AIAA Orange County Section

Student Launch Initiative 2011-2012

Critical Design 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

January 25, 2012

Image From: XPRS.ORG

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1. Summary of CDR Report

1.1. Team Summary

1.1.1. Team Name

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

1.1.2. Team Location

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

1.1.3. Team Officials/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 six 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 the 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 Since PDR

2.1. Changes Made to Vehicle Criteria

Based upon the results of the scale vehicle testing as well as comments from the PDR, we have made several changes to the vehicle

- The sabot is now ejected from the nose cone end of the top section of the rocket, rather than the avionics by. This was done to avoid the sabot from colliding with the avionics bay during ejection
- A piston was added to help push out the sabot. Too much of the ejection gases were leaking through the sabot making it difficult to push out.

- The vehicle has grown to 125 inches in length to make room for the piston.
- Additional length was added to the shock cords
- A second battery was added to the Raven flight computer, which separates the CPU from the Pyro battery to assure the Raven CPU does not get reset when the pyros fire. The Raven also has a capacitor to sustain CPU power for a few seconds even if the battery is removed.

2.2. Changes Made to Payload Criteria

The UAV Payload is essentially unchanged although additional information has been added.

2.3. Changes Made to Activity Plan

We have not made many changes in our activity plan. We have added two outreach events; these are the presentations to St. Norbert and Montessori Schools. We also have updated the Outreach events that have passed.

3. Vehicle Criteria

3.1. Design and Verification of Launch Vehicle

3.1.1. Mission Statement, Requirements, and Mission Success Criteria

We, the OC Rocketeers, will construct and launch a rocket that will reach a mile high while deploying an UAV. The rocket will include a dual deploy recovery and will remain reusable.

The vehicle Requirements is as follows:

Our team will design build and fly a rocket that has a dual deployment recovery system. It will reach an altitude of a mile at apogee. The data from the altimeters will be collected for the duration of the launch and reviewed after the vehicle has returned. The payload, the UAV, will deploy from the sabot at the second event and will detach from the parachute, be able to manually fly and will be able to fly to 3D way points in autopilot mode. The Rocket will remain reusable after the launch. The tracking system will work and enable the team to retrieve the rocket after each launch. The rocket will not exceed a mile, and will not land past 2,500 feet from the launch pad. The rocket will not accelerate faster than Mach1, and will not pose a safety threat to spectators or any other personnel.

The vehicle Criteria is as follows:

Our team's rocket will be designed and built by the team. It will be flown and reach a mile high. The recovery system will use dual deployment and will work successfully. For the payload 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 manually and on autopilot. 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.

3.1.2. Major Milestone Schedule (project initiation, design, manufacturing, verification, operations and major reviews)

- October 19, 2011Proposal Accepted
- October 21, 2011 Trail Web Ex Conference
- October 22, 2011 Girl Scout Workshop
- October 23, 2011 SLI Meeting (start writing PDR)
- October 23 – November 23, 2011 Work on PDR
- November 4, 2011 Website Presence Established
- November 5, 2011 Girl Scout Workshop
- November 20, 2011 Girl Scout Launch

- November 23, 2011 PDR Subsections Finished
- November 24 – 27, 2011 Proof reading of the PDR
- November 28, 2011 PDR Submitted
- December 5 - 14, 2011 WebEx PDR Presentation
- December 3 - 17 , 2011 Design Scale Model
- December 10, 2011 Order Parts
- December 11, 2011 Will Call
- December 3-17 , 2011 Build Scale Model
- December 16 - Ongoing Testing
- January 5, 2012 Presentation to St. Norbert School
- January 6, 2012 Presentation to Montessori School
- January 7 , 2012 Launch Scale Model
- January 14, 2012 Launch Sale Model
- January 23, 2012 CDR Submitted
- January 24 - 31 , 2012 Finalize Full Scale Design
- February 1 , 2012 Order Parts
- February 2, 2012 Will Call
- February 1 – 10, 2012 WebEx CDR presentations
- February 11- 25 , 2012 Build Full Scale Rocket
- March 10, 2012 Launch Full Scale Rocket
- March 26, 2012 FRR Due
- April 2 – 11 , 2012 WebEx FRR Presentation
- April 18, 2012 Travel to Huntsville
- April 19 – 20 , 2012 Flight Hardware and Safety Checks
- April 21, 2012 Launch Day
- May 7, 2012 PLAR Submitted

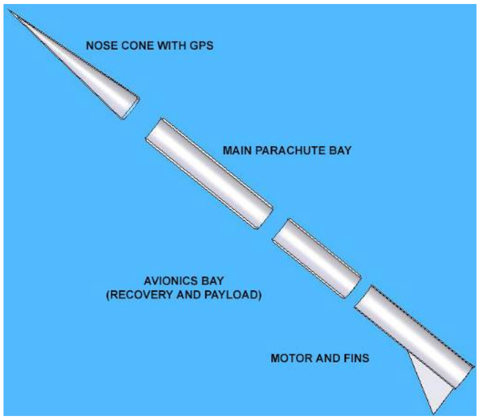
3.1.3. Review at System Level

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

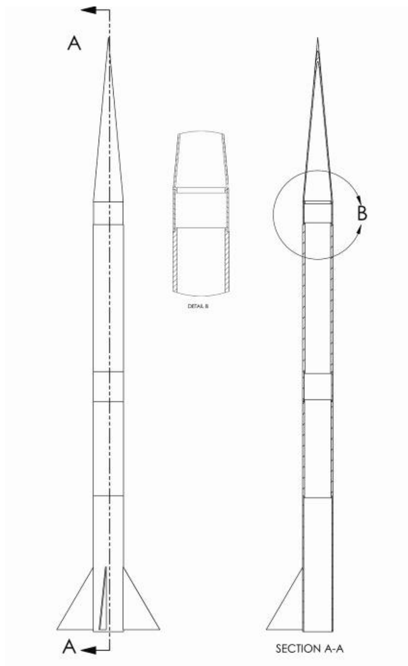
3.1.3.1. Vehicle

The vehicle is the rocket itself, it contains several sub systems: payload, recovery, and propulsion. All of these subsystems work together to create and form our project, without all of these working together our project would be incomplete and faulty. The payload was our team choice, we decide to launch a UAV from our Rocket that will fly around via RC down to 400 feet, and then fly to different way points and land autonomously. The recovery is one of the most important parts of rocket, if this is faulty the team could lose all electronics and data, the flight would be inconclusive, tragic, and poses a safety threat to the spectators. All of the recovery electronics will be located in the electronics bay, and our UAV will be launched via a sabot in the upper section of our rocket. The propulsion is the rocket engine. The team decided to use a K1050 motor from Aerotech.

3.1.3.2. Design Detail



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 will be a triple thickness bulkhead at the top of the nosecone shoulder for the shock cord to attach to. The nosecone will be attached to the upper section via 3 #2 sheer pins. Next is the 56 inch upper section that will hold our 31 inch sabot, 5 inch piston and 36 inch upper section parachute. The Sabot will be 31 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 will be a sealed I bolt on top side of the sabot to force the sabot open when deployed. There will be 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 will be attached to this shock cord. Next is the avionics bay. It is a 12 inch section that will house 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 will house the motor mount, motor, drogue parachute, main parachute, tender descended, GPS and the nylon shock cord that the GPS and the drogue and main parachutes will be attached to. All of the outer body tubes and the coupler around the middle of the payload bay will have a 5 inch outside diameter. The inside diameter of all body tubes and the outside diameter of the payload bay will be 4.9920 inches. The outside diameter of the shoulder on the nosecone will be 4.875 inches. Lastly is the tail cone. It will be made out of a nose cone and some centering rings and accept a 54mm motor. 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 flush with the bottom of the lower bay. The fins will have a root chord length of 10.3333 inches,



tip chord length of 8 inches, a sweep length of 7.4427 inches, a sweep angle of 53.285°, a semi span of 5.5 inches, and they will be 0.1875 inches thick. The fins will be made out of a G10 fiberglass frame with a light weight foam core all covered in a carbon fiber laminate. All exposed pieces of the Rocket will be made out of carbon fiber. The recovery section including the electronics and parachutes are covered in detail in section 3.2.

Component	Material	Qty	Weight (grams)	Total Weight (grams)	Length (inches)	Width (inches)	Thickness (inches)
Vehicle							
Nosecone	Carbon Fiber	1	360	360	24	5	0.028
Upper Body Tube	Carbon Fiber	1	1003	1003	56	5	0.056
Bulkhead	G-10 Fiberglass	1	114	114	n/a	5	0.18
Sabot							
Bulkhead	G-10 Fiberglass	2	114	288	n/a	5	.18
Coupler	Carbon Fiber	1	211	211	31	5	.028
Middle Body Tube	Carbon Fiber	1	21	21	2	5	0.056
Avionics Bay							
Coupler	Carbon Fiber	1	253	253	12	5	0.028
Bulkhead	G-10 Fiberglass	2	114	228	n/a	5	0.18
Lower Body Tube	Carbon Fiber	1	818	818	38.25	5	0.056
Fins	Carbon Fiber, G-10 Fiberglass, Balsa	3	72	217	10.333	n/a	0.06
Launch Rail Lug	Aluminum	2	4	4	1.526	0.75	0.29
Tail cone assembly	Polystyrene	1	75	75	1.25	5	n/a
Motor Retention	Aluminum	1	42	42	1	2.6	0.09
Propulsion							
Aerotech K1050 Motor	APCP, Plastic	1	2128	2128	25	2	n/a

The final rocket is custom designed to our needs and has the following characteristics:

- Length: 124.98 inches
- Diameter: 5.02 inches
- Span: 16.02 inches
- Mass: 342 ounces
- Center of Gravity: 78.27 inches behind the nose tip
- Center of Pressure: 94.03 inches behind the nose tip
- Stability Margin: 3.15

To select a motor we needed to have all of the details of components for the rocket (major vehicle components are in the table above, for complete list see appendix D). The total final weight from our table was 258 ounces, or 20.8 pounds (this varied as we loaded different motors). This corresponded closely with the weight of the individual components entered into Rocksim using their data base. We selected several different motors made by Cesaroni and Aerotech, since both manufacturers have a reputation for being consistent and reliable. Our target altitude was just under 1 mile. From the simulations, the K1050 single use motor carried our rocket to 5,177 feet – just short of the needed 5,280 feet (better to err on the low side of 1 mile) with a burn time of 2.3 seconds. Specifications of this motor as well as the thrust curve are in Appendix E.

Engine	Total Impulse (Ns)	Total Mass (g)	Max Altitude (ft)	Max Velocity (ft/s)	Max Accel (ft/s/s)
K1 440-WT	2368.3	1893g	4935	778	741
K660	2437.5	1949g	5100	683	351
K590-DT	2415	1994g	5122	637	608
K1130-BB	2550.7	2574g	5126	754	482
K1050-SU	2530.0	2128g	5178	766	458

If the design should need to change requiring less thrust, engines are available (e.g. the K590, K660, and k1440) as shown in the table above.

However, if more thrust is required, the only option is the K1130 (though is gives a lower altitude). This means that more than likely we would have to modify our design to gain altitude. This motor selection also keeps the vehicle from exceeding mach1, another requirement.

3.1.3.3. Launch System

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

3.1.3.4. Tracking System

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

3.1.3.5. Retrieval

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

3.1.3.6. Data Analysis

Data Analysis is when the team collects their data from the flight. We would collect the data from both flight computers to see the curve of the flight, when the ejection charges were fired and to see what height they acquired. For this process we would need the electronic device we were taking information from, a computer to download the information to, and a download cable so we could download the information.

3.1.3.7. System Performance and Characteristics

We expect all systems to work together so that our project is successful. All of our major systems include: vehicle, launch, tracking, retrieval, and data analysis. We expect the vehicle to work well with all of its subsystems. The vehicle contains the subsystems: recovery, payload, and propulsion. The recovery has to fire a total of six charges, two for the drogue, two for the UAV, and two for the main at Apogee, 1000 feet, and 900 feet respectively. The recovery should return the rocket safely to the ground, within the 2,500 feet range. The UAV will launch and land successfully. The propulsion will launch the rocket to a total of mile high without exceeding it. The motor that will be used is a K1050 by Aerotech. The launch subsystem will launch the rocket on a rail guide 200 feet away from the launch controller with a safety interlock system. The rocket will reach a safe speed before leaving the launch pad. Tracking the rocket is essential because it enables us to record the data from the launch. The Big Red Bee, Yaesu VX-6R Transceiver, Bionics Tiny Track 4, and Garmin E-Trex Vista will work together to give us an accurate location. We will retrieve the rocket using the tracking system. We will have a group of team members use the tracking system to find the rocket and return it. After the rocket is returned the electronics will be plugged into a computer and the data will be uploaded. After that the team will for analyze the data to reach a conclusion regarding the effect of the flight

3.1.3.8. Evaluation and Metrics

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

3.1.4. Final Drawings and specifications

All drawings and specifications are listed in section 3.1.18 “Drawings of Launch Vehicle, Subsystems, and Major Components”.

3.1.5. Final analysis and model results, anchored to test data

RockSim and our ground testing influenced the design of the rocket as detailed in section 3.2.3. The final design was further proven through simulations through rocksim.

3.1.6. Test Description and results

The tests that we conducted followed all aspects of the rocket here are tests that pertained to the rocket, recovery tests are mentioned in section 3.3.5.

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

3.1.7. Final Motor Selection

The motor we have selected in an Aerotech K-1050. Our simulations show that with this motor our rocket will reach 5,246 Feet.

3.1.8. Demonstrate that the design can meet all system level functional requirements. For each requirement state the design feature that satisfies that requirement and how that requirement has been or will be verified

Our design is stable and will reach almost a mile high with the Aerotech K-1050, we do not want to exceed a mile. The rocket can be launched safely because it is stable and has a recovery system. There will be a GPS Transceivers on both the upper and the sustainer section on the rocket, the rocket will separate and be under two main parachutes. The Avionics bay will have a coat of MG Chemicals SuperShield Conductive Coating 841 to minimize RF Interference. The rocket will have a dual deployment dual redundant recovery system. The recovery system will use the HCX G-Wiz Partners flight computer as the main altimeter and the Raven Flight Computer as the backup altimeter. These altimeters will eject the drogue, upper and main parachutes. The team members will be able to retrieve the rocket. The team will then collect data from both flight computers by disassembling the avionics bay. The payload will be an engineering payload and will send data down by telemetry.

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

The rocket has to be well assembled so that it can survive the flight and be flown again. We will be using West System Epoxy to construct the rocket and we will also be using 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.

3.1.10. Discuss planned additional component, functional or static testing

- Scale Model Flight
- Test payload battery life
- Test avionics equipment in scale
- Launch scale with all subsystems
- Black powder testing in full scale rocket
- Avionics testing in full scale
- Launch of full scale with all subsystems

3.1.11. Status and plans of remaining manufacturing and assembly

- Build UAV
    - Fabricate wing
    - Build body
    - Construct electronics
- Build full scale rocket
    - Fabricate fins and bulkheads

- Build main air frame
- Build avionics systems

3.1.12. Discuss Integrity of design

Our design was constructed on Rocksim and will be verified with the scale model launch. It has met all of our safety requirements and will be built using tried and true construction techniques we have used for multiple years. We also have mentors to help us where we run into problems, that have up to 50 years of model rocketry experience. We foresee no problems in the construction of our vehicle, but are prepared for any that may manifest during our work.

3.1.13. Suitability of shape and fin style for mission

We chose these fins based off of a previous rocket design and scaled them up for a 5 inch rocket. Considering that they gave us the needed stability margin, we decided to keep the design. They will also had the edges sanded into a point to allow for minimal air resistance during the flight.

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

Our Rocket is made with a carbon fiber nosecone, body tube, and couplers, with fiberglass bulkheads, centering rings, and fins. The eye bolts that hold the shock cord to the rest of the rocket is metal, along with the motor retainer and the rods for the sled in the Avionics bay. The sled itself is wood. The shock cord we will be using is 1 inch Kevlar.

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

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

- Use only commercial adhesives such as West System Epoxy for the airframe
- Carbon Fiber and Fiberglass needs to be well roughed up – using 60 grit sandpaper to get epoxy to adhere properly.
- Carbon Fiber and Fiberglass needs to be cleaned well using alcohol before applying epoxy
- All joints such as centering rings, bulkheads, and fins will have fillets in addition to the adhesive joining the two together
- Eyebolts should be attached securely with a washer between the bulkhead and the nut to distribute the pressure over a larger area
- Shock cords should be well secured at both ends using metal eyebolts or “U” bolts.
- Nuts from eyebolts and “U” bolts should either have Loctite securing them or be epoxied
- Nylon shock cord should be attached to the eyebolt or “U” bolt with a quick link or shackle of approximately the same material

diameter as the eyebolt to give a secure connection and allow for service

- All removable pieces of the vehicle that do not separate in flight should be secured using metal machine screws
- All removable pieces of the vehicle that do separate in flight should be secured using shear pins, using 2 to 4 #2 nylon screws
- Avionics bays will endure a high level of tension when the ejection charges fire. The bay should have load bearing bolts, such as ¼" threaded rods that secure the end caps. Load will then be transferred from the shock cord, to the eye bolt, to the bulkhead end cap on the avionics bay, to the threaded rods through to the other end cap and eyebolt rather then apply pressure to pull the avionics bay apart
- The highest load path is from the engine/fin body section, through the shock cord to its other attachment point (usually the avionics bay). The avionics bay must withstand the same tension across its length. On the other side of the avionics bay the load continues through attachment to the avionics bay (usually an eye bolt or U bolt), through the shock cord, to the final attachment point near the nose cone (another eye or U bolt).
- Fins should be carefully aligned using a fin jig to hold them in place while the epoxy is setting.

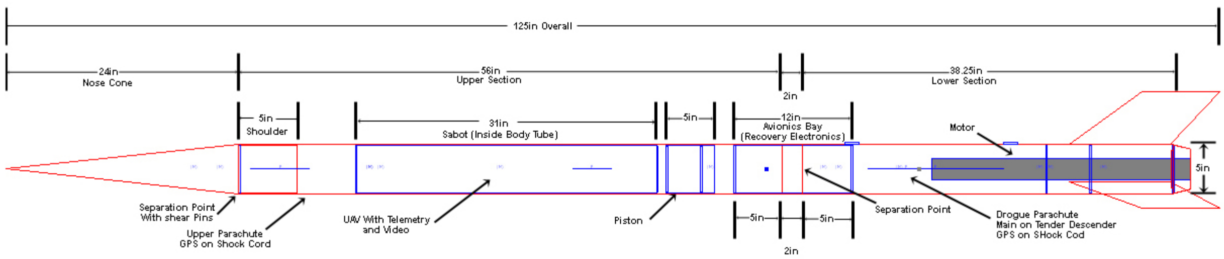
3.1.16. Sufficient motor mounting and retention

Our team will be using three centering rings for the motor mount, and will be using west system epoxy for the assembly. A motor retainer will be mounted on the end of the motor mount to ensure the motor does not leave the rocket. The motor retention we will be using is an Aero Pack 54 mm Quick-Change Motor retainer

3.1.17. Status of verification

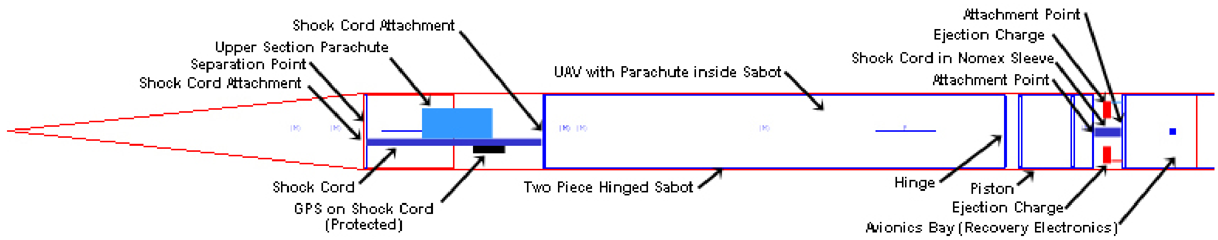
The rocket was simulated multiple times with a variety of engine and launch conditions and prove stable. The launch of the scale model vehicle was very straight and proved that our design was stable across all changed parameters. We have ran the flight simulations provided by the manufacturer on our flight hardware and validated that all pyro events triggered when expected.

3.1.18. Drawings of launch vehicle, subsystems and major components

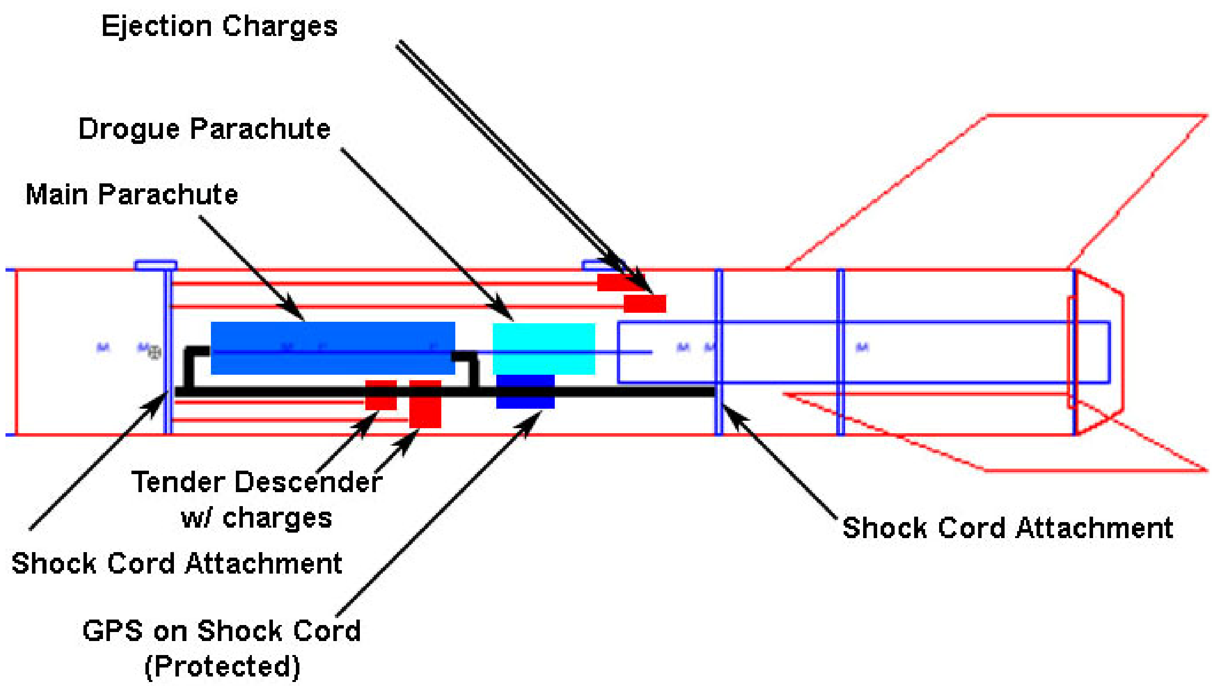


Parameter	Details
Length/Diameter	125 inches / 5 inches
Material	Carbon Fiber
Shock Cord	1” Tubular Nylon
Center of Pressure/Center of Gravity	94”/78.3”behind nose tip
Stability Margin	3.14
Launch System / Exit Velocity	1” 8ft Rail / 80.4 ft/s
Liftoff Weight	20.8 lbs
Descent Weight	17.8 lbs
Preferred Motor	Aerotech K1050
Thrust to weight ratio	11.35 (1050 Newtons average thrust = 236 lbs / 20.8 lb vehicle)
Maximum ascent velocity	748.62 ft/s
Maximum acceleration	445.61 ft/s/s
Peak Altitude	5244 ft
Drogue – Descent rate	77.75 ft/s
Lower section under Main – Descent rate (Kinetic energy at ground level)	17.4 ft/s (48 ftlb-force)
Upper section under its own chute – descent rate (Kinetic energy at ground level)	17.2 ft/s (24.4 ftlb-force)

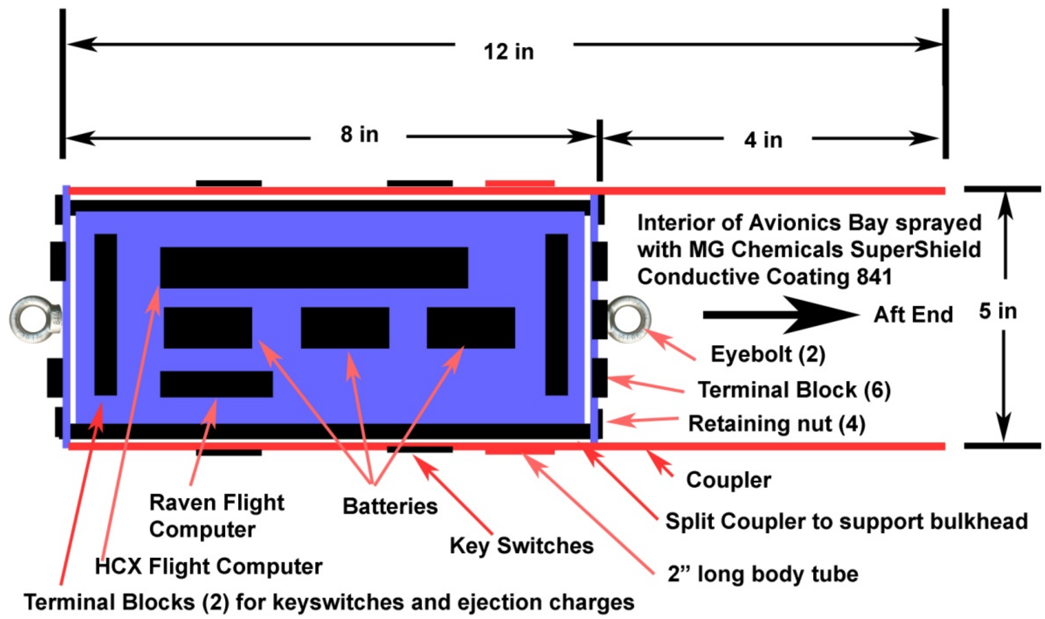
UAV on its own parachute – descent rate (Kinetic energy at ground level if UAV is not released)	18.5 ft/s (5.33 ftlb-force)



Parameter	**Details**
Nose Cone	Carbon Fiber 24" long
Body Tube	Carbon fiber 5" diameter x 56" long
Bulkhead	½" plywood with fiberglass on both faces 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 + 6 ft (across Tender Descender)
Rear Cavity	12.75” x 5” diameter for ejection charge, shock cord, GPS, and forward section parachute (38.75 + 3” for tailcone + 4” inside avionics bay – 6” for avionics bay overlap - 27” for motor)
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 1" long
Bulkhead	½" plywood with fiberglass on both faces with closed eye 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

3.1.19. Include a Mass Statement. Discuss estimated mass of the final design and its subsystems and components.

The mass statement of the rocket is in Appendix L. The estimated weight of the rocket is 21.39 pounds. We validated the weight of each component in rocksim to make certain that the weight matched the anticipated weight of that component. We anticipate zero weight growth.

3.1.20. Discuss the safety and failure analysis

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

3.2. Subscale Flight Results

3.2.1. Include actual flight data from onboard computers, if available.

The scale rocket was launched on January 14, 2012 at the ROC launch at Lucerne Dry Lake. This first launch was to check stability of the rocket; no electronics were flown. The electronics have been verified functional using the simulated flights supplied with the software with each flight computer. Christmas tree lights were used to verify when each ematch should fire. In addition, multiple ground tests of the black powder ejection charges were done. One additional flight is planned before the full scale launch to validate the entire system functions together properly in an actual flight

3.2.2. Compare predicted flight model to the actual flight data. Discuss results

The observed flight stability was exactly as predicted. That predicted flight stability was the result of simulations in RockSim. We do not have exact altitude attained since no electronics were included. However, the rocket appeared to exceed the predicted altitude in RockSim

3.2.3. Discuss how the subscale flight data has impacted the design of the full-scale launch vehicle

Testing before the subscale flight impacted the design of the full-scale launch vehicle much more than the actual flight itself. Extra testing was performed to make certain that we could push out the Sabot and deploy the UAV (inside the Sabot was a weighted Barbie on a parachute that simulated the weight of the UAV). The black powder testing led to design changes through the following discoveries:

- Forces on the sabot are substantial leading to a change in material
- Ejecting the sabot towards the avionics bay can contribute to damage through collision leading to ejection of the sabot in the direction of the nose cone
- Increasing the black powder charge with a lot of leakage will result in damage before total deployment is reached leading to the use of a piston for Sabot deployment to minimize gas leakage.
- The piston and sabot need to be very strong to avoid damage – we destroyed the phenolic sabot and piston. The final full scale will be made from fiberglass
- There is no need to substantially increase the black powder charge when using a piston since it seals well and makes very efficient use of the increased pressure. Too much pressure can lead to damage

Keep the pressure distributed evenly on contacting parts – an eyebold pushing on a bulkhead can be catastrophic. The final design has flat surface against flat surface, or soft materials (e.g. shock cords) in between.

3.3. Recovery Subsystem

3.3.1. Describe parachute, harnesses, bulkheads and attachment hardware

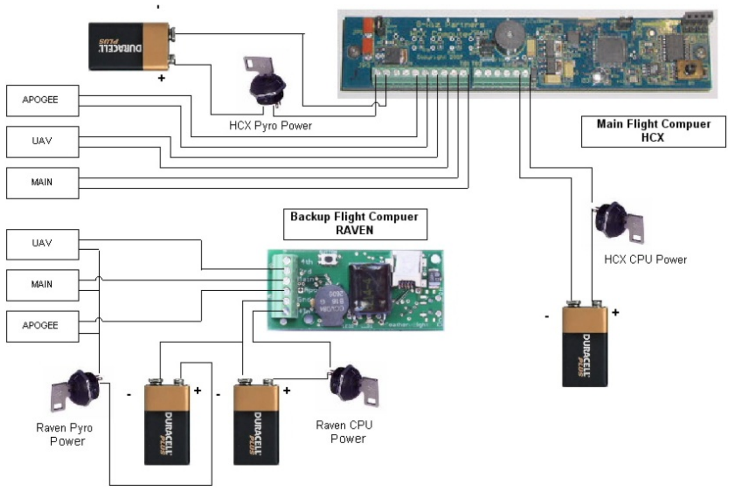
All Kevlar shock cords will be attached using quick links. For the upper section, we will have a bulkhead in the nose cone with a “U” bolt a quick link will attach the one inch Kevlar shock cord to the “U” bolt. The second attachment point for the Upper section is on the sabot. The sabot will have one eye bolt, the one inch Kevlar shock cord will be attached to the eyebolt with a quick link. These two attachment points will hold the nose cone and the upper section together. A 36 inch parachute will be attached to the shock cord roughly one third up from the nose cone. The third connection point will be on the five inch piston. The piston will have a bulkhead with a “U” bolt on one side a quick link will be used to attach one inch Kevlar shock cord. The fourth attachment point will be on the avionics bay, the avionics bay will have an eyebolt a quick link will attach the one inch Kevlar shock cord. These two attachment point will hold the piston to the avionics.

The sustainer section has both the drogue, , and the main, , parachutes. The main will be located closer to the avionics bay, and the drogue further away. The first attachment point will be on the avionics bay. The avionics bay will have an eye bolt and will use a quick link to attach the one inch Kevlar shock cord. The second attachment point will be a quick link attached to a smaller quick link which is attached to a tender Descender. Attached to the quick link which is attached to the smaller which is attached to a tender Descender is a one inch Kevlar shock cord. This shock cord will attach to the parachute bag, the parachute’s shroud lines and attached to the second tender descender. The first descender will be attached to the second tender descender (each tender descender has a smaller quick link on both ends)by the smaller quick link, the smaller quick link on the first tender descender will be attached to the smaller quick link on the second tender decender. The second smaller quick link on the second tender descenders will be attached to a larger quick link which will be two one inch Kevlar shock cords, the one attached to the shroud lines, parachute bag and the first tender descenders , and one attached to the “U” bolt on the centering ring on the motor mount. The drogue parchute will be 24 inches and the main parachute will be 84 inches.

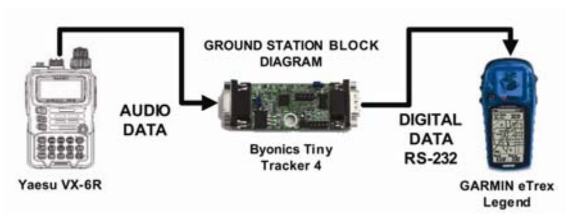
3.3.2. Discuss electrical components and how they will work together to safely recover the launch vehicle

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 sheer 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.

3.3.3. Include drawings/sketches, block diagrams and electrical schematics



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.

3.3.4. Discuss the kinetic energy at significant phases of the mission especially at landing

In order to find the kinetic energy at the significant phases of the mission, which consists of the drogue deployment, separation of sections, and main parachute deployment, we converted the kinetic energy equation to match the units in which we work with.

KE= (.5)(m*.434)(v*.3050)(.738)

M= the mass in pounds

V= the velocity in feet per second

KE= the kinetic energy in foot pound force

At apogee, in the most ideal condition, the kinetic energy would be zero because there would be no velocity of the rocket.

During the descent from the 5280 feet to 1000 feet, the rocket will remain a single mass, so the **mass** of the rocket would be 17.812 pounds. The descent velocity of the rocket would e 77.75 feet per second.

$KE_{5280\text{-}1000}$=(.5)(17.812*.434)(77.75*.3050)^2(.738)=1604.092

Once the rocket reaches a 1000 feet, the UAV is deployed and the rocket separates into the upper and lower section.

KE_{UAV}=(.5)(1*.434)(18.42*.3050)^2(.738)=5.055

KE_{Upper}=(.5)(5.499*.434)(17.26*.3050)^2(.738)=24.405

KE_{Lower}=(.5)(10.629*.434)(.3050*61)^2(.738)=588.980

Once the lower section reaches 850 feet, the main parachute will deploy. The UAV's and upper section's descent velocities will remain the same.

$KE_{Lower(850)}$=(.5)(10.625*.434)(17.43*.3050)^2(.738)=48.088

3.3.5. Discuss test results

Black Powder

Procedure can be found in Appendix H

Located	Amt.(g)	Successful	
Scale – Upper	.3	No	Need more gunpowder
Scale – Upper	1.1	No	Need more gunpowder
Scale – Upper	1.25	No	Need more gunpowder
Scale – Upper	1.5	No	Need more gunpowder
Scale – Upper	1.75	No	Do we need a piston?
Scale – Upper	2.00	No	We need a piston, stronger sabot and less gunpowder. We need to push the sabot out the nose
Scale – Upper w/out parachute	1.1	Yes	Add parachute
Scale – Upper w/ parachute	1.1	No	Increase 25 PSI
Scale – Upper w/parachute	1.25	Yes	☺
Scale – Lower	1.1	No	Seal off the motor casing better
Scale - Lower	1.1	No	Increase 25 PSI
Scale - Lower			
Full – Upper	1.5 grams	Rocket not completed	
Full – Drogue	2 grams	Rocket not completed	

Light Simulation

Procedure can be found in Appendix L

Electronic	Successful
Raven Flight Computer	Yes
HCX G-Wiz Partners	Yes

3.3.6. Discuss safety and failure analysis

The failure modes can be found in Appendix A.

3.4. Mission Performance Predictions

3.4.1. State the Mission Performance Criteria

Our team's rocket will be designed and built by the team. It will be flown and reach a mile high. The recovery system will use dual deployment and will work successfully. 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 manually and on autopilot. 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.

3.4.2. Show flights profile simulations, altitude predictions with final vehicle designs, weights, and actual motor thrust curve

	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
51	50		[K1050W-None]	5194.88	721.24	425.86	17.04	61.73	5194.88
52	51		[K1050W-None]	5177.36	766.82	458.31	16.61	57.77	5177.36
53	52		[K1050W-None]	5177.99	766.84	458.31	16.61	57.78	5177.99
54	53		[K1130-BB-None]	5125.79	753.50	482.16	16.64	58.73	5125.79
55	54		[K1130-BB-None]	5125.79	753.50	482.16	16.64	58.73	5125.79
56	55		[K1050W-None]	5177.99	766.84	458.31	16.61	57.78	5177.99
57	56		[K660-Classic-None]	5099.80	682.65	350.85	17.01	61.74	5099.80
58	57		[K1050W-None]	5177.99	766.84	458.31	16.61	57.78	5177.99
59	58		[K1050W-None]	5177.99	766.84	458.31	16.61	57.78	5177.99

We ran many flight simulations to get our rocket as close to a mile as possible. The flight simulations are above. Our altitude prediction is that our rocket will reach 5178 feet at apogee. The predicted mass of our rocket is 21.39 pounds. The mass statement for component weight is located in section 3.1.3.2.

3.4.3. Show thoroughness and validity of analysis, drag assessment and scale model results

The team designed the rocket on RockSim and details of the simulation have been compared against the desired and reasonable results: These results include:

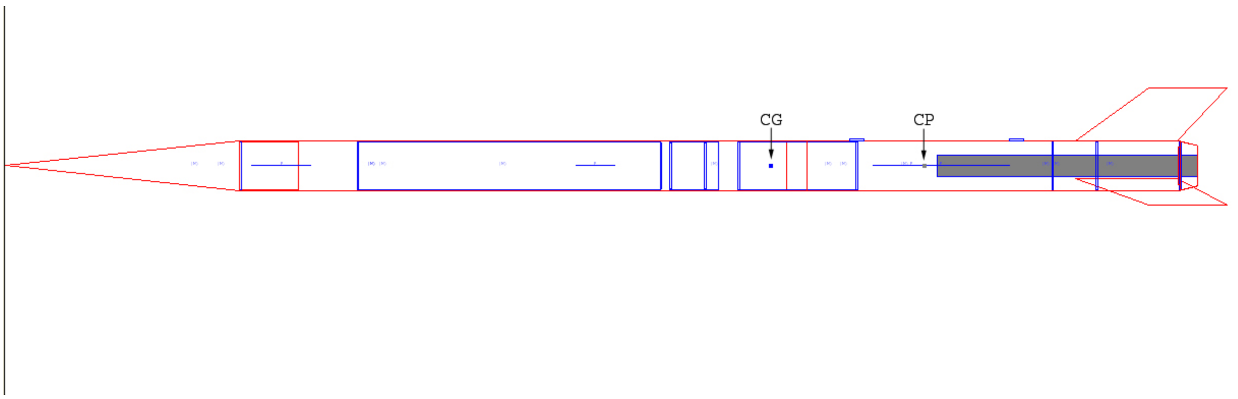
- Stability – Center of Gravity vs Center of Pressure
- Motor Selection shows that we have an adequate thrust-to-weight ratio together with enough thrust to reach our objective altitude, one mile.
- The maximum velocity is below mach1 for the requirements and to avoid unnecessary stress on the vehicle.
- Aeropack Qwik Change Motor Retainer has been used by mentors and many others to retain the engine without failure
- Parachute Deployment – black powder calculations show that we are generating enough pressure to separate the vehicle and shear the pins and deploy the parachutes

- Parachute size – by online calculators and by hand have determined that each section is descending at a safe target velocity for Upper, UAV, Drogue and Main.
- Redundant recovery electronics are from two separate manufacturers using different altitude detection to assure an extra margin of safety
- Launch Environment – use a 1" rail capable of launching larger rockets with a rail exit velocity providing stability

The calculated drag was done by rocksim and shows a reasonable coefficient of drag of roughly 0.65.

3.4.4. Show stability margin and actual CP and CG relationships and locations

The CG, center of gravity, is located 78.489 inches from the tip of the nose cone and the CP, center of pressure, is located 94.033 inches from the tip of the nose cone. This gives us a stability margin of 3.11. Below is the rocket with the locations of the CG and CP.



3.5. Payload Integration

3.5.1. Ease of integration

3.5.1.1. Describe Integration plan

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.

3.5.1.2. Installation and removal, interface dimensions and precision fit

The inner diameter of the rocket body tube is 4.9640 inches and the outer diameter of the sabot is 4.8640 inches, a tenth of an inch less, allowing for a moderately loose fit allowing for positive ejection. We do not need a tighter fit than that because the piston fits snugly inside of the body tube and the piston contains the ejection gases.

3.5.1.3. Compatibility of elements

We will be using a carbon fiber body tube and a fiberglass sabot. We are using a fiberglass sabot for two reason, the first is that we can sand the sabot if we need a looser fit (if you were to sand carbon fiber you risk weakening the body tube because you are disturbing the cross threading of the fibers) and second because we need the added strength. 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.

3.5.1.4. Simplicity of integration procedure

The integration plan of the sabot is very simple, first the piston is placed into the back end of the upper section after the shock cord has been attached and the upper section is then screwed onto the avionics bay using metal screws. The UAV is then placed into the Sabot, the winged wrapped around the fuselage and the micro switch open. The shock cord is then attached to the eyebolt on the sabot and the “U” bolt on the bulkhead in the nosecone. The sabot is then slid into the upper section until it pushes against the piston. The parachute is the packed and the nose cone is attached using shear pins.

3.5.1.5. Submit Draft of Final assembly and launch procedure

The vehicle itself is in three separate sections – a top section, the avionics bay, and the bottom section. Within the bottom section are the main and drogue parachutes as well as the motor. The top section has the UAV and its parachute inside of a sabot. In addition, there is a recovery parachute. To assemble the rocket:

1. Lower section initial assembly
    - **a.** Make certain that the shock cord is attached at both ends
    - **b.** Fold the drogue parachute and place inside of Kevlar shield
    - **c.** Make certain the drogue is attached to the shock cord
    - **d.** Fold the main parachute and place inside of the deployment bag
    - **e.** Connect the Tender Descenders across the deployment bag
    - **f.** Attach the GPS to the shock cord and make certain its shield is in place
2. Upper section initial assembly
    - **a.** Attach the upper shock cord to the nose cone and the eye on the sabot
    - **b.** Make certain that the UAV is prepared for flight and with charged batteries
    - **c.** Attach the parachute to the UAV via the release mechanism
    - **d.** Place the UAV and its parachute into the sabot assuring that the microswitch holds the power off
    - **e.** Fold the upper parachute and make certain it is attached to the shock cord
    - **f.** Attach the GPS to the shock cord and make certain its shield is in place
    - **g.** Slide the Sabot into the upper body tube, followed by the GPS and parachute
    - **h.** Securely attach the nose cone to the upper end of the body tube
3. Avionics Bay
    - **a.** Make certain that fresh batteries are installed in the avionics bay
    - **b.** Attach the 4 wires from the terminal blocks on the upper end of the avionics bay to the terminal blocks on the sled and slide into the outer housing

c. Attach the 8 wires from the key switches to the terminal blocks on the sled
d. Attach the wies from the terminal blocks on the lower end of the avionics bay to the terminal blocks on the sled.
e. The avionics bay con now be secured with the two wing nuts
f. Turn the switches ON and short each pyro charge on the terminal blocks and assure the beeping reflects an ematch connected
g. Make certain that all switches are off

4. Upper section final assembly
   a. Make certain that one end of the remaining shock cord is attached to the piston and the other to the avionics bay
   b. Prepare the two ejection charges for the sabot ejection and attach to the upper end of the avionics bay
   c. Slide the piston into the upper section followed by the ejection charges
   d. Secure the upper section to the top of the avionics bay with three #2 nylon screws
5. Lower section final assembly
   a. Prepare the two ejection charges for the drogue and attach to the terminal blocks on the avionics bay
   b. Prepare the two ejection charges for the tender descenders
   c. Place the two ejection charges for the drogue into the lower section body tube
   d. Slide the drogue inside of its Kevlar shield into the body tube
   e. Slide the deployment bag into the lower body tube
   f. Route the wires for the Tender Descenders along the shock cord, gently winding it around the cord leaving the wire very loose – allow an extra 3 feet along the length
   g. Cover the shock cord and charge wire with a Kevlar sleeve
   h. Attach the wires for the Tender Descender to the avionics bay
   i. Attach the lower section to the avionics bay with three #2 screws
6. Motor
   a. Prepare the motor for launch – do not install the ignitor
   b. Tape the ignitor to the outside of the rocket
7. Bring the rocket to the pad and place on the pad
8. Install the ignitor
9. Turn on the HCX and Raven CPUs batteries
10. Turn on the HCX and Raven Pyro batteries
11. Verify that the HCX and Raven beeps indicate ematch continuity.

3.5.1.6. 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

3.5.1.7. Motor Preparation

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

3.5.1.8. Igniter Installation

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

3.5.1.9. Setup on Launcher

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

3.5.1.10. Troubleshooting

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

3.5.1.11. Post flight Inspection

The post flight inspection can be found in Appendix D

3.5.2. Safety and Environment (Vehicle)

3.5.2.1. Identify safety officer for your team

The Safety officers for our team are Divya and Sjoen.

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

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

3.5.2.3. Update listings of personnel hazards and data demonstrating that safety hazards have been researched such as MSDS, operator's manuals and NAR regulations and that hazard mitigations have been addressed and enacted

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

3.5.2.4. Discuss any environmental concerns

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

4. Payload Criteria

4.1. Testing and design of the payload Experiment

Our UAV payload is going to deploy at 400ft, if we are able to obtain a Certificate of Authorization to do so. If we can, then we will fly the UAV manually from 900 to 400 ft, switching to autopilot there for the rest of the flight. We plan to take video throughout the flight as well. In addition, after a Skype conference with our mentor Doug Webbil, who works with Ardupilot electronics, we learned that we would have to rewrite some of its codes to be able to fly on autopilot after manual control rather than from the start of the flight

The body of the UAV is based on the ARF Rifle (from www.electrifly.com), an existent model without any electronics included.

After electronics have been installed, we will first fly the Rifle with our electronics but without the bendable wings, using the Rifle wings already given in their ARF kit, to test how well the electronics are working. Then we will add the carbon fiber wings to test them separately, so we could gauge their separate performances.

4.1.1. Review design at system level

We purchased the ARF Rifle kit from www.electrifly.com to use the existent model's body for our UAV. Then, we installed the autopilot (Ardupilot), an electronic speed controller (volcano), two servos, a Sony camera, camera transmitter, GPS (Mediatek), and Xbee telemetry onto the body.

The ArduPilot Mega is connected to the Xbee telemetry, ESC, and Mediatek GPS. The Xbee will transmit barometer information from the ArduPilot and GPS, to the Xbee receiver which is connected to the laptop.

The same battery powers the previously mentioned electronics. However, the camera and video transmitter are powered by a different battery. The Sony camera transmits video to Lawmate video transmitter, which sends us the live video feed to the receiver on the ground.

The battery used for the Ardupilot and connected electronics is a 3-cell lithium polymer 1800mAH 30c. The camera and its video transmitter will be powered by a 150mAH 15C lithium polymer battery.The motor is an Exceed Rocket 3000KV Brushless Motor, and its weight is 61grams. We had to use a different motor than previously planned, because the previous motor we had chosen was too heavy.

4.1.2. Drawings and specifications

We will modify the ARF Rifle body by installing our electronics and by replacing its wing with our bendable wing carbon fiber ones.

The carbon fiber wings we are using have a wingspan of 30 inches.

The length of the Rifle body is 24.5 inches (620 mm), and it weighs 17-18 oz.

4.1.3. Analysis results

The results should indicate that the plane can successfully fly with autopilot and manual control. It also should take live video and transmit barometer information. It includes a successful ejection from the rocket and the sabot. Also, the bendable wings must unfold successfully in order for it to fly.

A successful flight would mean that the UAV returned to the ground without need of significant repair, taking video along the way. Our margin of flight should be 5-10 minutes; 5 minutes is the best.

4.1.4. Test results

We have currently not conducted any test but, we are currently receiving parts for the UAV and have provided a test plan found in 4.1.17

4.1.5. Integrity of design

We will use zip ties to secure the batteries, which will each be strapped with two. Each will also have soldered connections to the wires. In addition, we will securely screw the electronics into the wooden sled. The carbon fiber wings design will be able to handle the stress level of the UAV and will be mounted to the main fuselage of the plane by two screws mounted on the front and back of the wing. The main fuselage is built from a pre-existing plane that functions correctly and is able to cope with the weight and stress of our electronics.

4.1.6. Demonstrate that the design can meet all system-level functional requirements

The ArduPilot is capable of controlling an autonomous flight, though it will have to be modified slightly so it can switch to manual control. We also have calculated the mAH of batteries we needed, selected light batteries, and made sure the UAV was not too heavy to fly.

We have made sure that the frequencies we are using do not interfere with each other. For example, the Lawmate video transmitter runs on the 1280 MHz frequency, while the Mediatek GPS uses a 1575.42 MHz frequency.

4.1.7. Specify approach to workmanship as it related to mission success

We must conserve battery to make sure the UAV has enough power to fly down with, but not too much that will make it too heavy. The micro switch we are planning to use will turn on the power when the UAV is deployed so the batteries would not be wasted as the rocket is waiting on the launch pad. The vehicle and payload are both essential to mission success. Throughout the process of the build we will ensure that safety is our number one factor. We will test all the electronics before placing them on the UAV and running them through a test and simulation. The test for the motor, servo, and ESC will be done before placing them in the plane to ensure that they are fully operational before sending it out in flight. For the ArduPilot Mega we will place it through a simulation in X-Plane on a PC to ensure that it is also fully operational before placed in flight.

4.1.8. Discuss planned component testing, functional testing or static testing.

We will test the electronics separately by flying it on the RC plane before we modify it as the UAV and use it in the rocket. We will also test the wings by adding them later after we made sure the electronics work. Also, we will perform static tests before we experiment with flying the UAV.

4.1.9. Status and Plans of remaining manufacturing and assembly

We currently have a test plane in which we will test all the electronics before placing them in the final UAV plane. We have a test plans for future builds and test in 4.1.17

4.1.10. Describe integration plan

The Video system consists of a Lawmate video transmitter, Sony video camera, and a 150mAH LiPo Battery. The Camera will be placed in between the motor and the leading edge of the wing, while the 150 mah will be placed towards the front of the plane. The rest of the electronics consists of the ArduPilot Mega, Spectrum receiver, GPS, air speed sensor, motors, Xbee, ESC. The motor will be placed in the front of the fuesalage, while the ESC, ArduPilot Mega will be placed under the wing. The XBee telemetry and GPS will be placed new the back of the wing. The Lawmate transmitter and AR8000 receiver will be placed in the front of the wing

4.1.11. Discuss precision of instrumentation and repeatability of measurement

The precision of instrumentation is high because all the data we are collecting is real time and the data that is not in real time will be checked if it is reasonable. The data that we collect can be repeated process – because the data we are collecting is in real time you cannot expect to see the same exact result, but you can repeat the process. The recovery system is dual redundant dual deploy, this means the recovery system will not fail because the recovery system has a backup.

4.1.12. Discuss the payload electronics with special attention given to transmitters

The RF down link for the telemetry the UAV will be using is the Xbee. We will buy the Xbee telemetry kit from DIY Drones.This kit includes the following: XtreamBee Board, Xbee-PRO 900 extended range module with RPSMA connector, Xbee-PRO 900 extended range module with wire atenna, XtreamBee UAB Adapter, Duck antenna optimized for 900Mhz and a Xbee-Oil Pan connector cable. The Xbee Pro has a 156 data rate and has 50 mW power output.

The ground station consists of a laptop, Xbee telemetry receiver, the video receiver, Video to USB converter and the Spektrum DX7. The laptop is connected to the Xbee and video receiver. The xbee telemetry receiver receives information on 900MHz. The video receiver receives information on 1.2 GHz. The video receiver is connected to the laptop using the video to USB converter. The Spektrum DX8 sends information out on 2.4 GHz. The computer will run a program called ArduPilot Mega Mission Planning. The program will show us the GPS location and the video.

The motor is an Exceed Rocket 3000KV Brushless Motor and its weight is 61grams. We had to use a different motor than previously planned, because the previous motor we had chosen was too heavy.

The controller/Main transmitter the UAV will be using is a Spektrum DX8. The controller has 8 channels and uses a 2.4 GHz band. The receiver the controller uses is an AR8000. The controller has a 30-model memory and has airplane. The controller has switch assignments and P-mixes. The controller uses 3-axis dual rate and expo and 3-position flap.

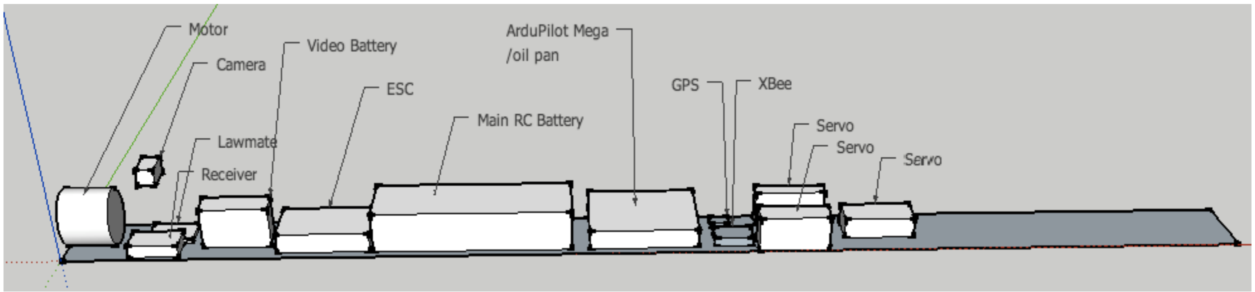
The servos the UAV will be using are 9G EXI Digital Metal Gear Servos D213F. The servo weighs 0.32 grams and has the dimensions of .89 inches x .45 inches x .87 inches. The servos use 4.8 Volts and use M20S motor. The gear type that the servo uses is metal bearings and the servo type is digital.

The Electronic Speed controller (ESC) that the UAV will be using is a Volcano Proton 30A. The output the ESC is 30A and a burst of up to 40A. The ESC input voltage uses a 2-3 cell LiPo Battery.. The ESC had a safety arming feature, the motor does not spin after the battery is connected, Throttle Calibration, throttle range can be configured to provide best throttle linearity, and many programmable items such as brake setting, battery type, Low Voltage protection mode, low Voltage cutoff Protection Threshold, start mode , and timing mode. The ESC has a military standard capacitor, extreme low resistance PCB, and a microprocessor that uses separate voltage regulator IC.

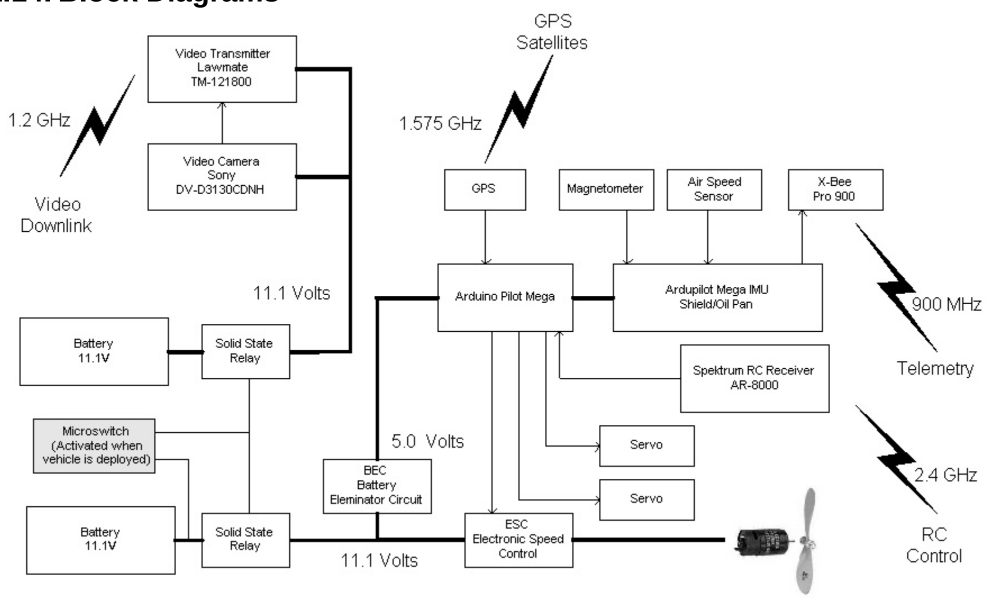
The autopilot system the UAV will be using is the ArduPilot Mega (Red). The ArduPilot is based on a 16MHz Atmega2560 processor, and has a built in hardware failsafe that uses a separate circuit which is a multiplexer chip and ATMega328 processor to transfer control from the RC system to the autopilot and back again. The ArduPilot has the ability to reboot the main processor midflight and has a dual-processor design with 32 MIPS of onboard power. The Ardupilot supports 3D waypoints and mission commands which is limited by memory which is approximately 600 to 700 waypoints. The ArduPilot uses 256k Flash memory, can use two way telemetry, hardware driven servo control and LEds for power failsafe status and autopilot status.

The ArduPilot has a shield/oil pan(Blue) which is the Interface. The Shield has a Dual 3.3V regulator and has a relay switch for cameras, lights or payloads. The Shield uses a 12-bit 16 MB Data Logger and 10-bit analog expansion ports. The shield has a built in voltage dividers to measure the aircraft battery, a new vibration resistance Invensense Gyros (triple axis), analog devices ADX330 Accelerometer, an airspeed sensor port and an Absolute Bosch pressure sensor and temp for accurate altitude. The Shield weighs around 0.5 oz. or 13 grams.

4.1.13. Drawings and Schematic



4.1.14. Block Diagrams



4.1.15. Batteries/power

There are two batteries on-board the UAV, one will power Lawmate video transmitter and the Sony camera while the other will power the rest of the electronics which include the ArduPilot Mega, Spectrum receiver, GPS, air speed sensor, motors, Xbee, ESC. The battery that will power the FPV (First Person View/Camera) system is a Venom 15c 150mAH 3 cell LiPo Battery, while the rest of the electronics will be powered by a 1800mAH 30c LiPo Battery. We have changed our initial battery for the FPV system to a lighter battery for weight reason.

4.1.16. Transmitter frequencies, wattage and location

The FPV system which includes the Lawmate video transmitter and the Sony video camera which sends a video down link of 1.2GHz to the ground station. The Lawmate vide transmitter has an output power of 1W at 30dB. The Sony DV -D3130CDNH use ~ 0.6W. The MediaTek GPS uses ~.24W and operates under 1.575GHz. The XBee Telemetry uses .05W and operates under 900MHz. The Spectrum AR8000 receiver operates at 2.4GHz. All the transmitters and receivers on board the UAV will be places towards the nose of the plane to all a greater reception to the ground station and satellites.

4.1.17. Test plans

We will conduct testing as follows:

- 1/28 and 1/29 - Trip to Lucerne one day - Launch scale model rocket (most important) AND build and fly the Wild Hawk with the new motors and Spektrum DX-8 Transmitter
- 2/4 and 2/5 - Trip to Lucerne one day - Launch scale model rocket if needed, integrate ArduPilot Mega autopilot and set up X-Plane hardware-in-the-loop testing and fine tune the Wild Hawk
- 2/11 - Trip to Lucerne one day - Fly the Wild Hawk with the ArduPilot Mega and the Rifle on RC only
- 2/12 - Move ArduPilot Mega to the Rifle
- 2/18 - Set up X-Plane hardware-in-the-loop testing on Rifle
- 2/19 - Trip to Lucerne one day - Fly the Rifle with the ArduPilot Mega
- Note that 2/17 and 2/20 are holidays - but if we are behind schedule we will need to meet on those days as well.
- 2/25 - Ask Dr. Davey help us move the Rifle to the bendable wing
- Date pending – move the Bendable wing onto the rifle
- Fly rifle with the bendable wing

4.1.18. Safety and Failure analysis

The onboard AR8000 receiver has a failsafe system which is known as the "SmartSafe" which sets the motors and servos into a prepositioned output when the radio signal is lost. The fail safe system also stop servos from over-rotating and stripping upon start-up, as well as an "unintentional" motor movement upon the start-up. The prepositioned outputs when the signal is lost can be override by the ArduPilot Mega if it is set to "return home" which commands the UAV to return home through GPS way points until the signal is regained where it could be switched back to user command.

4.2. Payload Concept Features and Definition

4.2.1. 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

4.2.2. 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

4.2.3. Suitable level of challenge

Though building the UAV will be difficult, the wing design in this case will bring challenges of its own. The bendable carbon fiber wing will be a challenging design to work with, because it is not only a new concept with little reference material but also likely to create problems with flight stability. Also, the duration of the flight must be short to conserve battery, because the amount of battery will be limited to conserve mass. The limits on the flight time may cause future problems, depending on how quickly we can get the plane back to the ground. These challenges will definitely make our project suitably demanding.

4.3. Science Value

4.3.1. Describe Payload Objectives

The scientific payload is designed to capture footage of ground surveillance with the safety of a UAV. The application use for the payload includes Military purposes in hostile environments that need surveillance at a distance.

4.3.2. State payload 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 ArduPilot Mega's barometer, artificial horizon, and servo control results are relayed to the ground station via the Xbee telemetry system from DIY Drones
- 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.

4.3.3. Describe the experimental logic, approach and methods 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.

4.3.4. Describe test and measurement variables and control

In order to test all variables we will test each subsystem that will eventually be in our bendable-wing UAV on a standard RC plane. The subsystems that will be tested are the ArduPilot, the MediaTek GPS, the Xbee Telemetry, the Servos, the ground station and the controller. We can determine the success of each of these systems during the test flights in the other RC plane. We will also conduct experiments to determine the battery life of the batteries that will be on board the UAV. Another test we will conduct is the opening of the sabot. Tests will be conducted separately for all components that are not actually part of the UAV. Once everything is tested then we will test the subsystems in our own UAV.

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

If no major problems arise, our experiment should yield the result that the deployment of a bendable- wing UAV that will be able to fly on autopilot and take video during flight from a rocket is possible. It should be easy to determine the success, as it will be visible if the UAV does not fly properly or it does not take video that is transmitted live to the ground station.

4.3.6. Describe the experiment process procedures.

To gather information, we are going to transmit video live from the UAV with our Lawmate video transmitter. In order to receive the information and data from the ArduPilot Mega, our Xbee transmitter on the UAV will send the collective data from the ESC, barometer, and Media Tek GPS to our ground station where it will be viewed on a laptop screen.

4.4. Safety and Environment (payload)

4.4.1. Identify your safety officer for your team

The Safety officers for our team are Divya and Sjoen.

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

Failure modes can be found in Appendix A. Mitigations can be found in appendix C.

4.4.3. Update the listing of personnel hazards and data demonstrating that safety hazards have been researched (MSDS operators manuals NAR regulations) and that hazards mitigations have been addressed and mitigated

Personnel hazards can be through materials and/or processes. For materials there is Material Safety Data Sheet (MSDS), which can be found on our team website along with manuals and have been referenced. Our team will comply with all NAR and TRA rules and regulations. We will also follow a safety checklist as a part of launch procedures. We will use all safety data instructions with our materials. For further information about the risks and mitigations, see Appendix A.

4.4.4. Discuss any environmental concerns

The environmental hazard can be found in Appendix B

5. Activity Plan

5.1. Show status of activities and schedule

5.1.1. 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 will sell see's candy in the spring seasons.

5.1.2. Timeline (in as much detail as possible)

The time line can be found in Appendix H.

5.1.3. Education 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.
- The SLI team will contact Discovery Science Center to attempt to participate in an event to promote SLI and aerospace. Last year at a fundraiser for SLI someone from Discovery Science Center spoke with the team about participating with Discovery Science Center.

6. Conclusion

The AIAA Orange County section SLI team is very excited to be a part of the Student Launch Initiative program for another year. We hope that we continue and complete the project with even better results than we had last year. We believe that our payload will work properly and will follow all commands. We believe that our rocket will achieve all the set criteria along with our payload. 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 half moon design	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
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	7 Risk: The parachute tangles around the UAV Mitigation: Make sure the	12 Risk: The engine explodes Mitigation: make sure there is no defects in	17 Risk: The UAV Motor propeller breaks during sabot release	22 Risk: Tracking device is damaged in launch Mitigation: Make sure	27 Risk: The black powder isnt the correct amount Mitigation: have a backup

fiberglass	parachute is correctly folded	engine	Mitigation: A folding propeller will be used – this opens up when the motor powers on.	Tracking device is secure and is fully encased in the styrofoam	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 Tender Descender charge 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

<table>
<tr><td colspan="2">Flight Computer Status Codes Normal Status Code
1. LED turns on then off.
2. The LED turns on and the beeper gives one (JP7 OUT) or two (JP7 IN) low pitch beeps.
3. LED turns off.
4. There is a half second pause.
5. Starting with pyro port one, each pyro port reports status with either a single quick “beep” (for good continuity) or a double “beep” if the port has incomplete continuity.
6. A one second pause, and then the sequence repeats from step 2.</td></tr>
<tr><td>Low Battery
1. LED turns on, then off.
2. The LED turns on and the beeper gives one (JP7 OUT) or two (JP7 IN) low pitch beeps.
3. After a half second pause, the beeper gives a short warble.
4. LED turns off.
5. There is a half second pause.
6. Pyro port report status
7. A one second pause, and then the sequence repeats from step 2.</td><td>SD Card is Unplugged
1. The LED turns on then off.
2. Long, High pitch beep.
3. Long, low pitch beep.
4. 3/4 second delay.
5. Normal status code starts.</td></tr>
<tr><td>Power-On Self-Test Failure (POST Failure)
1. Long warble.
2. Then a half second delay.
3. 1 – 7 high pitch beeps giving a failure code.
o For 1 to 4 beeps: Hardware error. Do not fly. See manual.
o For 5 or 6 beeps: Reformat or replace card. See manual for more information.
o For 7 beeps: The SD card is full. Reformat or replace card.
4. A 1 second pause, and then the sequence repeats.</td><td>Break Wire Error
1. Short warble.
2. A 1 second pause, and then the sequence repeats.

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.</td></tr>
</table>

Appendix E

Feedback Table

No	Feedback	Action
1	NAR will provide 8ft rail – not 6ft	This has been changed in RockSim and in the documentation
2	Max Mach is .68 – use Mach Delay	2 second Mach delay is in HCX and Raven
3	20 ft recovery is fine, longer is better	Rear is no 36 ft total and front is 20 ft + 4ft on piston
4	Will there be dedicated arming switch for each altimeter	Yes – dedicated CPU and Pyro switches for each altimeter (4 total)
5	How long will ematch for Tender Descender be?	Ematch wire is accordioned with additional 3 ft extra, protected by nomex sleeve
6	Lower stability margin to 3-4	Stability margin is now 3.18
7	Describe ejection events	Events are described in a series of drawings with explanation
8	Is charge pushing out sabot manual or altimeter based?	Altimeter
9	Is the UAV design proven	UAV is combination of wing from University of Florida on an Electrifly Rifle RC airplane
10	What altitude is the UAV deployed	1,000 ft on parachue – 400 ft to fly
11	Is parachute on UAV attached to the airframe until 1,000 ft or does it come down from apogee	UAV is inside vehicle until it descends to 1,000 ft and is on parachute until 400ft.
12	How will UAV be released	By control from a channel on the RC transmitter using a servo
13	Will the release mechanism be manual or automatic	Manual
14	What is KE of UAV under the UAV parachute	5.33 ft lbs force K.E. = ½ ((m*0.454) * (v * .305)^2) * 0.738 m in lbs, v in ft/s – 1 lb UAV on chute falls at 18.5 ft/s

		K.E. = ½((1*0.454) * (18.5 * .305)^2) * 0.738
15	How far will parachute drift after UAV is released	When the parachute is released from the Sabot, the shroud lines are no longer held at a point – 1 shroud line has a small ½ oz weight which comes down like a streamer. This will keep it within the 2,500 ft
16	Is the UAV manually controlled on the way down. If communications is lost what is failsafe	UAV is controlled manually. If signal is lost Spektrum RC has 3 failsafe modes. We will set it to lower the throttle and circle to descend. Alternatively, the APM can be set to return to home
17	If power is lost to control system and then comes back on what happens	The APM will automatically switch to RC when power is lost. If power is restored it can restart and pick up where it left off
18	How much load can the wing handle before it fails	9 lbs (per University of Florida's testing)
19	Has the team referenced AC-91-57. We may need to file a waiver	We have downloaded and read ("Do not fly model aircraft higher than 400 feet above the surface") and will look into the waiver
At CDR and FRR present details on the fail-safe mechanism for the UAV, both in design and control (see UAV safety slide)		
The UAV system will need to be tested in its full configuration during the full-scale flight test		
The team should investigate the possibility of filing a waiver to FAA AC-91-57		

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	

Appendix G

Timeline:

AIAA OC SLI 2011-2012 Project Timeline

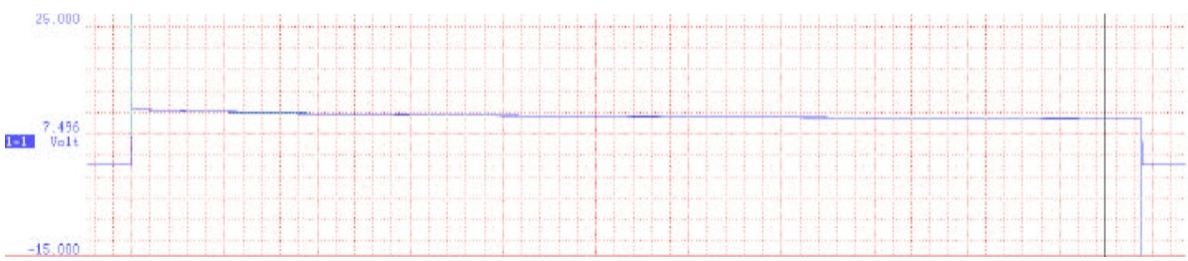
Items	Due Date
Prepare Proposal	
Proposal due for review	9/19/2011
Electronic Proposal Due to NASA	9/19/2011
ROCtober fest (outreach)	10/8-10/9
NASA accepts our proposal	10/17/2011
Girl scouts - present/assist in rockets (outreach)	10/15/2011
SLI team teleconference	10/21/2011
Girl scouts - present/assist 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)

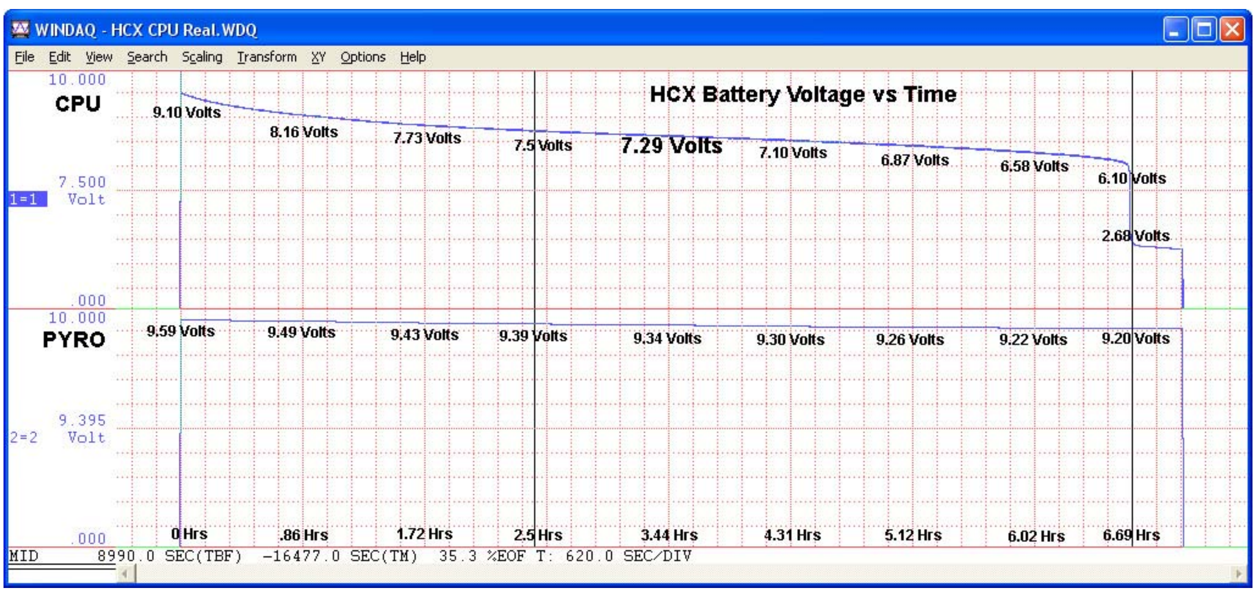
3. Battery Life - HCX

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.

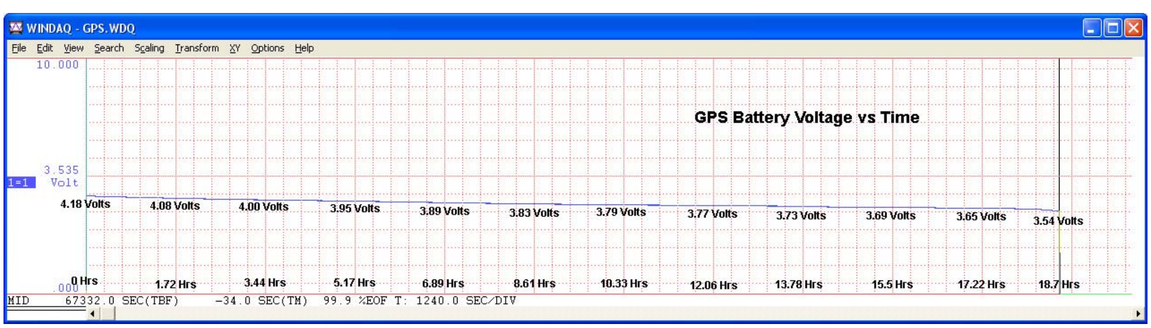
4. Battery Life – GPS

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 T				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				