06-May-2016

Preliminary Design Report

University of Wisconsin – River Falls

High Powered Rocketry: ORCA

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1. Executive Summary

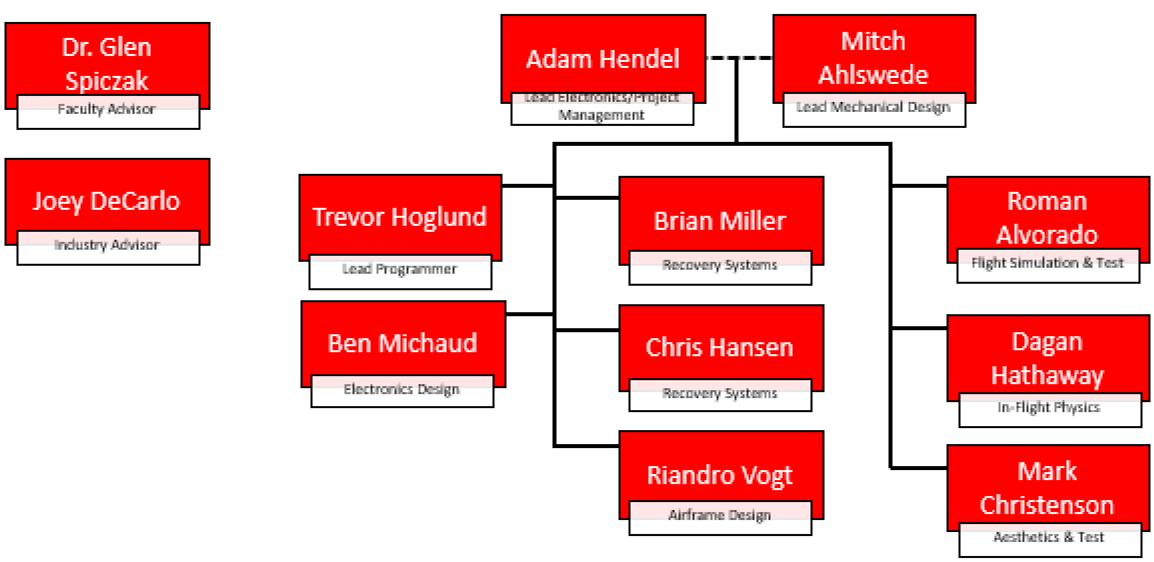
The 2016 Space Grant Midwest High-Powered Rocket Competition calls for competitive teams to design and construct a high-power rocket with an active drag system that will reach an apogee of at least 3,000 feet above ground level and be recovered safely and in flyable condition, predict its flight performance with the drag system both inactive and active, and construct a non-commercial on-board data collection package that will be capable of characterizing the rocket's coefficient of drag over time and capture on-board video to document the operation of the drag system. The main specified objectives are as follows:

1. Design and build a high powered rocket capable of reaching a minimum altitude of 3,000 ft.
2. Construct a non-commercial data collection system to characterize the rockets coefficient of drag over time.
3. Design and Construct an active drag system capable of decreasing the max apogee by 25%.
4. Conduct two high powered launches within 1 hour of each other.

The 2016 UW-River Falls High Powered Rocketry (UWRF-HPR) team rocket stands at 69 inches tall with a 4 inch diameter and adopts a traditional, low risk profile. The active-drag package developed for this competition is the Outward Reaching Cam Apparatus (ORCA). The rocket is expected to reach an apogee of approximately 5,100 feet on a "clean" launch, max velocity of 570ft/sec, max acceleration of 220ft/sec^2. Second launch will reach an apogee of 3,750 feet by engaging the ORCA.

2. Planning and Organization

The UWRF-HPR team officially began development for the 2016 Midwest Rocket Competition once funding was secured in December 2015. The team utilized a modified hierarchal structure to manage personnel and lead the development process (see below). Each team member is given a primary area of responsibility though world loads were shared amongst the team.



At the onset of development, a tentative schedule of key project milestones was outlined in order to ensure deadlines were met. This tentative schedule was continuously modified as requirement and priorities shifted. Refer to Appendix A for the schedule of tasks.

3. Rocket Design, Specifications and Components

a. Changes to Design since 09-April-16 Test Launch

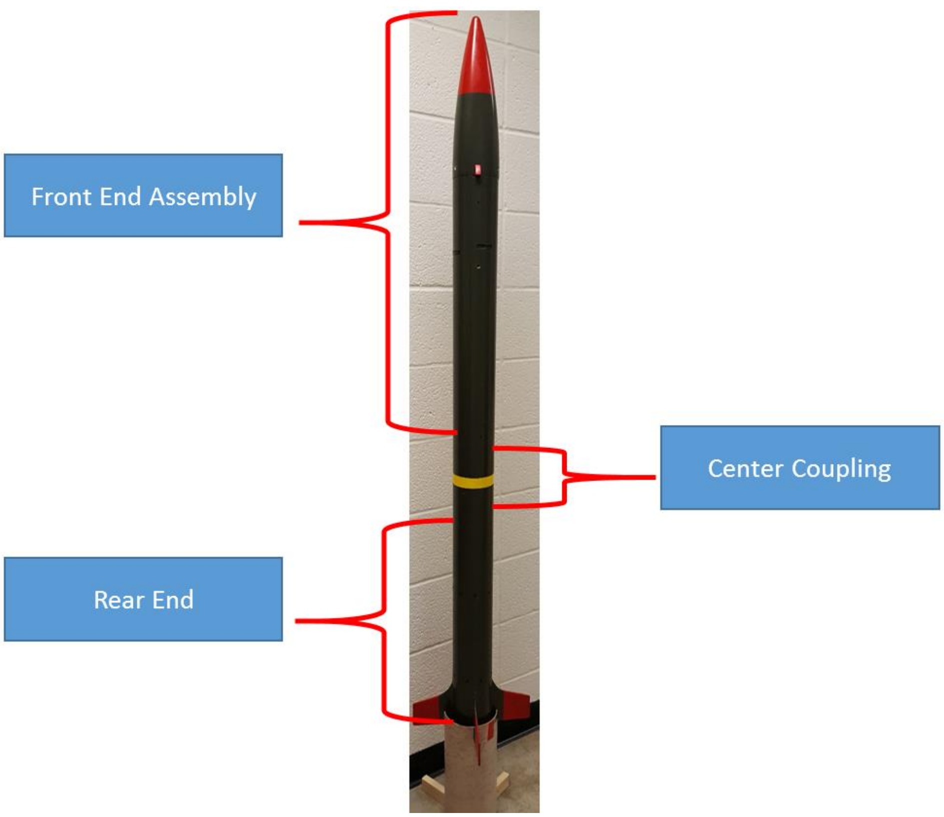
There were no structural or mechanical design changes as a result of the test launch. As outlined in this report, the test launch produced a stable flight, apogee within the predicted error margin, and a recovery according to plan. Programming logic and sequence were both completely redesigned, and are outlined in section 3.e. of this report.

b. Potential Design Improvements

A redesign of the payload layout would improve the reliability and accessibility of avionics and video capture systems. In the current design, any modifications to these systems require the complete removal of the nosecone and payload. A design that would allow direct access to the components by simply removing the nosecone would allow for faster in-between flight configuration changes and troubleshooting.

c. Airframe Design

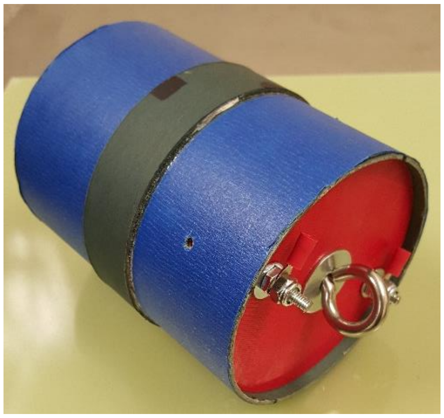
The airframe consists of three sections; the rear end, center coupling, front end assembly. All outer frame material is constructed with Blue Tube 2.0.



Rear End: The rear end consists of the motor housing, fin attachments and drogue chute bay. The motor housing is a 16 inch long Blue Tube of 54mm diameter that accepts the p/n P54-4G High-Power Reloadable Rocket Motor form that also contains a Pro54 case spacer. The fin attachments are made from ¼ inch 5 ply maple wood constructed into a channel design and attached to the motor housing using epoxy. The channels in the fin attachment are designed for four ¼ inch 5 ply maple wood fins to be secured to the airframe. The drogue chute bay is separated from the motor housing by a bulk head with an attached eye-bolt and is 8 inches long, and has two 3/16" vent holes drilled in it. Complete length of the rear end is 28.5 inches.

Rear End Assembly

Center Coupling: The center coupling's main purpose is to be the attachment point between the rear end and front end assembly and be capable of separating during recovery. It is 5 inches long with a centered 1 inch externally exposed point. The fore end has 4 holes to accept nylon sheer pins while the aft is secured by friction. Inside the coupling are two 3D printed frame to secure the turn buckle which connects to both the drogue and main parachutes. There are also two electrical communication rods which connect to the main and drogue deployment charges.



Center coupling

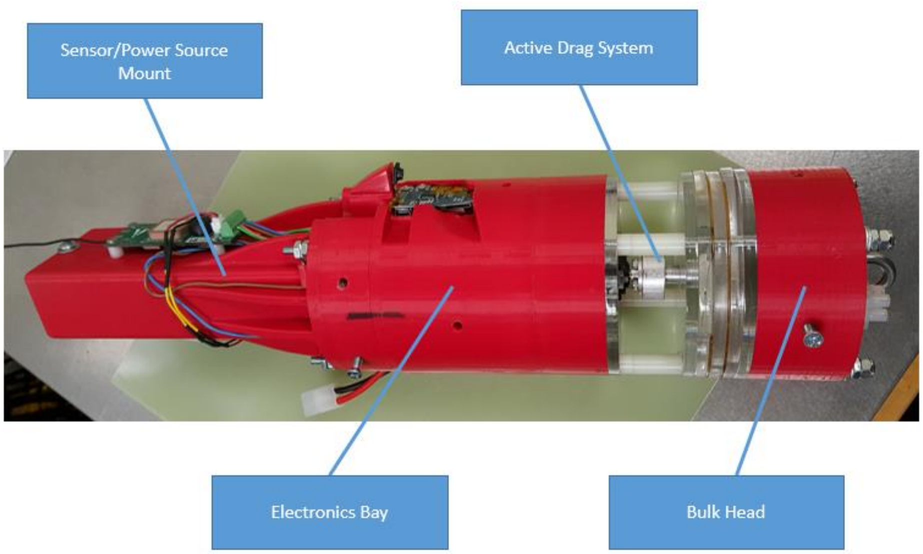
Front end Assembly: The front end assembly consists of the main parachute bay, the ORCA active drag system, electronics bay, and nose cone. The main parachute bay is 16 inches long, has four 3/16 inch vent holes drilled and is separated from the active drag system by a 3D printed bulk head. This bulk head has a centered eye bolt for main parachute attachment, four electrical communication nodes for both main and drogue parachute deployments, and in-wall nylon nuts used to attach the bulk head to the main blue tube frame of the rocket. The electrical communication nodes are dual purpose for communication and also securing the bulk head, drag system, and electronics bay assembly. The active drag system is positioned directly between the bulk head and the electronics bay. The electronics bay and sensor mount houses the flight computer and sensors, GPS unit, and power supply and fits inside the nosecone. The nosecone is a commercially available product procured from Apogee Rockets (PNC 3.9") and is constructed of Poly-propylene Plastic and is 12.75 inches long.

Front End Assembly

d. **<u>Electronics, Payload and Drag System</u>**

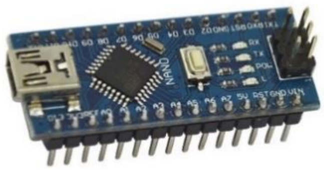
Electronics and Payload

The active drag system is controlled by a Atmel ATMEGA328P breakout board (Flight Computer) equipped with a fully supported breakout board (Flight Computer). Onboard sensors include a low power motion processing unit and barometric pressure sensor. The drag system is mechanically controlled through a Tower Pro MG996R servo, which is directly controlled by the flight computer.



The top of the sensor mount has a channel specific for the competition AltimeterTwo, which make convenient access to the sensor between and after flights. Also on the sensor mount is the Altus Metrum TeleMetrum v2.0 which will provide ground control with GPS position and also control the dual deployment recovery system.

The flight computer and high-torque servo are powered by a 7.2V / 1500mAh battery stored inside the Sensor/Power Source Mount. On-board video is powered by a separate dedicated 3.3V battery.



ATMEGA 328P Breakout Board

The ATMEGA328P breakout board has an onboard 5V voltage regulator which allows it to be powered by the rocket's main battery. It is flashed with the Arduino bootloader, which enables compatibility with programming via Arduino IDE. This board resembles the circuit design and footprint of the Arduino Nano.

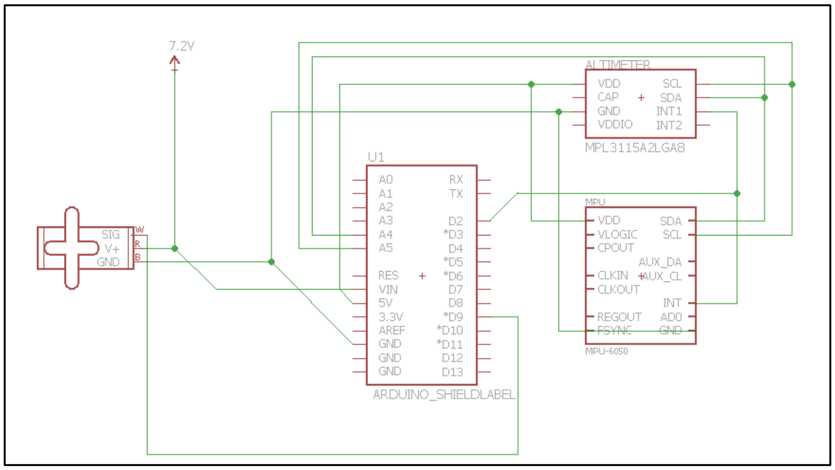
MPL311A2 Breakout Board

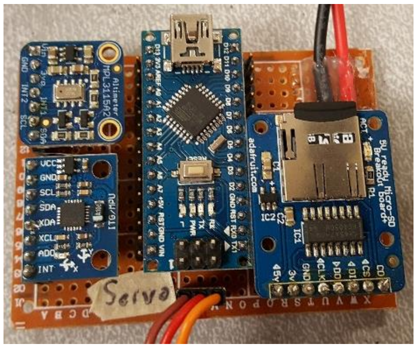
Pressure data is converted to altitude by way of the Sparkfun.com MPL311A2 library. This data is the most crucial piece of information in the drag system control program.

ADA254

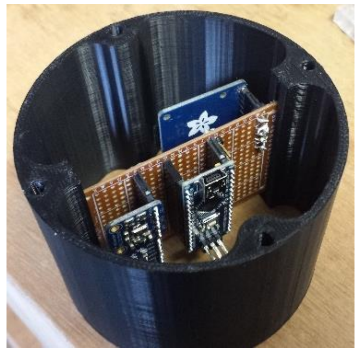
Altitude, time, and calculated velocity and acceleration data are logged to micro SD via the ADA254 breakout board. The flight computer utilizes Arduino SD card library.

All components are soldered onto a perf-board and mounted inside a custom 3D printed electronics bay following the schematic shown right.

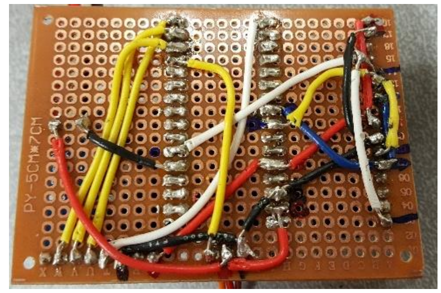




Perf board with components



Mounted Computer



Reverse side of perf-board

Video is captured utilizing a modified “808 keychain camera”. The internal circuit board and camera is removed from the factory key fob case and integrated into the frame of the rocket body. The 808 camera provides is powered by its own lithium-polymer battery and video capture at 480p resolution at full charge. The camera system will be removed in order to retrieve the video footage post-flight. The reliability of these cameras is lower than anticipated. To mitigate the risk of a camera not working on a launch, a new camera is used for each launch and included as a launch cost. Additionally, the camera will not be turned on until the rocket is on the launch pad in order to ensure recording captures the flight.

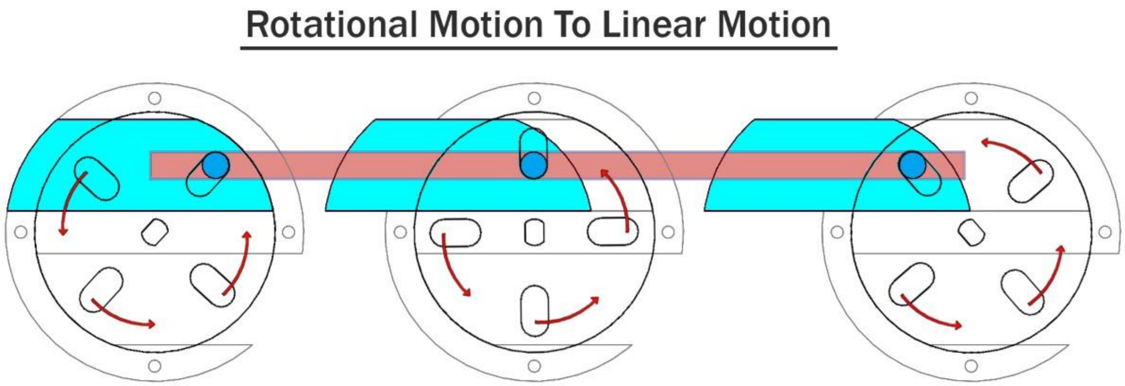
808 Keychain Camera

808 integrated with airframe

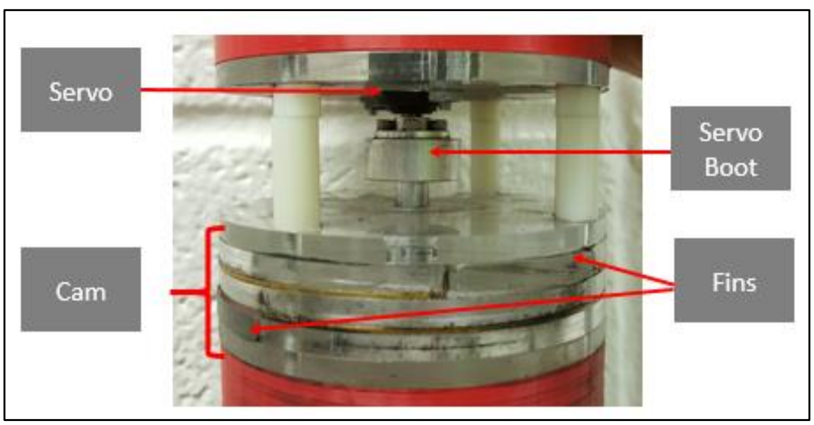
Drag System Operation

The ORCA drag system is situated directly between the bulk head and the electronics bay, and consists of four fins that extend out perpendicular to the direction of flight, and are made of ¼ inch Optix Acrylic Sheets. These fins are maneuvered by a rotational cam driven by a MG996R High Torque Servo with a max torque rating of 10kg/cm. Fins are controlled by rotating the servo, which is connected to a drive shaft on the cam.

The diagram below shows how the cam converts the rotation from the servo to linear motion of the fins within the confines of the diameter of the rocket body. The horizontal red line shows the fins connection point stays in the same horizontal plane from the fully retracted position on the left to the fully extended position on the right.

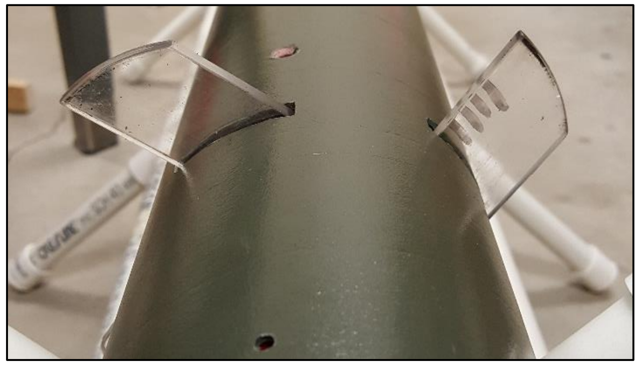


Below (left) is a profile view of the constructed drag system mounted inside the payload. The servo connects to the cam through a "boot". Two of the four fins are visible from the camera angle shown. Also below (right) is image of the stand-alone drag system with fins fully extended. The linear projection of the fins prevents the servo from having to counter the perpendicular force of drag created by the air flow on the surface of the fins.



The acrylic fins extend out of four channels placed evenly around the circumference of rocket. Below are images comparing the system stowed (left) versus the engaged (right).

Drag System Stowed



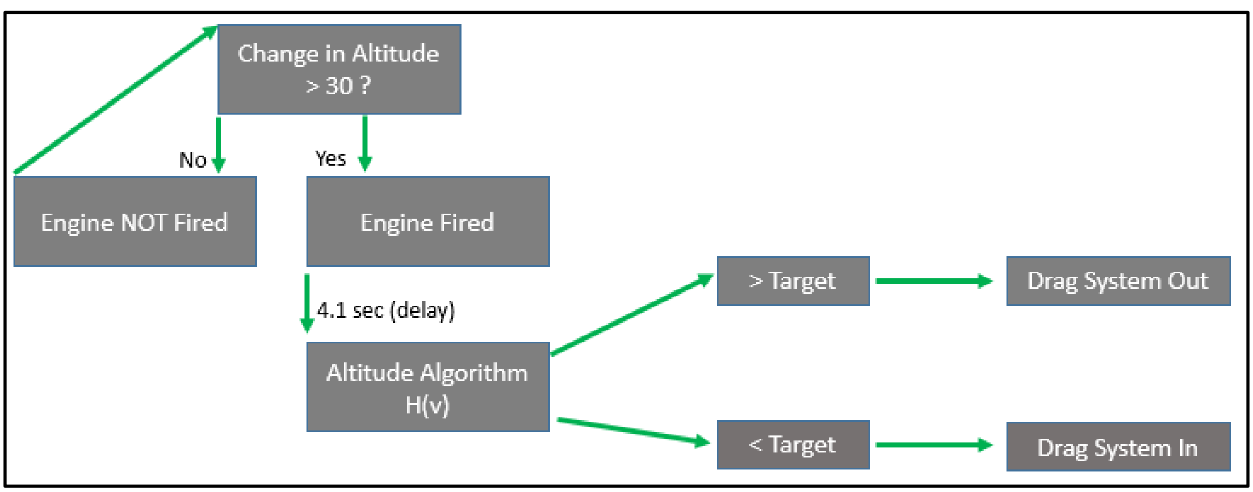
Drag System Engaged

In flight engagement and retraction criteria for the drag system are covered below, in the programming section of this report.

e. **Programming**

The ATMEGA328P is flashed with the Arduino bootloader in order to be programmed using the Arduino IDE. The program receives altitude data from the MPL3115A2 barometric pressure sensor and calculates change in altitude and change in time clocked by the processor to determine vertical velocity and acceleration of the rocket. Using change in altitude to calculate velocity simplified the flight algorithm by eliminated the use to calculate angular position of the rocket.

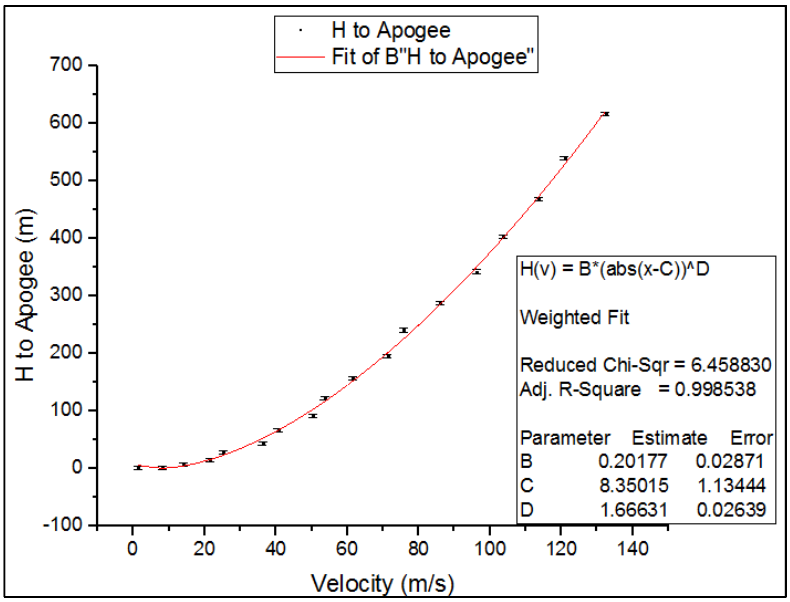
The main program loop first takes an altitude reading from the altimeter, then calculates change in time from the previous measurement, velocity and acceleration. The following flow chart describes the logic and series of events for the engagement or retraction of the drag system.



Logic to engage or retract drag system.

Distance to apogee as a function of velocity was determined by analyzing the flight data from the test launch on April 9th. The "clean" flight characteristics were able to be determined without explicitly calculating the coefficient of drag. This was calculated by first plotting velocity vs distance to apogee for the period of time between motor burnout and apogee from the two test launches. Then, with the assistance of data analysis software (Origin), our team experimented with different equations to fit to the curve. As a result, the onboard flight computer is able to predict the apogee of the rocket by using of velocity using the following equation:

H(v) = 0.20(abs(v-8.35)^1.67).*



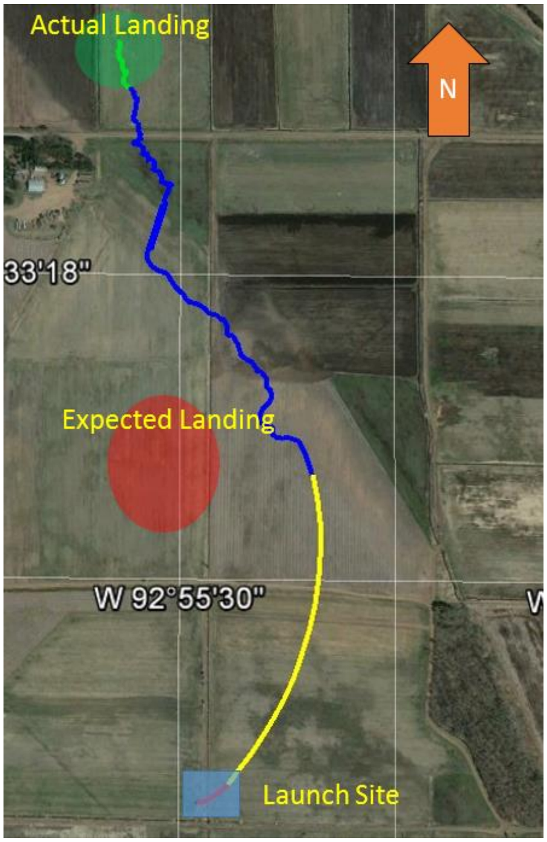
The figure shown left illustrates the burnout-apogee data points from the test launch, and the curve fit of H(v). While H(v) evaluates to greater than our set-point (75% of launch 1 - delay for time to retract drag system), the drag system will be deployed/engaged. When H(v) evaluates to less than or equal to the set-point, the drag system is stowed/retracted. A reduced chi square analysis resulted in a value less than one, which indicates a reasonable fit considering an observed error of 3 meters inherent to the onboard altimeter. Once the drag system is stowed the rockets flight performance is expected to return to this curve.

f. Recovery Systems

The rocket utilizes a dual deployment system, controlled by the TeleMetrum, consisting of a drogue and main parachute. The drogue's purpose is to decrease the amount of drift the rocket experiences between apogee and landing while also reducing the descent speed of the rocket prior to deployment of the main parachute. The following formula was used to calculate a diameter of 30 inches, at a coefficient of drag of 1.5, would be necessary for the drogue parachute:

$$D = \sqrt{\frac{2gm}{\rho C_d v^2 \pi}}$$

The commercially available parachute selected is the 30 inch elliptical from Fruity Chutes and weighs 3.1oz, has a 15.9 cubic inch packing volume. This will provide a 25 mph main chute deployment speed.



To meet the competition landing velocity requirement of 24 ft/sec, we utilized the same formula as above to calculate a diameter of 48 inches at a 2.4 coefficient of drag. The main parachute, 48 inch Iris Ultra Compact, was also procured from Fruity Chutes. This parachute weighs 4.3 oz. and has a packed volume of 26 cubic inches. Both parachutes will be secured 1500 lb. test Kevlar cord. High winds on the day of the test launch resulted in higher drift than expended, but a safe landing was achieved. The image to the right illustrates the expected vs actual drift on the test launch.

g. **Risk Mitigation Analysis**

Risk analysis was conducted as a team function using the following four step process and was embedded in to all aspects of design, construction and operation.

1. Identify hazards.
2. Analyze hazards to determine risk.
   a. Risk is defined at the cross section of the probability of the hazard occurring and the severity of the event taking place.
3. Develop and implement controls and procedure to mitigate the risk.
4. Continuously evaluate risks during design and construction.

Pre and post launch procedures were added and updated as a result of experience gained during the 09-April test launch and are outlined in Appendices C through F.

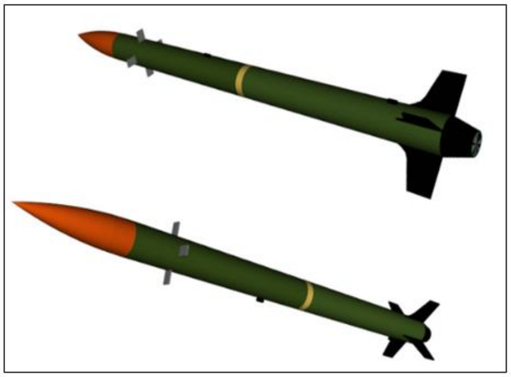
h. **Structural Analysis of Custom-Built Components**

Custom build components consist of 3D printed and wood crafted parts. 3D printed materials were tested using the physical properties of ABS plastic. Infill ratios were increased to 30% using a triangular pattern for components at higher stress portions of rocket. Non-structural components were printed with 20% infill and triangular pattern.

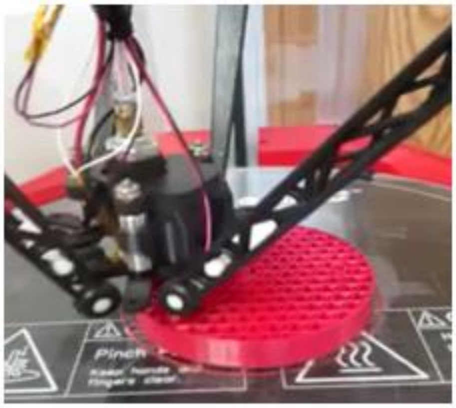
Institutional knowledge of design and performance of both 3D printed and wood constructed parts were leveraged during the design process.

i. **Construction Solutions and Techniques**

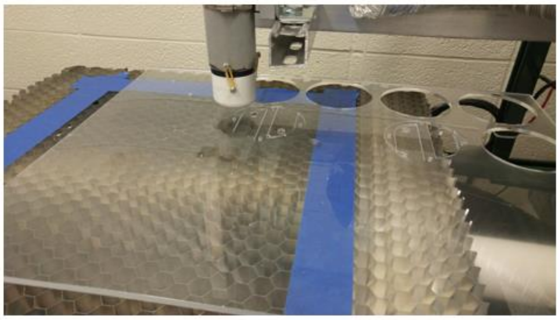
All 3D design files, laser cut patterns and wood forms are retained in the University of Wisconsin-River Falls Physics Department. All 3D printed and laser cut components were designed using SolidWorks.



Render of initial concept



3D printing of center coupling



Laser cutting of drag system components

MatterControl and Cura were used to prepare STL files for 3D printing. BlueTube, nosecone and wood fin materials were cut using a rotatory tool and the wood fins were cut to design using a jig saw.

j. **Additional Safety and Material Handling Procedures**

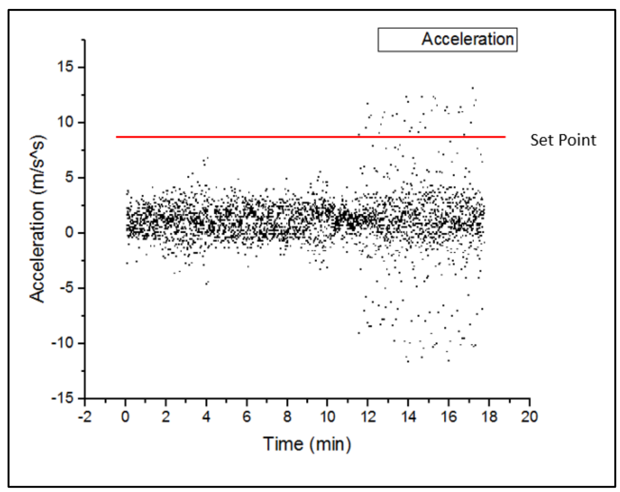
- Materials must be stored and handled with care at all times.
- Materials such as paint epoxy, ejection charges can be hazardous and must only be handled in well ventilated areas.
- Electronics present risk of shock during test.
- Proper personal protective equipment (PPE) must be worn at all times.

4. Test Launch: Actual vs Predicted Performance

Two test launches were conducted on 09-April-2016. Apogee predictions were very close to simulations, though actual values were all slightly higher. All deviations between max apogee, peak velocity and peak acceleration are well within the 10% manufacturer deviation in the J-295-16A motors manufactured by Cesaroni Technology. The drag system failed to engage, so the drag system apogee was consistent with the first flight apogee. See below for a side-by-side comparison of the data.

Category	Predicted	Actual	Difference
First Apogee (m)	1,490	1,555	65
Drag System Apogee (m)	1,100	1,720	620
Peak Velocity (m/s)	170	190	20
Peak Acceleration (m/s^2)	250	290	40

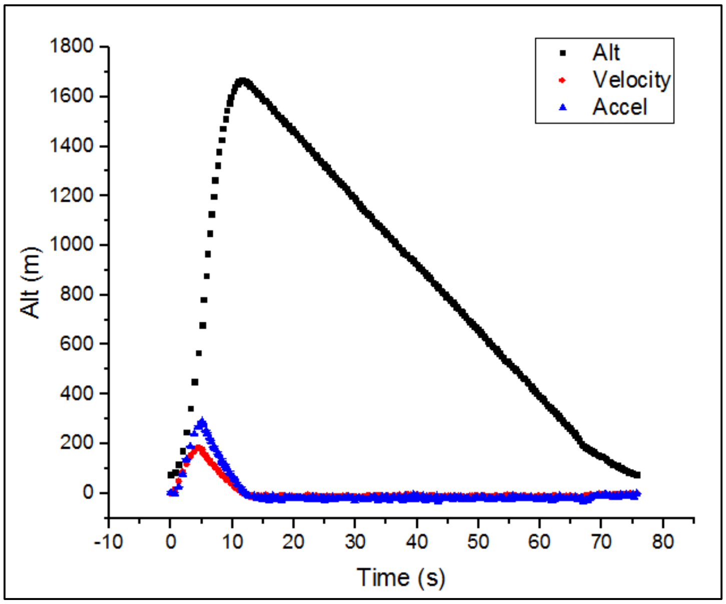
Drag System Performance



As stated above, the drag system failed to engage on the test launch. After analyzing the flight data, it was determined this was the result of variations in altimeter data and faulty programming logic. Version one of the drag system control program was based on acceleration as the initiating indicator. The graph to the right displays the acceleration recorded by the flight computer during the "pre-ignition" portion of the launch. The set point at $7 m/s^2$ is the point at which our system would register a "launch". The noise from approximately minute 11 to 17 was created from carrying the rocket to the launch pad. The altimeter integrated with our flight computer has static variations of up to 3 meters altitude (in lab), which combined with the movement of the rocket from the preparation station to the launch pad was enough to trigger an erroneous "launch" criteria.

Drag System Updates

In order to mitigate the effects of altimeter fluctuations, the primary indicator in the drag system control algorithm now refers to a change in altitude. If the rocket experiences a change in altitude of 20 meters, it will now assume the motor ignited. Additionally, several failsafe mechanisms were added to the flight computer program to engage and/or disengage the drag system if one indicator fails. Refer to the programming section (3.e.) of this report for the complete programming sequence.



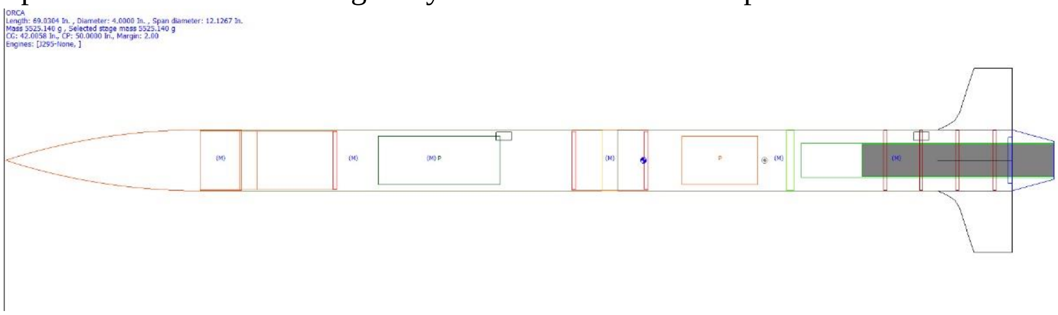
The graph to the left displays the altitude (m), velocity (m) and acceleration (m/s^2) from the 09-April test launch.

5. Center of Pressure & Center of Gravity Analysis

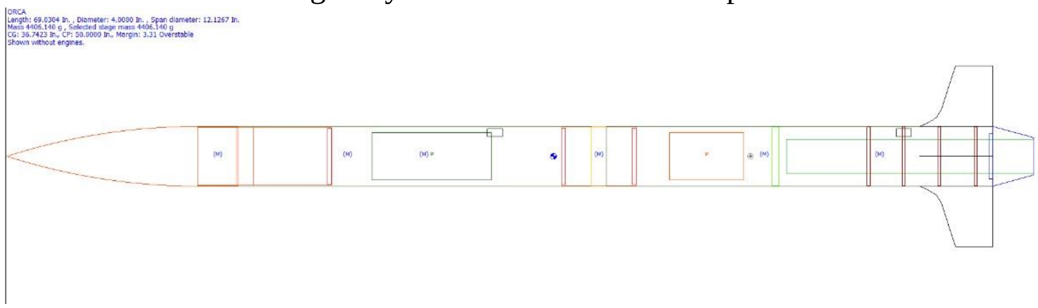
No mechanical or structural design changes were made after the test launch. Therefore, center of pressure and center of gravity remain the same.

The simulation software is not made to accurately calculate dynamic fins such as on the drag system, all static margins in each possible scenario in motor/drag system combinations will be no less than 2 to ensure maximum risk mitigation is rocket instability.

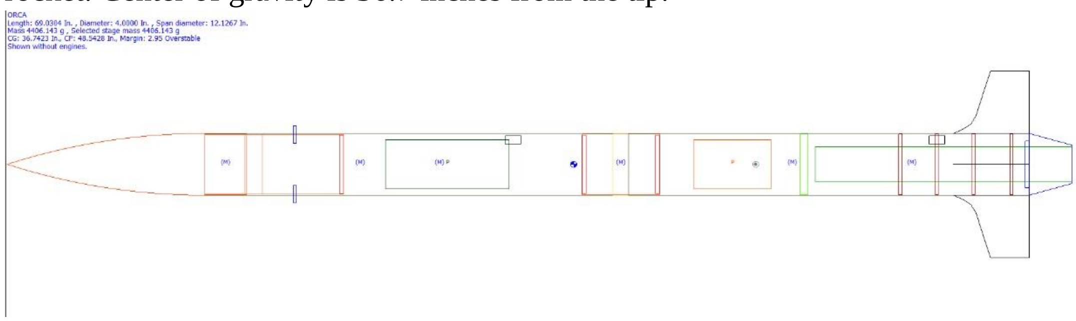
Center of pressure with motor and drag system disengaged is located 50 inches from the tip of the rocket. Center of gravity is 42 inches from the tip.



Center of pressure without motor, drag system disengaged remains 50 inches from the tip of the rocket. Center of gravity is 36.7 inches from the tip.



Center of pressure without motor, drag system engaged is 48.5 inches from the tip of the rocket. Center of gravity is 36.7 inches from the tip.



6. Funding and Budget

Funding for the 2016 High Powered Rocket Team was acquired via the University of Wisconsin-River Falls Undergraduate Research, Scholarly and Creative Activity (URSCA) Grant and the Falcon Travel Grant.

Refer to Appendix B for a line-by-line account of the cost of the UW-River Falls High Powered Rocket Team's participation in the 2016 Space Grant Midwest High-Powered Rocket Competition.

Appendix A: Project Task Tracker

Task Tracker				
2016 Midwest Rocket Competition				
University of Wisconsin - River Falls				
Main Task Category	**Subtask**	**Responsibility**	**Notes**	**Due Date**
Registration	Submit/Email	Mitch	Submit Regration and fee	29-Jan
Declaration of Competition Attendance	Submit/Email	Mitch	Submit List to Midwest Rocket Competition	12-Feb
Declaration of Competition Attendance	Finalize Team Members	Mitch/Adam	Complete at 1st Meeting	9-Feb
Submit Photos to Competition	Submit/Email	Mitch	Email photos of model rocket launch	
Submit Photos to Competition	Launch Model Rocket	All	Launch model rockets at 2nd meeting	4-Feb
Preliminary Design Report	Submit/Email Report	Mitch		18-Mar
Preliminary Design Report	Final Draft	Adam	Final Draft Complete	16-Mar
Preliminary Design Report	Rough Draft	Adam	Rough Draft Complete	9-Mar
Preliminary Design Report	First Draft	Adam	First Draft Complete	2-Mar
Preliminary Design Report	Motor Selection/Design	Mitch/Roman	Select Motor and Design Housing	29-Feb
Preliminary Design Report	Electronics/Circuit Board	Adam/Trevor	Design Circuit Board and housing	29-Feb
Preliminary Design Report	Drag System	Mitch	Complete Design and Mechanism	29-Feb
Preliminary Design Report	Air Frame	Mark/Riando	Complete design of tube, fins and nosecone	29-Feb
Preliminary Design Report	Chutes	Brian	Complete design of parachutes	29-Feb
Preliminary Design Report	Programming	Adam/Trevor	Complete arduino program for controlling drag and chute sy	29-Feb
Test Launch	Conduct Test Launch	All	Test Rocket at North Branch Site	26-Mar
Test Launch	Schedule/Confirm Launch	Mitch	Schedule or Confirm launch availability near 15-Apr	29-Jan
Test Launch - Assembly	Rocket Completely Assembled	All	Assemble all rocket components, then begin painting	18-Mar
Test Launch - Assembly	Motor Assembly Complete	Mitch/Roman	Motor complete and fixed to airframe	18-Mar
Test Launch - Assembly	Electronics/Circuit Board Assembly Com	Adam/Trevor	Elecronics installed in airframe	18-Mar
Test Launch - Assembly	Drag System Assembly Complete	Mitch	drag system installed in airframe	18-Mar
Test Launch - Assembly	Air Frame Assembly Complete	Mark/Riando	air frame assembled and ready for component installation	15-Mar
Test Launch - Assembly	Parachute Assembly Complete	Brian	parachute installed in air frame	18-Mar
Test Launch - Assembly	Programming Assembly Complete	Adam/Trevor	program loaded to microcontroler	18-Mar
Outreach Event	Conduct Outreach Event	All	Event at High School or SPS meeting	22-Apr
Outreach Event	Schedule Outreach Event	Trevor	Event should be the week after test launch, to present the r	25-Mar
Outreach Event	Submit Outreach Form to Competition	Mitch	Email/submit form	22-Apr
Flight Readiness Report	Submit Readiness Report to Competitio	Adam/Mitch	Email/submit form	6-May
Flight Readiness Report	Final Draft Complete	Adam	Prepare for submission	4-May
Flight Readiness Report	Rough Draft Complete	Adam	Prepare for review	29-Apr
Competition Weekend	PowerPoint Slides	Adam	Prepare/inform team on presenation responsibilities	1-May
Competition Weekend	Launch Tasks	All	TBD, pending test launch	
Competition Weekend	Admin/Logistics	Mitch	Hotels, Transportation, etc.	

Appendix B: Budget

2016 Space Grant Midwest High-Powered Rocket Competition								
UWRF High Powered Rocktry: ORCA								
Budget								
Components and Materials	**Unit Price**	**Qty**	**Total**		**Components and Materials**	**Unit Price**	**Qty**	**Total**
Plywood 1/4" 2'x4'	9.92	1	9.92		Racer's Edge 7.2V 1500mAh 6 cell NiCd	10.98	2	21.96
shelf pin 1/4" brass	1.97	1	1.97		ARR Blue AC-98x48" FLC	39.95	1	39.95
1" metal spring clamp	0.99	2	1.98		Blue Tube 98/48	38.95	2	77.90
Sheet Metal Screw Zinc #6x1/2"	1.18	1	1.18		Blue Tube 54/48	23.95	2	47.90
Sheet Metal Screw Zinc #8x1/2"	1.18	1	1.18		LOC PNC-3.90 (98mm)	23.05	1	23.05
Mini Spring Clamp	0.37	2	0.74		Jolly Logic Snap Mount	10.65	1	10.65
8"x10" Non Glare Picture Glazing	1.98	2	3.96		Jolly Logic AltimeterTwo	69.95	1	69.95
Thrded Rod 12x8-32	0.98	1	0.98		Jolly Logic AltimeterThree	99.95	1	99.95
Trnbckle Eye 1/4"x5-1/4"	5.24	1	5.24		Kevlar Shock Cord 1500#	0.92	30	27.60
Paint, Spray Black	7.37	1	7.37		Hatchbox 1.75mm ABS Filament	21.98	1	21.98
Insulating Pipe 3/4C Gray	2.79	1	2.79		Kootek GY-521 MPU-6050	5.99	2	11.98
PVC 3/4"	2.99	2	5.98		Adafruit Altimeter MPL311A2	10.99	2	21.98
CAP 3/4" SCH40	0.69	8	5.52		Adafruit ADA254 SD	14.99	2	29.98
3/4" TEE SXSXS SCH40	0.69	4	2.76		MG996R Metal Gear High Torque Servo	11.99	4	47.96
PIPE SCH40 3/4"/x10 END	2.79	2	5.58		LDO 3.3v 0.8A Voltage Reg	2.00	2	4.00
1/4" Oak Panel	4.39	2	8.78		Ribbon Set	7.29	1	7.29
.22"x24x18" Acrylic Sheet	19.98	2	39.96		Metal Servo Horn	7.99	1	7.99
4x20mm Machine Screws	2.97	3	8.91		5x7cm Protoboards	2.10	1	2.10
Machine Screws Rnd 1/4"	1.18	3	3.54		Osoyoo USB Nano Atmega328p module	7.50	3	22.50
Eye bolt 1/4" x 4	0.48	2	0.96		Tenergy Universal Smart Charger	15.99	1	15.99
Threaded rod 24x10/24	1.46	2	2.92		GPS/altimeter control	458.57	1	458.57
Threaded rod 12x8-32	0.98	4	3.92		Test Motors	85.95	3	257.85
Eye bolt 1/4" x 2-1/2" Zinc	1.18	1	1.18		Micro SD Cards	10.00	2	20.00
Rocker Switch	3.99	1	3.99		Competition Motors	85.95	2	171.90
808 Keychain Camera	7.90	2	15.80		Cesaroni Pro54 4G Casing	84.69	1	84.69
Subtotal			147.11		Subtotal			1,605.67
Components and Materials Total			1,752.78					
Logistics and Administrative								
Competition Registration			400.00					
Shipping			300.00					
Hotels			400.00					
Sustainment			200.00					
Logistics and Admin Total			1,300.00					
Total Costs			**3,052.78**					

Appendix C: Arrival Procedures

Arrival Procedures				
	Task	Initials	Initials	Notes
[ ]	Setup Prep Site			
[ ]	Prepare 6x 1.3g ejection charges			
[ ]	Prepare 2x main parachutes			
[ ]	Prepare 2x drogue parachutes			
[ ]	Layout Launch Materials			
[ ]	Prepare Camera			
[ ]	-remove from fob			
[ ]	-add SD card			
[ ]	-mount camera			
[ ]	Flight Computer			
[ ]	-drag system off			
[ ]	-confirm flight load			

Appendix D: Recovery Procedures

Recovery Procedures				
[ ]	Task	Initials	Initials	Notes
[ ]	Recover Rocket			
[ ]	Remove e-bay			
[ ]	Conduct structural integrity inspection			
[ ]	Retrieve Alt. 2			
[ ]	Transfer Alt. 2 to judges			
[ ]	Flash Arduino with target altidude			
[ ]	Continue to PreLaunch Proecedures			

Appendix E: Launch Pad Procedures

Launch Pad Procedures				
	Task	Initials	Initials	Notes
[ ]	Load Rocket on to Rails			
[ ]	Power on Camera			
[ ]	Connect to Teletrum			
[ ]	Enter Configure Altimeter			
[ ]	Confirm vertical position of rocket			
[ ]	Reboot telemetrum in configure window			
[ ]	Enter Monitor Flight Window			
[ ]	Confirm continuity of charges			
[ ]	Place Main motor charge/igniter			
[ ]	Test continuity with igniter			
[ ]	Procedure to Launch Position			

Appendix F: Pre-Launch Procedures

PreLaunch/Prep Procedures				
	Task	**Initials**	**Initials**	**Notes**
[ ]	Load New Camera			
[ ]	-confirm SD card present			
[ ]	Screw e-bay to airframe			
[ ]	Load Motor			
[ ]	Confirm attachment of D ring to e-bay			
[ ]	1 layer dog barf top			
[ ]	2x 1.3g ejection charge top			
[ ]	1 layer dog barf top of charges			
[ ]	Weave main chute cord and pack			
[ ]	-wod cloth facing charges			
[ ]	Place main chute covered in wad cloth			
[ ]	Connect charge wires to center coupling			
[ ]	Confirm D-ring to coupler			
[ ]	Place Coupler to top portion			
[ ]	Confirm attachment of D ring to bottom half			
[ ]	Load 1 layer dog barf to bottom			
[ ]	Attach charges to coupler, place charge to bottom			
[ ]	Load 1 layer dog barf			
[ ]	Wod cloth facing charges			
[ ]	Confirm D-ring on parachute			
[ ]	Load drogue parachute			
[ ]	Load weaved drogue line			
[ ]	Close rocket			
[ ]	Continuity Test with telemetrum			
[ ]	-Install sheer pins if test passed			
[ ]	Plug in main power to flight computer			
[ ]	Confirm program flash status (drag on / off)			
[ ]	Prepare Altimeter 2			
[ ]	-confirm on status Alt. 2			
[ ]	-Install and confirm bolt status			
[ ]	Secure NoseCone			
[ ]	Procede to Launch Pad			
[ ]	Start Launch Pad Procedures			