsville Mitigation: 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 all parachutes and set them aside
- Remove the payload bay and remove the sleds assembly from inside the bay
- Remove the UAV and parachute if still in the sabot

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 all shock cords are not frayed or burned (replace if needed)
- Verify that all shock cords are attached securely with quick links to the “U” bolts
- Verify that all Nomex parachute shields are in good shape and not burned through

□ **Payload and recovery**

- Verify that both flight computers are programmed correctly (see manuals – this should have already been completed)

HAZARDOUS MATERIAL – SEE MSDS

- Make certain that the 4 recovery power and shunt switches are in the OFF position
- Remove the old 9VDC batteries and discard correctly. Replace with new batteries and secure with tie wraps.

□ **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 6 wires from the aft (main/drogue) bulkhead assembly through the avionics bay to the upper end (UAV)
- Connect the 6 wires from the aft (main/drogue) bulkhead assembly to the terminal block on the upper end (UAV) – the wires are color coded

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

□ **Test the flight computers**

- Turn ON the Raven flight computer
- Align the payload bay vertically as if it were on the launch pad
- Verify the first set of beeps is 9 (indicating the battery is 9VDC) .
- A low beep repeating every 2 seconds indicates an error
- If there is no error, you will hear a series of 4 beeps: (1st) is the drogue, (2nd) is the UAV, (3rd) is the Main, (4th) is unused – a low beep indicates no continuity and a high beep indicates continuity
- Short out the DROGUE pyro terminals for the Raven and verify you hear 1 high beep as the 1st beep
- Remove the short above and short out the UAV pyro terminals for the Raven and verify you hear 1 high beep as the 2nd beep
- Remove the short above and short out the MAIN pyro terminals for the Raven and verify you hear 1 high beep as the 3rd beep
- Turn OFF the Raven and turn ON the HCX CPU and PYRO
- You should hear two beeps (for JP7 enabled for stage) and no warble (bad battery) followed by a series of four sets of two beeps each (2 – 2 – 2 – 2) (this indicates the HCX is working but there is no continuity)
- Short out the DROGUE pyro terminals for the HCX and verify the series of 4 sets of beeps changes so the second is 1 beep (2 – 1 – 2 – 2) – this indicates continuity
- Remove the short above and short out the UAV terminals for the HCX and verify the series of 4 sets of beeps changes so the third is 1 beep (2 – 2 – 1 – 2) – this indicates continuity.
- Remove the short above and short out the MAIN terminals for the HCX ans verify the series of 4 sets of beeps changes so the fourth is 1 beep (2 – 2 – 2 – 1) – this indicates continuity
- Turn OFF both HCX switches

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 Tender Descender ejection charges**

- Measure the black powder for each **TENDER DESCENDER** main parachute ejection charges
- Twist the wire ends of the e-match together
- Insert an e-match and into the Tender Descender cavity for the ejection charge and tape in place
- Remove the retainer assembly from the Tender Descender if installed
- Pour the black powder into the cavity
- Re-install the retainer assembly
- Make certain the payload power switches are in the OFF position
- Secure the wires to the Tender Descender to the shock cord so they will not be fouled upon deployment
- Untwist the ends of the e-matches and connect to the **TENDER DESCENDER** terminal blocks

□ **Prepare the TWO UAV parachute ejection charges**

- Measure the black powder for each **UAV** parachute ejection charges
- 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 **UAV** terminal blocks
- Secure the glove finger/e-match/black powder so it won't shift during launch

□ **GPS preparation – installed on the shock cord**

- Verify that the battery for both GPS units are 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 GPS into its protective covering
- Secure the GPS and protective covering onto the shock cord (near DROGUE/MAIN and the second near UAV).

□ **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 Deployment bag
- 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

□ **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 **MAIN AND DROGUE** end of the payload bay into the rear body tube (with fins) and secure with four #2 nylon shear screws

□ **Vehicle preparation – UAV parachute**

- Open the **UAV** parachute completely and verify the shroud lines are in good shape and not tangled
- Connect the **UAV** parachute to the shock cord using the swivel
- Carefully fold and roll the **UAV** parachute, rolling the shroud lines ½ way around the parachute, then reversing direction and continue rolling
- Place the **UAV** 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

□ **Vehicle preparation – UAV**

- Verify that the two rechargeable UAV payload batteries are at full charge by measuring with a voltmeter. They should measure at least 11.55VDC and may be as high as 12.6VDC if recently removed from the charger.
- Verify that all connectors are seated correctly
- Connect the parachute and verify that the parachute release mechanism is assembled properly and the parachute can be released
- Roll the wings around the fuselage
- Place the UAV into the Sabot with its parachute and close the sabot assuring that the microswitch holds the power OFF.
- Carefully route the ejection charge wiring through the channel in the sabot.

- Insert the sabot into the forward body tube
- Place the UAV end of the Avionics Bay into the the forward body tube and secure with four #2 nylon shear screws

□ **Vehicle preparation - propulsion**

- Remove the Aerotech engine from its cardboard tube and locate the igniter
- Twist the bare metal ends of the igniter together and set it aside
- Assure the delay is correct
- If using the reloadable motor (preferred is single use) follow these instructions:
    - o Place the delay element on the end of the propulsion grains
    - o Lightly grease the outside of the plastic grain and delay case and insert into the metal casing
    - o 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 Raven recovery electronics (one switch) and verify the following beeps
    - o Nine indicating the battery is at least 9 volts
    - o Three high pitched beeps followed by one low beep indicating continuity of the three electric matches.
    - o If you hear a low pitched beep every 2 seconds, something is wrong.
- Turn the HCX CPU and Pyro switches on (two switches)
- Turn the HCS shut switch ON – this is the final arming of the HCX and verify the following beeps
    - o Two low pitched beeps indicating we are not set for multiple stages or clustering
    - o A pause
    - o A series of two beeps, followed by one beep, followed by one beep, followed by two beeps, a pause, then this series repeats
    - o If you hear any other series of beeps, there is a problem. Consult the beep table on the next page
- Untwist the bare metal ends of the igniter and insert completely into the motor and secure

□ **The vehicle can now be launched**

G-Wiz HCX Flight Computer Beep Code Table

Flight Computer Status Codes Normal Status Code
1. *LED turns on then off.*
2. *The LED turns on and the beeper gives one (JP7 OUT) or two (JP7 IN) low pitch beeps.*
3. *LED turns off.*
4. *There is a half second pause.*

5. *Starting with pyro port one, each pyro port reports status with either a single quick “beep” (for good continuity) or a double “beep” if the port has incomplete continuity.* 6. *A one second pause, and then the sequence repeats from step 2.*	
Low Battery 1. *LED turns on, then off.* 2. *The LED turns on and the beeper gives one (JP7 OUT) or two (JP7 IN) low pitch beeps.* 3. *After a half second pause, the beeper gives a short warble.* 4. *LED turns off.* 5. *There is a half second pause.* 6. *Pyro port report status* 7. *A one second pause, and then the sequence repeats from step 2.*	**SD Card is Unplugged** 1. *The LED turns on then off.* 2. *Long, High pitch beep.* 3. *Long, low pitch beep.* 4. *3/4 second delay.* 5. *Normal status code starts.*
Power-On Self-Test Failure (POST Failure) *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.*	**Break Wire Error** 1. *Short warble.* 2. *A 1 second pause, and then the sequence repeats.* **1.1.1.1.1.1** 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**.

Appendix E

Appendix F

Budget:

Description	Unit Cost	Extended Cost
Scale vehicle and engines		
scale vehicle, engines and engine retainer	160.00	
H size motors (each)	30.00	
Tender Descender HDPE	60.00	
Total Scale Vehicle Cost		**$250.00**
contigent second rocket in case rocket is destroyed	250.00	
Vehicle		
6" diameter body tubes 90"	$274.94	
Couplers	90.00	
Bulk Heads (3 @ $15)	75.00	
Centering rings(3 @ $10)	30.00	
Nosecone	$202.34	
Material for fins	60.00	
Tail cone	100.00	
"U" Bolts, Closed "eye" Bolts	75.00	
metal rods	10.00	
saftey interlock switches (4 @ $5)	20.00	
engine retainer	20.00	
Launch Lugs	7.00	
K1050 54mm engines (3@ 135.99)	408.00	
Total vehicle cost		**$1,372.28**
contingent second rocket in case rocket is destroyed	1,372.28	
Recovery		
Raven Altimeter	155.00	
Download Cable for MAWD	From Last Year	
G-Wiz Partners HCX/50 flight computer	From Last Year	
Download Cable for HCX	From Last Year	
Mini Sd card for HCX 8GB	From Last Year	
Electric Matches - 30 at $1.50 each	From Last Year	
Gun Powder FFFF 1 Lb	From Last Year	
Sheer Pins	4.00	
Batteries	5.00	
Battery Holders	From Last Year	
Terminal Block	From Last Year	
Saftey Switches	From Last Year	
Remove Before Flight Switches 2 at $5.00 each	From Last Year	
Misc (wiring, rubber gloves, cable ties, ect.)	From Last Year	
Main Parachute	From Last Year	
Drogue Parachute	From Last Year	
UAV Parchute	From Last Year	
Copper Screen	34.00	
Total Recovery Cost		**$198.00**
Contingent second recovery just in case first is destroyed	198.00	

Description	Unit Cost	Extended Cost
Payload		
Ardu Pilot Mega Kit w/ GPS	250.00	
X Bee Telemitry Kit	150.00	
Lawmate transmitter	85.00	
Lawmate Reciever	43.99	
Sony Video Camera D3130CDNH	99.99	
Roll/Tilt Camera Mount	19.99	
H5-55 Micro Servo (2) at 12.99 each	25.98	
Blue Lipo 3 cell 3,000 mA a Battery	15.58	
Alpha 480 (1020 kv) OutRunner Brushless Motor	16.70	
Absolute Pressure and Temperature Sensor- BMP085	24.95	
UAV Body	25.00 est	
UAV Wing	75.00 est	
UAV Rudder	50.00 est	
Horizontal Stabilizer	50.00 est	
Vertical Stabilizer	50.00 est	
Folding Propellor	4.46	
Folding Prop Hub	3.95	
Electronic Speed Control	15.00	
Total Payload Cost		**1,005.59**
Contingent second payload just in case first is destroyed	1,005.59	
GPS System		
Beeline GPS (70 cm)	From Last Year	
Byonics Tiny Track 4	From Last Year	
Garmin Legend Handheld GPS Navigator	From Last Year	
Misc (wiring, connectors, etc.)	From Last Year	
Beeline GPS (70 cm, on different frequency)	300.00	
Total Payload Cost		**300**
Contingent GPS Rocket Transmitter (Beeline)	300.00	
Educational Outreach		
Travel to local launches (per vehicle)	50.00	
Travel to educational Events (per vehicle)	25.00	
Printing Costs (flyer, brochures)	100.00	
Rocket Kits	100.00	
Total Educational Outreach		**275.00**
Travel (16 team members, 4 days)		
Travel to Huntsville, Alabama ($450 per person)	7,200.00	
Cost of food ($30 per person)	480.00	
Cost of hotel ($200 per person at 2 per room)	3,200.00	
Total Travel (estimated)		**10,880.00**
Total Estimated Project Expenses		**$17,406.74**

Appendix G

Timeline:

AIAA OC SLI 2011-2012 Project Timeline

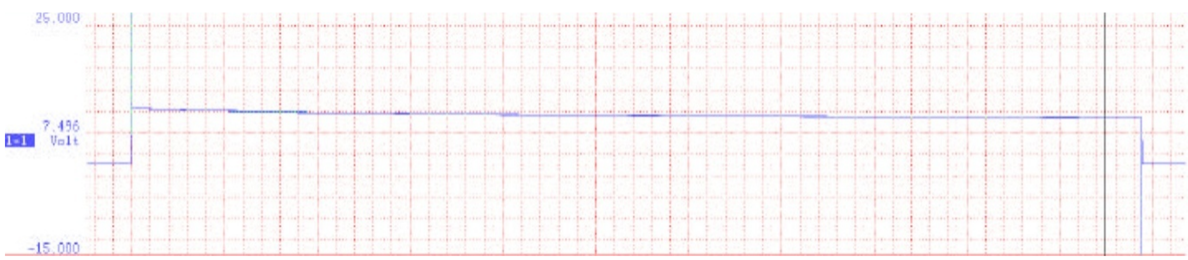
Items	Due Date
Prepare Proposal	
Proposal due for review	9/19/2011
Electronic Proposal Due to NASA	9/19/2011
ROCtober fest (outreach)	10/8-10/9
NASA accepts our proposal	10/17/2011
Girl scouts - present/assist in rockets (outreach)	10/15/2011
SLI team teleconference	10/21/2011
Girl scouts - present/assist in rockets (outreach)	10/29/2011
Establish and create website	
Website presence established	11/9/2011
Girl Scout Launch (outreach)	11/5/2011
More detailed design of full sized rocket	11/28/2011
More detailed design of scientific payload	11/28/2011
Prepare PDR report presentation	11/28/2011
PDR report and presentation on website	11/28/2011
PDR presentation	12/5-12/14
Integrate GPS electronics (vehicle and ground)	12/3-12/17
Build Payload and Recovery Electronics	12/3-12/17
Design Scale Model Rocket	12/3-12/17
Build Scale Model Rocket	12/3-12/17
Test GPS functionality and Range	12/17/2010
Launch Scale Model Rocket	12/17- 1/6
Fly Foam and Glider	12/17-1/6
Prepare CDR report and presentation	12/3-1/22
CDR reports and presentation posted on website	1/23/2012
CDR presentation	2/1-2/10
Finalize design of full size rocket	2/4-3/3
Build full size rocket	2/4-3/3
Build UAV	2/4-3/3
Test Gunpowder for dual deployment	1/28- 2/10
Launch Full Sized Rocket with UAV	2/25- 3/10
Prepare FRR report and presentation	2/11-3/10
FRR reports and presendtation posted on website	3/26/2012
FRR Presentations	4/2-4/11
Travel to Huntsville	4/18/2012
Flight Hardware and Safety Checks	4/19- 4/20
Launch Day	4/21/2012
Prepare Post Launch Assessment Review	4/21-4/28
Post-Launch Assessment Review posted on Web	5/7/2012
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**
    200 pounds 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.

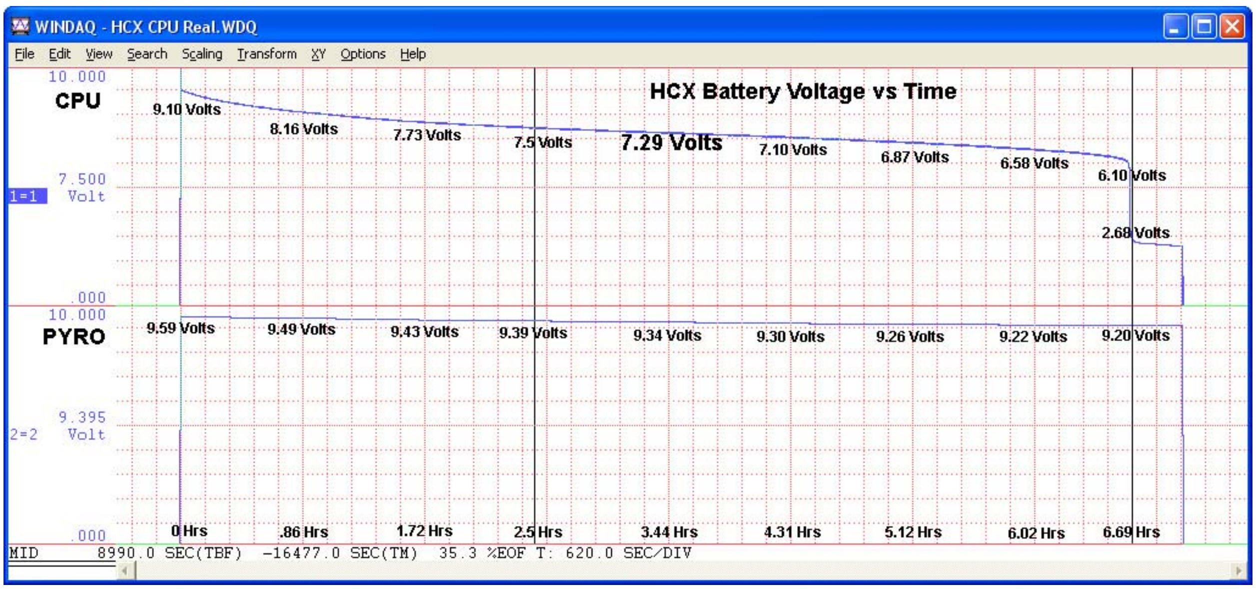
Appendix I

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 - Raven**
   a. **Equipment**
      i. One Raven Flight Computer
      ii. One brand new Duracell MN1604 9V Battery
   b. **Procedure**
      i. Connect Christmas tree bulbs to the Raven in place of electric matches for the Main, Upper 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 Raven and begin recording



   c. **Observation**
   The operating voltage of the Raven flight computer is 3.8 – 16 Volts. The 9 Volt Duracell battery maintained a voltage well above the .86 volt minimum for the duration of the test. The test was discontinued at 12 hours with a battery voltage of approximately 7.5 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. In addition, the Raven has a capacitor across the CPU voltage that assures that the pyro charges will not reset the CPU as long as the input voltage is at least 3.5 volts.
   d. **Conclusion**
   The single Duracell battery will provide more than enough life to power the Raven 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**

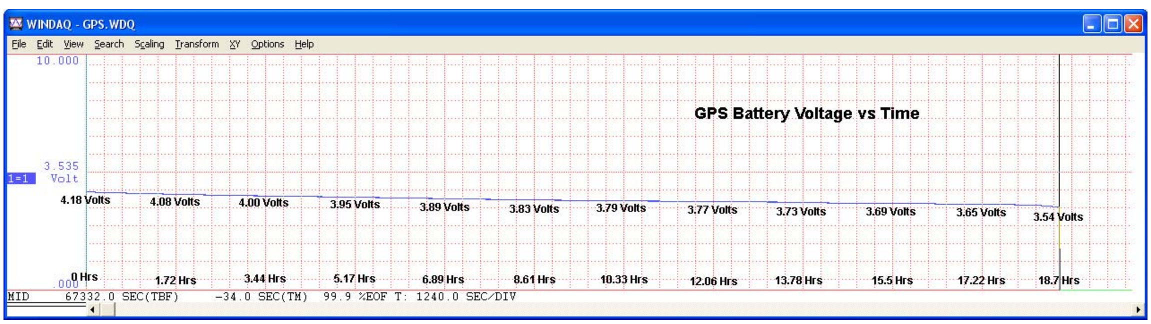
   The operating voltage of the HCX flight computer CPU is 7.5 – 12 Volts and PYRO is 7.5 – 15 Volts. The 9 Volt Duracell battery maintained a voltage of 7.5 volts for 2.5 hours.. . The test was discontinued at 6.69 hours when the CPU battery died; the PYRO battery was still at 9.22 volts.

   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).

Appendix J

5. 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.

Appendix K

6. **Light Testing**
   m. **Equipment**
      i. Raven Featherweight
      ii. HCX G-Wiz Partners
      iii. Christmas Tree Light
      iv. Cables
      v. Computer
   n. **Procedure**
      i. Connect Christmas tree lights to drogue, upper and main terminal blocks on Raven
      ii. Connect battery and connect to computer
      iii. Fire all three Charges
      iv. Run flight simulation
      v. Pull data from flight computer
      vi. Connect Christmas tree lights to drogue, upper and main terminal blocks on HCX
      vii. Connect Batteries and connect to computer
      viii. Fire all three Charges
      ix. Run flight simulation
      x. Pull data from flight computer
   o. **Observation**
      The flight computers reacted and responded how the team predicted they would
   p. **Conclusion**
      Pyro outputs all work meaning our flight computers are not defective.

Appendix L

Mass Statement

Component	Material	Qty	Weight (g)	Total Weight (g)	Length (in)	Width (in)	Thickness (in)	Comments
Vehicle								
Nosecone	Carbon Fiber	1	333	333	24	5	0.028	Fiberglass with gel coat
Foam		1	60	60	22	4	n/a	Foam Fill around removable GPS
GPS Transmitter	PCB, Copper Wire	1	57	57	3	1.25	0.75	6.5" antenna
Battery	LiIon	1	51	51	1.75	1.25	0.25	Power for GPS
Bulkhead	G-10 Fiberglass	3	33	99	n/a	5	0.09	Total 0.27 thick 99g weight
Bulkhead Cover	G-10 Fiberglass	1	8	8	n/a	1.75	0.09	Cover for GPS access
Retaining Nuts	Steel	2	1	2	n/a	#6	n/a	Retention for cover (2g total)
Retaining Screws	Steel	2	1	2	0.5	#6	n/a	Retention for cover (2g total)
"U" Bolt assembly	Steel	1	37	37	2	2.1	0.2	Attachment for shock cord
Upper Body Tube	Carbon Fiber	1	1077	1077	51	5	0.056	Home for sabot and upper section parachute
Upper Section Parachute	Ripstop Nylon	1	405	405	n/a	60	n/a	
Swivel	Steel	1	75	75	3	0.5	n/a	1500 lb test
Shock Cord	Nylon	1	135	135	180		09/16/11	15 ft flat nylon strap 2000lb test
Kevlar Sleeve	Kevlar	1	25	25	36	1	0.015	Protect Shock Cord during eject
Nomex Shield	Nomex	1	53	53	n/a	18	0.015	Protect Parachute during eject
Quick Link	Steel	2	33	66	2	1	125	
Screws	Steel	4	1	4	0.5	#6	n/a	Retention for nose cone
Launch Rail Lugs	Aluminum	1	4	4	1.526	0.75	0.29	
Sabot	Carbon Fiber	1			31	4.75	0.028	will house the UAV during accent
Bulkhead	G-10 Fiberglass	2	33	66	n/a	5	0.06	0.12 total thickness
Bulkhead Shaved	G-10 Fiberglass	2	32	64	n/a	4.8	0.06	
"U" Bolt assembly	Steel	2	37	74	2	2.1	0.2	Attachment for shock cord
Middle Body Tube	Carbon Fiber	1	21	21	1	5	0.056	Over the payload bay
Avionics Bay								
Coupler	Carbon Fiber	1	253	253	12	5	0.028	
Bulkhead	G-10 Fiberglass	2	33	66	n/a	5	0.06	0.12 total thickness
Bulkhead Shaved	G-10 Fiberglass	2	32	64	n/a	4.8	0.06	
Threaded Rod	Steel	2	66	66	13	n/a	0.25	Holds A-Bay together
0.25" tube	Cardboard	2	4	8	10	0.25	n/a	On sled - slides over rod
Captive Nuts	Steel/Nylon	2	2	4	n/a	0.25	n/a	One end of threaded rod
Nuts	Steel	6	3	18	n/a	n/a	n/a	On threaded rod inside of Avionics Bay
Wing Nuts	Steel	2	5	10	n/a	n/a	n/a	Removable end of threaded rod
Small Washer	Steel	4	2	8	n/a	0.62	0.08	Outside - between nut and bulkhead
"U" Bolt Assembly	Steel	2	37	74	2	2.1	0.2	Attachment for shock cord
Electronics Sled	Plywood	2	57	114	11.75	3.625	0.25	Attachment for electronics
Terminal Block (2 wires)	Nylon/Steel	4	4	16	0.67	0.58	0.55	Electrical Contact for e-matches
Rubber Glove Finger End	Nitrile	4	0.5	2	1.8	1	n/a	Containment for black powder
Small zip ties	Nylon	4	0.5	2	4.125	0.1	0.045	Seal glove-black powder-ematch
Black Powder	Gun Powder	2	0.33	0.66	n/a	n/a	n/a	Main Parachute Ejection Charge
Black Powder	Gun Powder	2	2	4	n/a	n/a	n/a	Drogue Parachute Ejection Charge
Black Powder	Gun Powder	2	1.5	3	n/a	n/a	n/a	Upper and Lower section separation Charge
Electric Match	Copper/Pyrogen	6	6	36	6	n/a	n/a	J-Tek

Recovery Electronics								
Raven Computer	PCB	1						
Attachment hardwar	Steel	1	6	6	n/a	n/a	n/a	Standoffs, nuts, screws
HCX Computer	PCB	1	44	44	5.5	1.125	0.75	Accelerometer altitude flight computer
Attachment hardwar	Steel	1	6	6	n/a	n/a	n/a	Standoffs, nuts, screws
9V Batteries	Alkaline-Zinc Mangan	3	46	138	2	1	0.65	1 for MAWD and 2 for HCX
Battery connector	Steel, Plastic, Copper	3	3	9	n/a	n/a	n/a	for 3 9VDC batteries
Wiring	Copper	1	20	20	n/a	n/a	n/a	Multiple lengths of copper wire
Safety Interlock Swit		2	27	34	0.75	0.875	n/a	Externally accessible to arm recovery
Tie Wraps	Nylon	12	2	24	14	0.17	0.05	To secure batteries to sled
Scientific Payload								
Volcano 30A brushless Mo	Metal, plastic	1	110	110	1.42	1.4	n/a	Motor of the UAV
ArduPilot	Metal, plastic	1	15	15	n/a	n/a	n/a	Autopilot for the UAV
Shield/ oil pan	Metal, plastic	1	13	13	n/a	n/a	n/a	
EXI-Servo-D213F	Metal, plastic	2	0.32	0.64	0.89	0.4	0.89	
Sky Lipo 4000mAh 11.1v	Lipo	1	192.4	192.4	4.1	1.34	1	Powers components
Battery 1300 mAh 11.1 25c	Lipo	1	328	328	5.4	1.7	1.1	Powers components
Lawmate Video transmitter	Metal, plastic	1	35	35	2	1	0.53	Transmits live video feed
Xbee Telemetry	Metal plastic	1	3	3	n/a	n/a	n/a	Transmits GPS location and other information
Camera	Metal, plastic	1	48.2	48.2	1.2	1.2	n/a	To capture video in real time
MediaTek GPS	Metal, plastic	1	8	8	0.24	0.24	0.24	To located the UAV
AR700 Reciever	Metal, plastic	1	14	14	1.85	1	0.62	To control the UAV manuals via Spektrum DX7
Wiring	Copper	1	20	20	n/a	n/a	n/a	To interconnect diagrams
VEHICLE AND PAYLOAD				6228.5				219.70385986 Ounces
Propulsion								
Aerotech k1050 Motor	APCP, Plastic	1	2128	2128	24	2	n/1	Burnout = 766g
PROPULSION TOTAL				2128				
GRAND TOTAL				8356.5				