NORTHWEST INDIAN COLLEGE
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98226

Northwest Indian College Space Center USLI Team

2010-2011 NASA USLI Critical Design Review

January 24, 2011

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Northwest Indian College Space Center
RezRiders
Critical Design Review

I) Team Summary

Team name: RezRiders
Rocket Name: Frankenstein

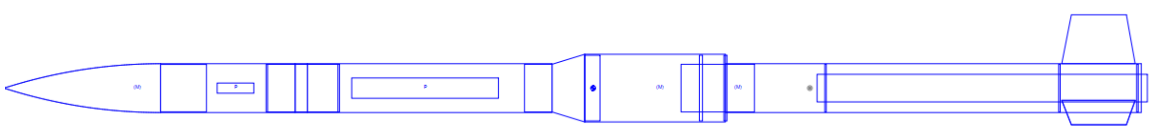
Location: Northwest Indian College, 2522 Kwina Road, Bellingham, WA, 98226
Lummi Nation Reservation

Team official/Mentors

Gary Brandt – Team Advisor NAR L2
David Oreiro – Assistant Team Advisor – NAR L2
William Munds –Mentor – NAR L2

Launch Vehicle Summary

Length: 93.4750 In. , Diameter: 5.5400 In. , Span diameter: 12.0000 In.
Mass 10.686509 Lb. , Selected stage mass 10.686509 Lb.
CG: 48.1674 In., CP: 65.8839 In., Margin: 3.20 Overstable
Shown without engines.



Size:

- 93.48 Inches
- Diameter: Main Airframe – 4 inches; Science Payload Bay – 5.54 inches
- 12.00 Inches span diameter
- 10.69 Pounds – fully loaded w/o motor
- 48.17 Inches Center of Gravity
- 65.88 Inches Center of Pressure
- 3.20 Static Margin (over stable)

Motor choice: CTI K660 Classic
Recovery system: Redundant dual deployment parachutes using two Perfectflite MWAD altimeters on separate power systems.
Rail size: 72" x 1" x 1" 80/20 1010 T-slotted aluminum mounted on ¾" black pipe tripod

Payload Summary

We are doing the NASA SMD's scientific payload that monitors atmospheric temperature, humidity, barometric pressure, solar irradiance, and UV radiation. Images will be taken during descent and upon landing. Additionally we are measuring rocket roll and science payload bay temperature.

II) Changes Made Since PDR

Changes Made to Vehicle Criteria

Rocksim predicted that Frankenstein should achieve 2,890 feet with the J500G under ideal conditions. As mentioned earlier, its apogee was 1,429 feet, well short of the prediction. We went back to the drawing board and modified the Coefficient of Drag until we matched the predicted to actual altitude. The adjusted CD is 0.57. After having done that, we discovered that there are no 54mm motors, Aerotech or CTI, that would get us close to the target 5,280 feet.

This afforded us an opportunity to re-evaluate our design, have a check of our planning, testing, and data analysis. We have made some design changes that are not difficult nor time consuming, but are significant in the achieving the desired results.

1. We have lengthened the main parachute bay from 15 inches to 20 inches. We deduced that the main parachute may have failed to deploy partially because we had to stuff the parachute into the bay because of the limited room in the main parachute bay. Additionally, the ematch did fire; however, there was some unburned BP in the main parachute's BP cup which indicated that match wasn't "hot" enough or something inhibited the BP from burning. It appears to have a bit of a "bump" on the flight data readout at/near the 500 foot level.
2. We have reduced the science payload bay's diameter from 7.67 inches to 5.54 inches.
3. Interestingly, Rocksim shows an increase in airspeed and altitude if we eliminate the aft transition; therefore, we have eliminated the aft transition from the 5.54 inch science payload bay to the 4 inch airframe and replaced it with series of centering rings.
4. We have a new forward transition that matches the 5.54 science payload bay to the 4 inch airframe.
5. The aft rail button stand-off has been shortened to maintain alignment with the forward rail button fastened to the 5.54 inch science payload bay.
6. We have shortened the fins by 4 inches, thereby reducing the span from 20 inches to 12 inches.

These changes give us a predicted altitude, using the Coefficient of Drag from our first Frankenstein launch and a Cesaroni Technologies Incorporated K660-17A, of 5,392 feet with the rocket fully loaded. We, of course, will be making further test flights to refine our CD calculations.

Changes Made to Payload Criteria

The smaller science payload bay (from 7.67" to 5.54") requires us to reposition some of the printed circuit boards and to modify the connections of the data logger memory sticks.

Changes Made to Activity Plan

Three major events have required changes to our activity plan:
1. Changing Frankenstein's design
2. Rain, rain, and more rain
3. Our launch area was inadvertently requisitioned by the Lummi Natural Resources Department.

The changes in Frankenstein's design requires additional ground testing as well as flight testing. And, this is directly impacted by 2., the RAIN.

The Pacific Northwest is experiencing a very wet winter Two scheduled launches since December 5, 2010 have had to be scrubbed because of either active precipitation on launch day, or because a large portion of the recovery area was under water. As of this writing (1/20/11), the Lummi Nation Reservation has had three of its four access roads blocked by flood waters since 1/15/11.

On January 1, Dave Oreiro, our assistant advisor contacted me and sent a text photo of a 200 foot tower and its required supporting guy wires, in the middle of our cleared launch area. This happened as a result of some miscommunication and was partially rectified within the following week and the Lummi Department of Natural Resources have since helped us locate a temporary, but not nearly as suitable, area near enough to our original to not require re-filing our launch waiver. Unfortunately, one of the only high spots within the FAA required launch parameters now holds that 200 foot tower.

III) Vehicle Criteria

Design and Verification of Launch Vehicle

<u>Flight Reliability Confidence</u>

Mission Statement

Through the USLI program the Northwest Indian College Space Center's RezRiders Team enhances its involvement in science, math, engineering and technology and encourages others in Tribal communities to do the same.

Mission Requirements

RezRider's Rocket will:

1. utilize the Science Mission Directorate (SMD) option to build and fly a deployable science payload meeting the following minimum criteria:

    a. The payload will gather data for studying the atmosphere during descent and after landing. Measurements will include pressure, temperature, relative humidity, solar irradiance and ultraviolet radiation. Measurements will be made at least every 5 seconds during descent and every 60 seconds after landing. Surface data collection operations will terminate 10 minutes after landing.
    b. The payload will take at least 2 pictures during descent and 3 after landing.
    c. The payload will remain in an orientation during descent and after landing such that the pictures taken portray the sky toward the top of the frame and the ground toward the bottom of the frame.
    d. The data from the payload will be stored onboard and transmitted to the team's ground station after of completion of surface operations.
    e. Additional experiments include:
        i. Measure the science payload bay temperature
        ii. Detect and measure rocket roll

2. deliver the science payload closest to, but not exceeding an altitude of 5,280 feet above ground level (AGL).

3. carry two Perfect Flight MAWD altimeters for recording and one will be designated for the official altitude used in the competition scoring.
4. utilize recovery system electronics that has the following characteristics:

    a. Redundant altimeters.
    b. Each altimeter will be armed by a dedicated arming switch and have a dedicated battery.
    c. Each arming switch will be accessible from the exterior of the rocket airframe.
    d. Each arming switch will be capable of being locked in the on position for launch.
    e. The recovery system will be designed to be armed on the pad.
    f. The recovery system electronics will be completely independent of the payload electronics.

5. remain subsonic from launch until landing.
6. be designed to be recoverable and reusable.
7. use dual deployment recovery.
8. use removable shear pins for both the main parachute compartment and the drogue parachute compartment.
9. have a landing velocity under the main parachute between 17 and 22 ft/s, inclusive.
10. have a descent rate under the drogue parachute between 50 and 100 ft/s, inclusive.
11. be capable of being prepared for flight at the launch site within 4 hours, from the time the waiver opens at the field until RSO inspections have been successfully completed.
12. be designed to land within 2500 ft. of the pad with a 10 mile/hour wind.
13. be capable of remaining on the pad for 1 hour before launching without losing the functionality of any vehicle or payload component after being fully armed for launch.
14. be launched from a standard firing system (provided by the Range) that does not need additional circuitry or special ground support equipment to initiate the flight or complicate a normal 10 second countdown.
15. Data from the science or engineering payload will be collected, analyzed, and reported by the team following the scientific method.
16. use a GPS tracking device that transmits the rockets position to the ground.
17. use only commercially-available motors that have approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA) and/or the Canadian Association of Rocketry (CAR).
18. not use motors which expel titanium sponges (Sparky, Skidmark, MetalStorm, etc.).
19. provide our launch equipment and motors, with the exception of the electronic launch system which will be provided by the range.

Furthermore

20. We will successfully launch our full scale rocket prior to Flight Readiness Review (FRR) in its competition flight configuration, and,
21. The flight certification form will be filled out by Bill Munds our L2 NAR mentor and observer.

Mission Success Criteria

Criteria number 1 is no individual is harmed or put at risk through the team’s failure to successfully identify and mitigate a hazard.

Flight success criteria:

- attain an altitude within .01% of 5280 feet
- rocket launches as designed
- drogue parachute deploys at apogee
- main parachute deploys at 500 feet above ground level
- descent rates are within design parameters
- recovery is within 2500 feet of the launch pad
- rocket is recovered with minimal damage and able to be launched again within four hours

Picture success criteria:

- Pictures are oriented within 95% of normal viewing orientation

Science payload success criteria:

- 85% of the measurement applications function as designed
- 100% of the data is collected from the functioning science applications

Schedule and Time Line (milestones in bold italics)

October 2010:

1 One electronic copy of the completed proposal due to NASA MSFC.
4 Web presence established
4 Post proposal and MSDS on website
5 Parts ordered for scale rocket
12 Schools notified of selection
12 Order altimeters
13 Construct scale rocket
14 Order science payload components
20 Meet with Bill Munds, NAR L2 mentor
21 USLI team teleconference (tentative)

November 2010:

3 Test recovery ejection systems
3 Begin assembling and testing payload components
6 Dual deployment test & NAR L2 certification flights
6 Launch scale rocket
19 Preliminary Design Review (PDR) report and PDR presentation slides posted on the team Web site
29 Full-scale rocket construction complete
30 ~~Full-scale rocket low-altitude test flight~~

December 2010:

5 Test flight of full-scale rocket
6-10 Preliminary Design Review Presentations (tentative)

January 2011:

15 ~~launch competition rocket~~
22 – ~~23 launch competition rocket~~ (1/21 more rain and flooding!!)

24 Critical Design Review (CDR) reports and CDR presentation slides posted on the team Web site.
25 Finalize competition team
28 All science experiments complete and tested
29-30 launch competition rocket with J300G

February 2011:

2-8 Critical Design Review Presentations (tentative)
19 Hi altitude launch competition rocket w/o science payload

March 2011:

12 Hi altitude launch competition rocket with science payload
21 Flight Readiness Review (FRR) reports and FRR presentation slides posted on the team Web site.
28-31 Flight Readiness Review Presentations (tentative)

April 2011:

13 Travel to Huntsville
14-15 Flight Hardware and Safety Checks (tentative)
16 Launch Day

May 2011:

9 Post-Launch Assessment Review (PLAR) posted on the team Web site.
20 Announcement of winning USLI team

System Level Design Review

The general design review of Frankenstein is outlined in the following table, where the requirements and our selection rationale are presented.

System	Sub-System	Requirements	Selection Rationale
Air Frame	Polystyrene Nosecone	Aerodynamic and lightweight to assist in reducing drag during flight.	Commercially available
	Kraft Phenolic Airframe	Withstand the pressure of flight and adequately contain all the payload equipment.	Commercially available and flight proven for the size of our rocket and motor combination. The edges are coated with CA glue to strengthen them and help resist de-lamination.
	¼" Birch Aircraft Plywood Bulkheads	Withstand the aerodynamic forces of flight and landing. Provide secure anchoring for the airframe, motor mount and science experiments.	Strong, flexible, easily cut and shaped. Additionally, various adhesives bond very strongly
	Kraft Phenolic Couplers	Connect different sections of the airframe together. When used in conjunction with the Electronics Bay and drogue and main parachutes, the couplers permit easy separation. When used in conjunction with the science payload bay, the couplers permit easy access and a strong connection point.	Commercially available and flight proven for the size of our rocket and motor combination. The edges are coated with CA glue to strengthen them and help resist de-lamination.
	¼" Birch Aircraft Plywood Fins	Withstand the aerodynamic forces of flight and landing. Provide sufficient rigidity to avoid fin flutter as well as an adequate bonding surface.	Strong, flexible, easily cut and shaped. Additionally, various adhesives bond very strongly
Propulsion	Motor	Propel the vehicle to one mile in altitude without going supersonic.	Use a combination of Rocksim design and prediction and test flights to choose adequate motor.
	Motor Mount Tube	Withstand acceleration forces while maintaining motor alignment with air frame.	Commercially available and flight proven for the size of our rocket and motor combination.

	Motor Mount Centering Rings	Withstand acceleration forces while maintaining motor alignment with air frame.	Commercially available and flight proven for the size of our rocket and motor combination.
	Motor Retention system	Easily applied and adjusted while restraining the motor so that it remains with the rocket.	Inexpensive and easily obtained materials that can be fashioned to fit various motor systems/
Recovery	Shear pins	Withstand the forces of drag separation and still shear under the ejection force of the parachute deployment black powder charges.	Required by USLI mission requirements.
	Drogue Parachute	Bring the rocket down from apogee between 50 and 100 f/s.	Parachute is commercially available and flight proven for the size of our rocket and motor combination.
	Main Parachute	Bring the rocket down from 500 feet above ground level between 17 and 22 f/s.	Parachute is commercially available and flight proven for the size of our rocket and motor combination
	Altimeters	Record altitude; provide an interface between the rocket's altitude and electronics to deploy parachutes.	Required by USLI mission requirements.
	Black Powder	Provide sufficient gas pressure to separate the parachute air frame components and release the parachutes.	Ejection material of choice by HPR rocket builders/flyers. Numerous sources for calculating appropriate amounts for successful parachute ejection.
Science Payload	Basic Stamp Microcontroller	Control sensors and record data	Students have some familiarity with constructing and programming. Required by USLI project.
	Mini camera	Record images	Required by USLI project.

Updated Drawings and Specifications

The following is a detailed description of Frankenstein's components listed from the nose cone to the motor retainers.

Commercial components are from LOC precision. West Systems epoxy resin was used for construction adhesive. All edges that are slip joints are reinforced with CA glue. This provides a hard surface that facilitates inserting the tubes within each other and reduces damage to the Kraft Phenolic edges. All screw holes are also reinforced with CA glue. This creates a firmer connection medium and helps prevent distortion of the screw holes.

Nose Cone

Weight: 5.64 oz
Size: 12.8” x 4.0”
Material: Polystyrene
Payload: Astro 220 DC20 GPS Transmitter and ¼” birch aircraft plywood mounting platform with ¼” eyebolt for drogue parachute attachment.

This is a stock LOC Precision nose cone whose base has been modified so that a Garmin Astro 220 DC20 GPS unit can be inserted. The DC20 is mounted on a ¼ inch birch plywood platform that is inserted into the nose cone.

The nose cone is attached to the drogue parachute bay with two #6 5/8” screws that pass through the airframe tube into the DC20 GPS’s plywood bulkhead via the polystyrene nose cone shoulder.

Drogue Parachute Bay

Weight: 0.9 oz
Size: 11” x 4” diameter LOC Precision airframe tubing
Material: 4” Kraft Phenolic
Payload: 17” drogue parachute

The drogue parachute bay is LOC Precision 4” airframe tube. The open edges are reinforced with CA glue for a hard surface that facilitates inserting the tubes within each other and reduces damage to the Kraft Phenolic edges. The screw holes are also reinforced with CA glue for a firmer connection medium that helps prevent distortion of the screw holes.

3 1/8” vent holes allow for easier separation from the electronics bay during the drogue ejection sequence.

Electronics Bay

Weight: 20.28 oz
Size: 6” x 4” diameter
Material: 4” x 1” Kraft Phenolic tubing over
3.9” x 6” Kraft Phenolic tube coupler
3.8” x 5.5” Kraft Phenolic “stiffy”
2 - ¼” x 3.9” diameter ¼” birch aircraft plywood bulkheads
4 – ½” x 1” PVC black powder cups
2 – ¼” x 2” eye bolts, washers, and retaining nuts
5” x 4” 3/16” plywood mounting platform for electronics
2 - 5” x ¼” diameter Kraft Phenolic tubing as rail guides
2 - 7” x ¼” diameter threaded rod as rails and fasteners for the bulkheads
4 – ¼” nuts
2 – ¼” thumb screws
8 – 40 x 1 ½” brass headless screws to connect electronics to electric matches
16 – 40 brass nuts

Payload:
2 – Perfectflite MAWD altimeters
2 – 9v batteries
2 – contact switches to power MAWD altimeters
1/8” rod to trigger switches


Main Parachute Bay

Weight: 7.6 oz
Size: 20” x 4” diameter LOC Precision airframe tube
Material: 4” Kraft Phenolic
Payload: 72” main parachute

The main parachute bay is LOC Precision 4” airframe tube. The open edges are reinforced with CA glue for a hard surface that facilitates inserting the tubes within each other and reduces damage to the Kraft Phenolic edges. The screw holes are also reinforced with CA glue for a firmer connection medium that helps prevent distortion of the screw holes.

Three 1/8” vent holes allow for easier separation from the electronics bay during the main ejection sequence.

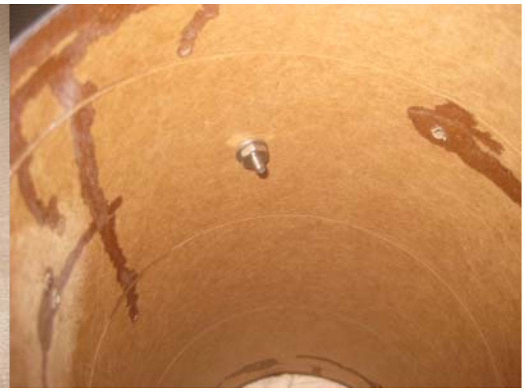
Forward Transition

Weight: 17.1 oz (with parachute connection hardware)
Size: 6” long, 3.9” fwd diameter with 2” shoulder, 5.54” diameter with 2” shoulder. 2” exposed
Material: balsa wood

The forward transition is solid balsa wood. A ¼” threaded rod is through-bolted with 1” washers at either end to provide a mounting point for the main parachute. A 3” x ½” strap is formed around the 1” washer and a 220 lb breaking strength quick link completes the forward transition parachute mounting system. The 5.54” base is fastened to the science payload bay with 6 - #6 5/8” screws.

Science Payload Bay

Weight: 6.7 oz
Size: 11.5” x 5.54” diameter LOC Precision airframe tub
Material: Kraft Phenolic
Payload: Science experiments



The science payload bay is LOC Precision 5.54” airframe tube. The open edges are reinforced with CA glue for a hard surface that facilitates inserting the tubes within each other and reduces damage to the Kraft Phenolic edges. The screw holes are also reinforced with CA glue for a firmer connection medium that helps prevent distortion of the screw holes.

The forward rail button is through-mounted near Frankenstein’s center of gravity.

Openings will be made for the various measuring probes, UV, IR, temperature, humidity and camera.

Aft Transition

Weight: 3.5 oz
Size: 6” x 3.9” diameter
Material: 3.9” LOC Precision coupler tube
    2 – 5.38” to 3.9” centering rings
    ¼” birch aircraft plywood for increased mounting surface.
Payload: Rear-looking cameras

The aft centering ring has been notched to support and restrain the three aft-facing cameras. Three 1/8” thread rod will be fastened via t-nuts to the forward most centering ring. These will support the science printed circuit boards. The battery packs will be mounted in the aft end of the aft transition to keep the center of gravity low.

The open edges are reinforced with CA glue for a hard surface that facilitates inserting the tubes within each other and reduces damage to the Kraft Phenolic edges. The screw holes are also reinforced with CA glue for a firmer connection medium that helps prevent distortion of the screw holes.

Fin Can

Weight: 11.7 oz
Size: 4” x 34” LOC Precision airframe tube
Material: Kraft Phenolic

The fin can is LOC Precision 4” airframe tube.

The open edges are reinforced with CA glue for a hard surface that facilitates inserting the tubes within each other and reduces damage to the Kraft Phenolic edges. The screw holes are also reinforced with CA glue for a firmer connection medium that helps prevent distortion of the screw holes.

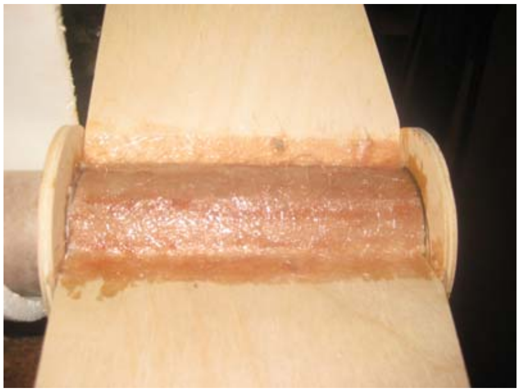
Rail Button Stand-Off

Weight: .5 oz
Size: 2” x 1”
Material: ¼” birch aircraft plywood

A rail button stand-off is needed because the diameter of the science payload bay is about 1 1/2” larger than the main airframe, 5.54” to 4” respectively. The stand-off goes through the airframe, in the same fashion as through-the-wall fin mounting. It is fiber glass and epoxy resin reinforced at its attachment points. The rail button is bolted to the stand-off with a 1” bolt.

Fins

Weight: 10.6 oz
Size: 6” base root, 4.5” tip root, 4” span
Material: ¼” birch aircraft plywood



The fins were “oversized” for this rocket because of the uncertainty of effect of turbulence generated by the larger science payload bay. Our test flight on December 5, 2010 did not show any adverse effect from the, at that time, 8” diameter science payload bay. Since the test flight, we have shortened each fin by 4”. Rocksim indicates that Frankenstein is still over stable. However, the shortened fins will give us more altitude.

The fins are mounted via the through-the-wall method. The aft end of the airframe tube is cut for the fins with the cut extending to the end of the airframe. Three centering rings are mounted on the motor mount tube; 1 at the forward end of the motor mount, 1 at the forward end of the fins and 1 and the aft end of the fins. The fins are then tacked to the motor mount using the airframe and its fin slots for alignment. When the fins are dry the fin/motor mount assembly is removed from the fin can whereupon fiberglass reinforcement can be applied to the fins and the motor tube.

The fins have a tab and are mounted through the airframe wall and butt against the motor mount. They are fastened to both the airframe and to the motor mount with West Systems epoxy resin. Furthermore, the fin tabs are bonded to the motor mount with fiberglass and epoxy resin. The fiberglass runs from the top of one fin tab, over the motor mount and to the top of the adjacent fin tab; the fiberglass is then coated with West Systems epoxy resin to bond all in place.

T-nuts are fastened to the aft centering ring to provide secure motor retention.

The fin/motor mount assembly is then fastened in place in the fin can with West Systems epoxy resin. Epoxy resin and micro-bubbles are used to make the filets between the fins and the airframe.

Similarly, the stand-off goes through the airframe to the motor mount. It is fiber glass and epoxy resin reinforced at its attachment points.

Motor Tube

Weight: 7.5 oz (includes 3 centering rings)
Size: 27” long, 54mm LOC Precision motor mount
Material: Kraft Phenolic

Three centering rings are mounted on the motor mount tube; 1 at the forward end of the motor mount, 1 at the forward end of the fins and 1 and the aft end of the fins.

Motor Retainer

Weight: 0.5 oz
Size: ½” x 3”
Material: galvanized iron

The motor retainer is made from two ¾” conduit straps that have been formed to securely hold the motor in place. The straps are placed over the base of the motor and are fastened to the aft motor mount bulkhead with #8 1 ½” long bolts. The bolts seat in T-nuts on the underside of the bulkhead.

The photo here is with a Rouse Tech 54mm motor casing. Since we are not using motor ejection but rather altimeter-based electronic ejection, the motor retention devices will not be subjected to extreme backward forces.

DEMONSTRATE THAT THE DESIGN CAN MEET ALL SYSTEM LEVEL FUNCTIONAL REQUIREMENTS.

Frankenstein has been made about 2” thinner and 3” longer. The length was added to the main parachute bay to ensure that the parachute would not have to be stuffed into the bay and become a potential factor for non-deployment. We reduced the science payload bay’s diameter by 2 inches to reduce aerodynamic drag and increase the likelihood of reaching the target altitude of 5,280 feet AGL.

Construction techniques have remained the same as the original build. West Systems epoxy resin has been used through out as the adhesive of choice. West Systems epoxy resin impregnated fiberglass cloth has been used at key structural points such as fin-to-airframe connection, and the aft rail button-to-airframe connection. Cyanoacrylate glue, CA, has been liberally applied wherever the Kraft phenolic tubes slide into one another. This technique helps eliminated wear and tear on the airframe tubes while attempting to join them as in the case of sliding the EBay into the drogue and main parachute bays. CA glue has also been applied to all openings in the airframe and the science payload bay. We’ve done this to strengthen the cardboard to prevent distortion when using screws as well as to provide a more secure mounting medium. Therefore we are very confident that the design can meet all system level functional requirements.

The RezRiders team will be doing additional static testing of the parachute deployment process. Frankenstein will be flown several more times with lower power motors in order to remain within our altitude waiver so that we can improve our altitude prediction skills, and, at full power with full load, again to verify our predictions.

The manufacturing and assembly status of the airframe and the recovery system is complete. Propulsion choices are being refined. All that remains is to choose a color scheme and apply it to Frankenstein.

Analysis Results

Test Results

Our design is a bit unusual in that our rocket, Frankenstein, had 7.67 inch science payload section on a 4 inch airframe. We had indicated in our PDR and our presentation that we would be using an Aerotech K1250 for our competition flight. On December 5, 2010, the Northwest Indian College RezRiders launched its full-scale USLI competition rocket. We used an Aerotech J500G with a 54mm to 38mm motor adaptor. We chose this motor to ensure that we had a safe thrust-to-weight ratio and liftoff speed to establish stability prior to leaving the pad.

Launch guide data from Rocksim:

- Launch guide length: 72.0000 In.
- Velocity at launch guide departure: 68.0876 ft/s
- The launch guide was cleared at : 0.195 Seconds
- User specified minimum velocity for stable flight: 43.9993 ft/s
- Minimum velocity for stable flight reached at: 29.5961 In.

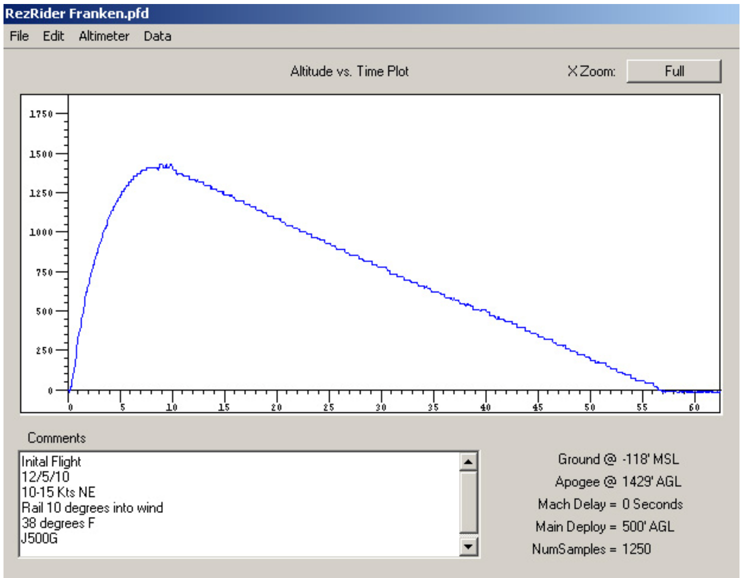
Frankenstein carried a Garmin Astro 220 DC20 GPS tracker and a single dual deployment package. No other weight was included for this flight.

The weather was a chilly 38 degrees and the wind was blowing 15 kts as measured by our portable weather station. The launch rail was tilted 10 degrees into the wind to compensate for drift. Frankenstein lifted off the pad as designed and flew to 1,429 feet. The drogue ejected at apogee and the main failed to deploy. Frankenstein landed undamaged about 300 feet from its launch site. We had used a larger drogue to ensure a safe recovery, whether or not the main deployed.

PREDICTED ALTITUDE VS ACTUAL ALTITUDE

2,890 feet predicted altitude with an Aerotech J500G with simulated wind set to 8-14 Kts and the launch rail angled 10 degrees into the wind.

1,429 feet actual altitude with an Aerotech J500G with wind mostly at 15 kts and launch rail angled 10 degrees into the wind.



Flight Data from PerfectFlite MAWD altimeter

Here is a YouTube link to a [video of Frankenstein's Flight]

We have worked extensively with Rocksim and changed the Coefficient of Drag to have the simulated launch altitude be very near the actual altitude. We, of course, matched the weather conditions in the simulation as closely as possible to the actual weather conditions of the flight on December 5, 2010.

As a result, the CD has been changed to 0.57, which will override Rocksim's calculated CD.

Motor selection

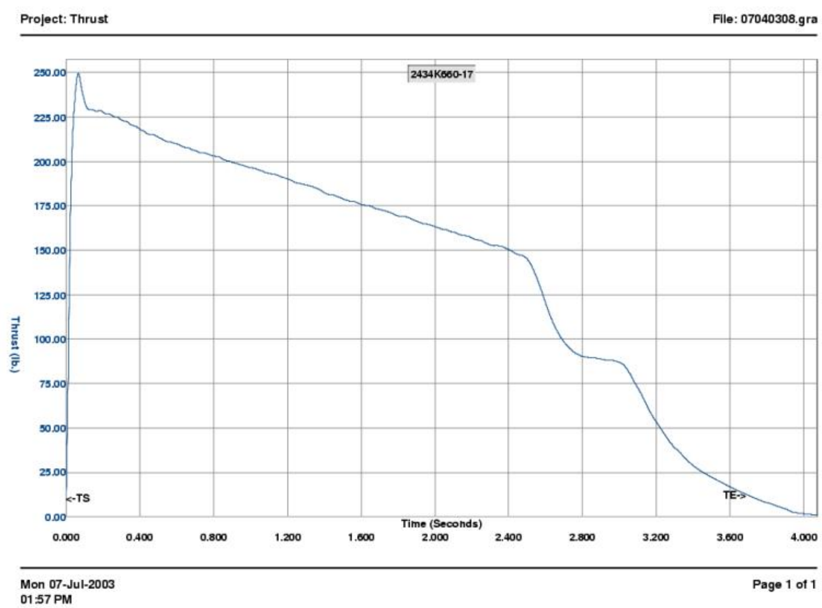
Based upon our flight test results and the redesign of Frankenstein, we reexamined our initial motor choices. We want a relatively slow burn time that will not exceed 17 g's of acceleration and yet provide sufficient thrust-to-weight for a safe launch rail exit speed.

We are choosing the Cesaroni K660-17A motor. It has the following characteristics:

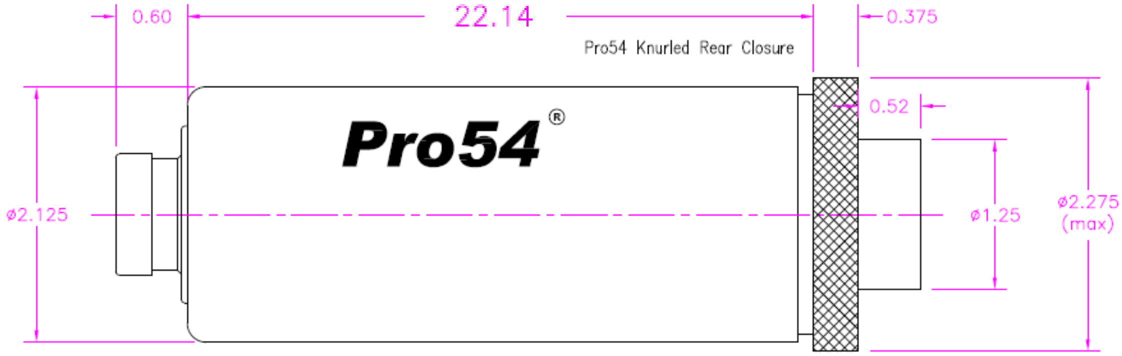
Cesaroni K660

Motor Data

Brandname	Pro54 K660 Classic	**Manufacturer**	Cesaroni Technology
Man. Designation	2437 K660-17A	**CAR Designation**	K660-A
Test Date	2003-07-06		
Single-Use/Reload/Hybrid	Reloadable	**Motor Dimensions mm**	54.00 x 572.00 mm (2.13 x 22.52 in)
Loaded Weight	1949.00 g (68.22 oz)	**Total Impulse**	2437.00 Ns (548.33 lb/s)
Propellant Weight	1177.00 g (41.20 oz)	**Maximum Thrust**	1078.90 N (242.75 lb)
Burnout Weight	734.00 g (25.69 oz)	**Avg Thrust**	659.00 N (148.28 lb)
Delays Tested	17 - 7 secs, infinitely adjustable	**ISP**	211.10 s
Samples per second	1000	**Burntime**	3.69 s
Notes	Classic Propellant		



Furthermore, the CTI K660-17A is listed in the January/February 2011 "Sport Rocketry", the official journal of the National Association of Rockery in the Comprehensive CAR/NAR/TRA Rocket Motor Certification List, page 36 as a currently certified motor.



Airframe and Flight Subsystems Verification Plan

We have constructed and flown our full-size rocket, Frankenstein, with the exception of the science payload. We want to be as certain as possible that Frankenstein successfully launches, fly's, and is recovered before we test fly with the science payload. We have flown the rocket without the science payload and have tested these components, both vehicular and science:

• Launch and recovery of full scale rocket	successful
• Flight test of Garmin Astro 220 GPS tracking system	successful
• Black Powder ejection test without altimeters	successful
• Black Powder ejection test with altimeters	successful
• Flight test of dual deployment recovery system	50%
• Drogue deployment during flight test	successful
• Main deployment during flight test	0%
• Safe main parachute-to-ground descent rate	no damage
• Science sensor modules ground tested after building	80%
• Predicted altitude	50% successful
• Launch rail and GSE equipment function	successful
• Recovery team performance	successful
• Range setup	successful
• Safety implementation	successful

Verification Plan and Its Status

To date we have accomplished the mission goals with minor schedule changes. We've adapted our Schedule and Time Line to reflect anticipated difficulties.

Mission	Criteria as of 1/24/11	Completion/Test Date	Data Recovery %	Success %
Scale rocket	Complete	10/20	N/A	100%
Scale rocket flown	Yes	11/6	N/A	100%
Altitude prediction	3000'	11/6	100%	72%
BP test	Eject drogue & main	11/3	N/A	100%
GPS tracker test	Track rocket	11/6	100%	100%
Competition rocket built	Yes	11/19	N/A	
Competition rocket launch	Yes	12/5/10	N/A	
Competition altitude prediction	2,890'	12/5	100%	49%
Photography	Capture images	11/6	100%	100%
Photos properly oriented	98% vertical	1/29		
Competition rocket launch	Competition motor	2/5/11		
Altitude prediction	100%	1/29		
Prototype science modules built: Atmospheric temp Atmospheric pressure Humidity UV Solar Irradiance Interior temp Rocket roll	 95% 80% 100% 100% 100% 90% 75%	1/29		
Prototype science module tested: Atmospheric temp Atmospheric pressure Humidity UV Solar Irradiance Interior temp Rocket roll	 90% 50% 100% 100% 100% 80% 75%	1/29		
Actual science modules built: Atmospheric temp Atmospheric pressure Humidity UV Solar Irradiance Interior temp Rocket roll	 0% 0% 0% 100% 100% 25% 25%	2/15		

Actual science modules flight tested	0%	3/12		
Competition rocket launch	Competition motor	2/26		
Altitude prediction	100%	1/29		
Competition rocket launch	Competition motor	3/12		
Altitude prediction	100%	3/12		

Quality control via frequent inspections by several team members will make certain that each part we use doesn't have any visible flaws or anomalies that could reduce performance and cause failure of one or more systems in Frankenstein. Ground tests will determine the amount of black powder necessary to ensure that the calculated black powder quantities shear the pins consistently and that there is enough force to eject the drogue and main parachute bays. Preflight and post flight checks via checklists with ensure that our rocket remains structurally sound. We will also make sure that the motor casing gets cleaned immediately and thoroughly after use and is carefully inspected to ensure that there is nothing to cause problems and potential catastrophic failure of the motor. Continuous weighing and entering the weights into Rocksim will ensure that our predictions are made on the best information available.

Safety and Failure Analysis

We have been able to re-examine our safety and failure analysis since the scale flight and the full-size flights. The biggest changes are the confidence increase and knowledge that our design flies.

Personal Safety Hazards	***Potential Effects of Failure***	***Failure Prevention***	***Occurrence Probability***
Individual health issues when working with epoxy, fiberglass, paint, etc.	Person will become sick or experience discomfort.	Wear appropriate safety clothing/equipment such as gloves and clothing to cover skin, face masks, etc. Have adequate ventilation. Have MSDS prominently posted.	1%
Accidental injuries such as lacerations, bruises, etc.	Harm to team members (possible hospitalization).	Be attentive to task at hand. First aid kit is available.	10%
Potential fire when working with flammable substances	Harm to team members (possible hospitalization).	Be aware of locations of nearest first-aid kit, fire extinguisher, and eye wash station	0%
Untidy work area	Harm to team members (possible hospitalization). Loss of tools, hazardous working conditions	Everything has a place and everything in its place. Clean up debris during and after working.	25%

Schedule Risks	***Potential Effects of Failure***	***Failure Prevention***	***Occurrence Probability***
Team members have other obligations that interfere with presentations or launches.	Team participation decreases which results in lower membership.	Notify team members of any presentations, launches, or due dates well ahead of time.	25%
Team has difficulties meeting set deadlines.	Deadlines will not be met.	Assign enough time for the completion of tasks.	10%
Meeting times conflict with certain members' schedules.	Certain members will be unable to attend meetings and will miss important information.	Choose times that best fit the majority of the membership. The team will also work with members that still have conflicts.	80%
NWIC's exams and/or holidays overlap with deadlines set by USLI.	Reports or presentations might not be completed.	Check the dates of final exams, holidays, and major events against the USLI timeline and PLAN!.	35%
NWIC sessions changes from fall to winter to spring quarter.	Team members' schedules will change.	Vote by majority for meeting times and plan accordingly.	100%

Financial Support Failures	Potential Effects of Failure	Failure Prevention	Occurrence Probability
Fundraising activities do not generate enough funds.	Team will be unable to have travel money for all of the members	Hold several small-scale fundraisers to allow for more diverse interest in the team.	15%
Incorrect parts or supplies are purchased.	Delay in build sessions, and possible milestones.	Ensure all orders are verified by team officers.	1%
Problems could arise with space grant funding for the team.	Delays in purchasing needed supplies and parts.	Adhere to budget guidelines and discuss financial matters with team advisor.	1%

Structural Failures	Potential Effects of Failure	Failure Prevention	Occurrence Probability
Fins fail during flight due to shear forces or inadequate use of adhesive.	Rocket will experience an unstable and unpredictable flight trajectory.	Use suitable building materials, through-the-wall fin mounting, and ample application of adhesive and fillets.	1%
Rocket experiences drag separation during flight.	Rocket will prematurely separate, leading to early parachute deployment and a mission failure.	Ensure that all joints are secure and drill a hole in the body tube to equalize pressure between the interior of the rocket and the atmosphere.	1%
Rocket joints do not separate at parachute deployment.	Parachute bay will experience over-pressurization from the ejection charge but will not deploy the parachute.	Conduct pre-launch separation testing.	10%
Parachute deploys too	High-speed deployment causes the shock cord	Test the altimeter for drogue	10%

early or too late in flight.	to produce a “zippering" effect.	deployment at apogee and the correct deployment altitude for the main is set..	
Rocket components are lost or damaged during transport to launch site.	Team risks not launching the rocket unless repairs can be made.	Pack components safely and securely for transport and have replacement components and needed tools available at the launch site.	15%
Rocket structure is crushed due to in-flight forces.	Rocket will have a ballistic trajectory, and the mission is a failure.	Test, evaluate, test again	1%
Center of gravity is too high or too low.	Rocket will be unstable or over stable.	Adjust weight so that center of gravity is 1-2 calibers ahead of center of pressure.	90% chance of being over stable
Center of pressure is too high or too low.	Rocket will be unstable or over stable.	Adjust fin sizing and position so that the center of pressure is 1-2 calibers behind the center of gravity.	0%
Connecting holes through airframe distort	Potential undesired and untimely separation of airframe parts	Coat all opening liberally with CA glue to stiffen Kraft phenolic material	2%
Edges of Kraft phenolic airframe tubes fray and/or distort	Difficult to insert airframe sections	Coat all opening liberally with CA glue to stiffen Kraft phenolic material	2%

Payload Failures	***Potential Effects of Failure***	***Failure Prevention***	***Occurrence Probability***
Altimeter and/or science payload battery power supply fails	Avionics will fail to record data, resulting in the inability of the altimeter to eject the parachutes.	Check batteries prior to launch and have extra batteries located at the launch site. The team will also use separate power supplies for each section containing electronic devices to prevent the failure of all electronics.	1%
Wire connections in the rocket loosen during transport or flight.	Data will not be complete, causing a payload objective failure. Ejection electronics may not deploy parachutes, causing a ballistic recovery.	Secure wires with wiring loom and ensure that all wires are properly connected prior to launch.	10%
Altimeter fails to record data during flight.	Altitude may not be properly measured resulting in parachute deployment failure.	Test the altimeter for functionality prior to launch. Calibrate the altimeter before launch.	1%
GPS system fails to record the position of the rocket.	Recovery of the rocket will become more difficult. The rocket may possibly be lost.	Test the GPS before launch and use a secondary tracking system.	1%
Avionics are broken during the transport, storage, or flight.	Data will not be collected, and the payload objective will be considered a failure.	Store equipment in a safe, dry place during both storage and transport.	15%
Static discharge to electronics.	Electronic instruments are damaged.	Team members should properly ground themselves before handling electronics.	5%

Recovery Failures	***Potential Effects of Failure***	***Failure Prevention***	***Occurrence Probability***
Drogue and main parachute bays experience separation during flight.	Parachutes will deploy early, causing the rocket to miss the target altitude. A zippering effect may also occur.	Ground test shear pins and ensure proper pressure equalization in parachute bays.	1%
Shock cords snap upon parachute deployment.	Rocket will experience an uncontrolled descent.	Test shock cords to ensure that they are sufficiently strong and long enough to withstand expected loads.	1%
Altimeter fails to deploy the drogue and main parachutes.	Rocket will experience an uncontrolled descent.	Ensure that the altimeter is functioning properly prior to launch. A double-redundant ejection system will be used.	5%
Drogue and main parachutes are packed too tightly to release.	Rocket experiences uncontrolled descent.	Ground test efficiency of the packing technique before launch.	1%
Parachute melts or chars due to ejection charge heat.	Parachute becomes partially or entirely ineffective, causing an uncontrolled descent.	Use flame/heat retardant material between the parachute/shock cord and the ejection charge.	5%
Parachute lines tangle upon deployment.	Parachutes will be ineffective, causing an uncontrolled descent.	Test deployment prior to launch and use a parachute/shock cord packing procedure that minimizes tangling.	5%

Propulsion Failures	Potential Effects of Failure	Failure Prevention	Occurrence Probability
Propellant fails on the launch pad.	Launch will be unsuccessful.	Test the ignition system and ensure that the connection points and the installation of the igniters are correct.	5%
Igniter fails on the launch pad.	Motor of the rocket will fail to ignite.	Ensure that the igniter is secure before attempting ignition.	15%
Motor centering rings fail.	Thrust vector is will not be aligned with the axis of symmetry, causing erratic and unpredictable flight.	Use strong centering rings that are well mounted and have holes in the true center.	1%
Motor mount fails.	Rocket and the payload might be destroyed by the motor traveling up through the rocket body.	Test the motor mount system for correct construction. The team will also conduct an inspection of the mounting system prior to launch.	1%
Motor retention system fails.	Free-falling ballistic objects could be produced, possibly harming people around the launch site.	Use an adequate motor retention system to ensure that the motor will remain in the rocket.	1%
Motor explodes on the launch pad.	Rocket will explode and the mission will be a failure.	Use appropriate casings for motors and stand an appropriate distance away from the launch pad at the time of ignition.	5%

Launch Operation Failures	Potential Effects of Failure	Failure Prevention	Occurrence Probability
Power supply for the ignition fails.	Rocket will fail to launch, and the mission will be a failure.	Ensure that the power supply is fully charged.	1%
Launch rail buttons malfunction.	Launch will be unsafe, and the rocket could have an unpredictable trajectory.	Ensure that the rail buttons are securely attached to the rocket body and that they are correctly aligned with one another.	1%
Rocket snags on the launch rail.	Launch buttons will strip off, causing the rocket to have an unpredictable trajectory.	Clean the launch rail and apply a lubricant, such as WD-40, prior to the launch.	1%
Grass at the launch site catches on fire after launch.	Equipment will be destroyed and people at the launch site will possibly be harmed.	Use a fire-retardant blanket if the grass near the launch site is not excessively dry. Have a fire extinguisher readily available.	1%
Rocket is carried out of range by the wind.	Rocket will be lost.	Not fly in heavy or unsafe winds. Use a GPS tracking device	15%

Recovery Subsystem

To ensure a successful flight and recovery, the rocket will be equipped with a redundant recovery system consisting of two PerfectFlite MAWD altimeters that are independent of each other. One PerfectFlite altimeter will provide primary parachute deployment functionality. A second PerfectFlite altimeter will provide secondary deployment functionality. The rocket will carry a single drogue parachute and a single main parachute. Each flight computer will control a separate set of ejection charges and will have it own separate electrical system. Each set of ejection charges are to be ignited in sequence, with a short delay (~1 second) between ignitions. The primary drogue charge will ignite beginning at apogee followed closely by the secondary drogue charge, and then the main charges will ignite (primary then secondary) at approximately 500 feet AGL. We will use progressively larger charges, in the event that the primary charge does not deploy the applicable parachute due to a blockage inside the rocket. Although the charges increase in power amount, all charges will be calculated so as not to over pressurize the parachute bays of the rocket.

We have tested the altimeters in a bell jar. The altimeters were installed in the EBay and the electronics connected to the electric match posts. However, instead of electric matches, we used miniature holiday lights. The bell jar was depressurized with a vacuum pump. When we stopped pumping, the altimeter sensed apogee and the drogue lights flashed in sequence as programmed. We slowly allowed pressure to enter the jar and the main lights flashed in sequence. Analysis after the fact indicated that the main "charges" lit at 500 feet as programmed.

Parachute size

The drogue parachute is an 18" in diameter which results in a calculated 82-85 feet per second descent rate. The main parachute is 72" in diameter. The descent rate after the main is deployed is calculated to be 21 feet per second.

PARACHUTE SIZE CALCULATION

Rocket Weight	10.68	pounds		
Parachute Drag Coefficient	1.50			
	Vastsas Chute Calculator Program			
	Drogue (50-100 f/s)		**Main (17-22 f/s)**	
Descent Rate	85.00	feet/second	21.20	feet/second
Diameter	18.01	inches	72.10	inches
Shroudline length	12.00	inches	50.00	inches

The above table show the results for a web-based calculator from www.vatsas.org.

Rocksim's results are:

Rocksim PARACHUTE SIZE CALCULATION

Rocket Weight	10.68	pounds		
Parachute Drag Coefficient	1.50			
	Rocksim			
	Drogue (50-100 f/s)		**Main (17-22 f/s)**	
Descent Rate	82.40	feet/second	21.00	feet/second
Diameter	18.00	inches	72.00	inches
Shroudline length	15.00	inches	53.00	inches

Supplied with this information, we are confident that our parachute selection will bring Frankenstein safely to the ground.

Test Results of Ejection Charge and Electronics

We tested both the scale rocket and the original Frankenstein's ejection charges and electronics. Both rockets' electronics and black powder charges ground tested successfully. The scale rocket deployed both parachutes as designed. Our first full-scale flight had the drogue parachute deploy successfully at apogee; however, the main charge fired (partially fired?) but the main did not deploy. We had taken precautions by using a larger than called for drogue parachute. Therefore Frankenstein descended at 50 f/s and suffered no damage upon impact.

BLACK POWDER CALCULATION

We have calculated the amount of black powder both by hand and by using BP calculators on the Internet.

Black Powder Ejection Charge Calculator
by Chuck Pierce
© 2001 All Rights Reserved

Desired Pressure =	15	psi	
mass BP =	1.1	grams	m=PV/R/T
Ejection F =	188.5	lbf	F=P*(pi/4)*d^2

4Fg Black Powder Gas Properties

R =	22.16	ft*lbf/lbm/R
Tc =	3307	R

Conversions: 1 lb = 454 grams
1 oz = 28.3 grams

Drogue Parachute

Volume =	138.23	in^3	
Dia =	4	inch	
Length =	11	inch	
mass BP =	1.1	grams	1.3 grams secondary

Main Parachute

Volume =	251.33	in^3	
Dia =	4	inch	
Length =	20	inch	
mass BP =	1.9	grams	2.1 grams secondary

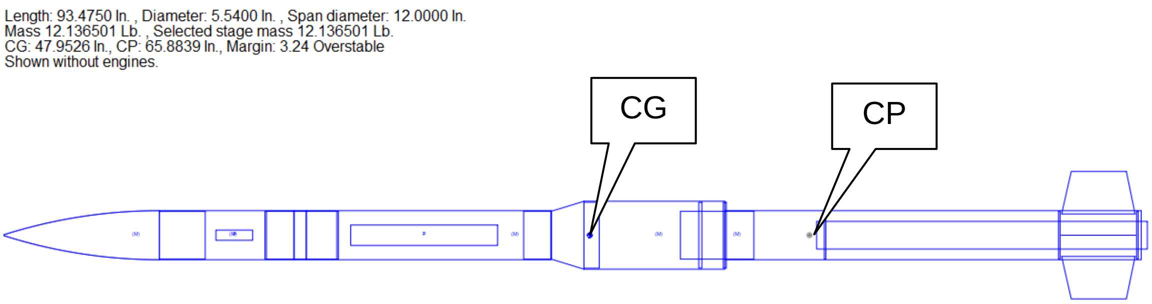

Nose & Drogue bay separating

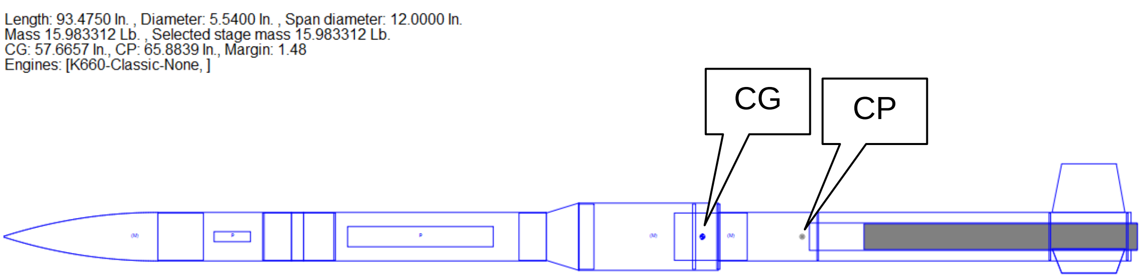
EBay (on right) and Main parachute separating

Both the drogue and main shock cords are 20 feet of 9/16 inch tubular nylon attached to quick links. The drogue is connected to the shock cord 7 feet from the attachment at the nose cone and the main is connected to the shock cord 7 feet from the point of attachment on the bottom of the EBay,

Mission Performance Prediction

The goals of the RezRider's rocket is to safely deliver the payload to 5280 feet (AGL) conduct the science experiments and then safely descend to the earth using the redundant dual deploy recovery system. There are several parameters that affect the predicted performance of the rocket. To provide stable flight the rocket must maintain a stability margin between 1.4 and 2.0. The RockSim model below shows the location of the center of pressure and the center of gravity with and without the CTI K660 motor installed.





The center of gravity is 57.67" from the nose tip and the center of pressure is 65.88". This provides a stability margin of 1.48 calibers which is within the 1.4 to 2.0 calibers required.

Mission Success Criteria

Criteria number 1 is no individual is harmed or put at risk through the team's failure to successfully identify and mitigate a hazard.

Flight success criteria:

- attain an altitude within .01% of 5280 feet
- rocket launches as designed
- drogue parachute deploys at apogee
- main parachute deploys at 500 feet above ground level
- descent rates are within design parameters
- rocket is recovered with minimal damage and able to be launched again within four hours

Picture success criteria:

- Pictures are oriented within 95% of normal viewing orientation

Science payload success criteria:

- 85% of the measurement applications function as designed
- 100% of the data is collected from the functioning science applications

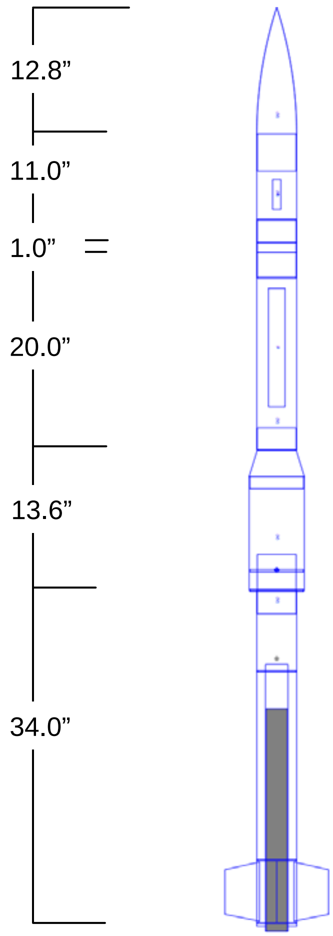
Simulations Using Real Vehicle Data

Component Weights

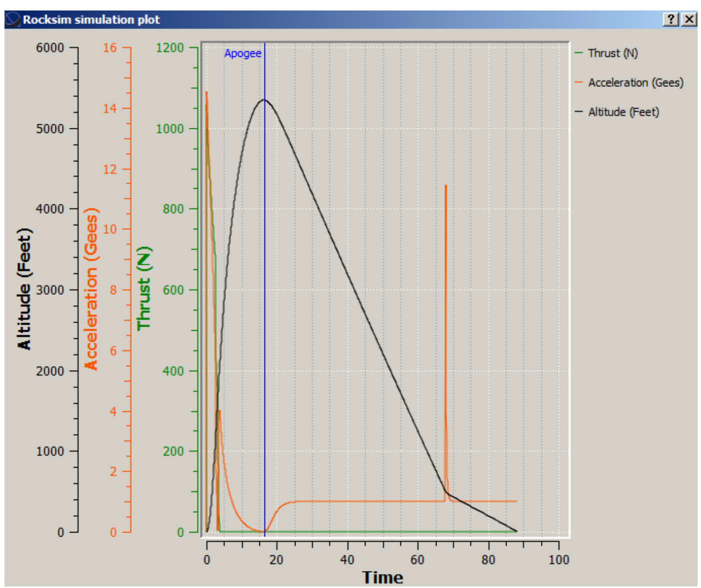
	Air Frame Wgt	
	g	oz
Nose Cone	180	6.35
DC20 & Mount	270	9.52
Drogue Parachute Bay	95	3.35
Drogue Shock Cord	100	3.53
Drogue Quick Link	**In Ebay Total**	
Drogue Parachute	14.07	0.50
Ebay & Electronics	597	21.06
Primary Altimeter 1	**In Ebay Total**	
Main Black Powder	1.9	0.07
Drogue Black Powder	1.1	0.04
FWD Electric Match	1	0.04
AFT Electric Match	1	0.04
Secondary Altimeter 2	80	2.82
Main Black Powder	2	0.07
Drogue Black Powder	1.2	0.04
FWD Electric Match	1	0.04
AFT Electric Match	1	0.04
Main Parachute Bay	215	7.58
Main Parachute	197.632	6.97

Main Shock Cord	100	3.53
Main Quick Link	100	3.53
Fwd Transition	425	14.99
Parachute Connection Bolt	60	2.12
Science Bay	190	6.70
FWD Rail Button	**In Science Bay Total**	
Stbd Camera	45	1.59
Port Camera	45	1.59
UV	195	6.88
UV Battery	60	2.12
IR	50	1.76
Humidity	143	5.04
Humidity Battery	60	2.12
Pressure	150	5.29
Pressure Battery	60	2.12
Temperature	150	5.29
Temperature Battery	60	2.12
Internal Temp	140	4.94
Internal Temp Battery	60	2.12
Light Detect	208	7.34
Light Detect Battery	60	2.12
Cam 1 808 Camera	40	1.41
Cam 2 808 Camera	40	1.41
Cam 3 808 Camera	40	1.41
Aft Transition	100	3.53
Fin Can	985	34.74
Fins	**In Fin Can Total**	
Rail Button Stand Off		
AFT Rail Button		
Motor Retainers (2)	15	0.53
	Grams	**Oz**
	5,499.90	194.00
		Lbs
	Total Weight	**12.13**

Dimensions



Flight Profile Simulations



The above is Rocsim's graph of the altitude, acceleration, and thrust based upon Frankenstein's current vehicle data. The orange acceleration plot shows the acceleration increase at the drogue ejection and another spike at main ejection.

Altitude Predictions

We examined Huntsville, AL weather data on April 15 for the years 2010, 2009, and 2008 and averaged key data.

Weather Data, Huntsville, AL

600.4' alt, - lat 34.6537°, long -86.5817°

	4/15/2010	4/15/2009	4/15/2008	Averages
Mean Temperature (°F)	69	50	47	**55**
Max Temperature (°F)	82	59	59	**67**
Min Temperature (°F)	56	46	39	**47**
Dew Point (°F)	53	37	30	**40**
Average Humidity (%)	62	59	51	**57**
Maximum Humidity (%)	84	76	70	**77**
Minimum Humidity (%)	34	45	34	**38**
Sea Level Pressure (in)	**30.37**	**30.11**	**30.32**	**30.27**
Wind Speed (mph)	**4 (SE)**	**8 (NNW)**	**5 (North)**	**6**
Max Wind Speed (mph)	**8**	**12**	**8**	**9**
Max Gust Speed (mph)	**14**	-	**16**	**10**

When we examined the actual data, the afternoons showed a steady increase in temperature and a decrease in pressure. Winds were relatively steady. We, therefore set our Rocsim launch conditions to mimic Huntsville's weather conditions. Our predicted altitude is 5295 feet agl.

LAUNCH CONDITIONS

Altitude: 600.39370 Ft.
Relative humidity: 77.000 %
Temperature: 65.000 Deg. F
Pressure: 30.2683 In.
Wind speed model: Slightly breezy (8-14 MPH)
Low wind speed: 8.0000 MPH
High wind speed: 14.9000 MPH
Wind turbulence: Fairly constant speed (0.01)
Frequency: 0.010000 rad/second
Wind starts at altitude: 0.00000 Ft.
Launch guide angle: 0.000 Deg.
Latitude: 34.654 Degrees

Launch conditions

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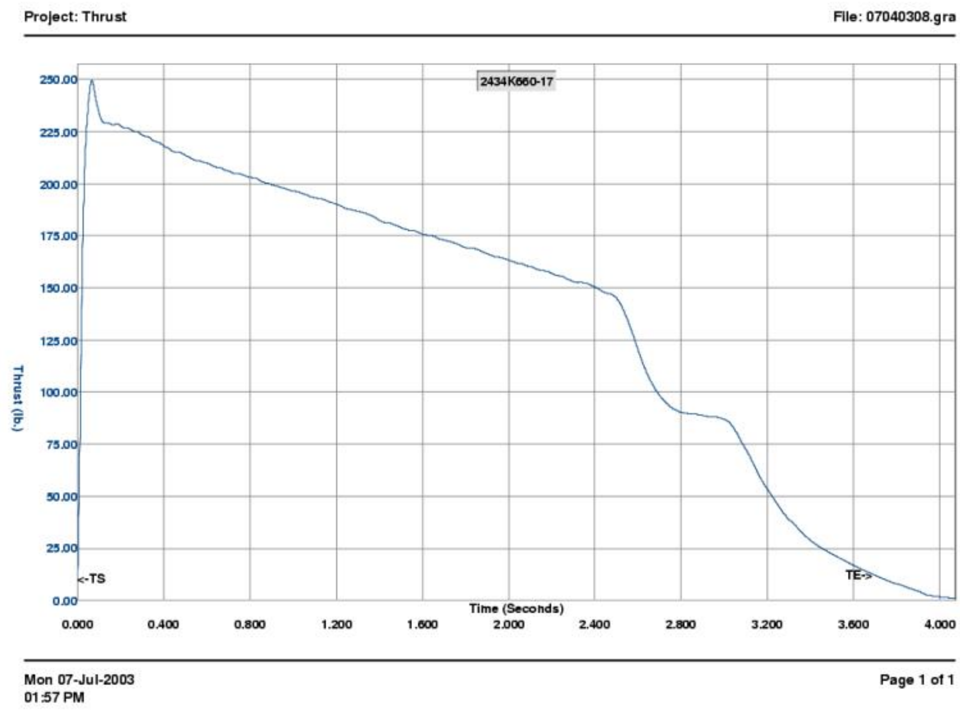
Frequency: 0.010000 rad/second
Wind starts at altitude: 0.00000 Ft.
Launch guide angle: 0.000 Deg.
Latitude: 34.654 Degrees

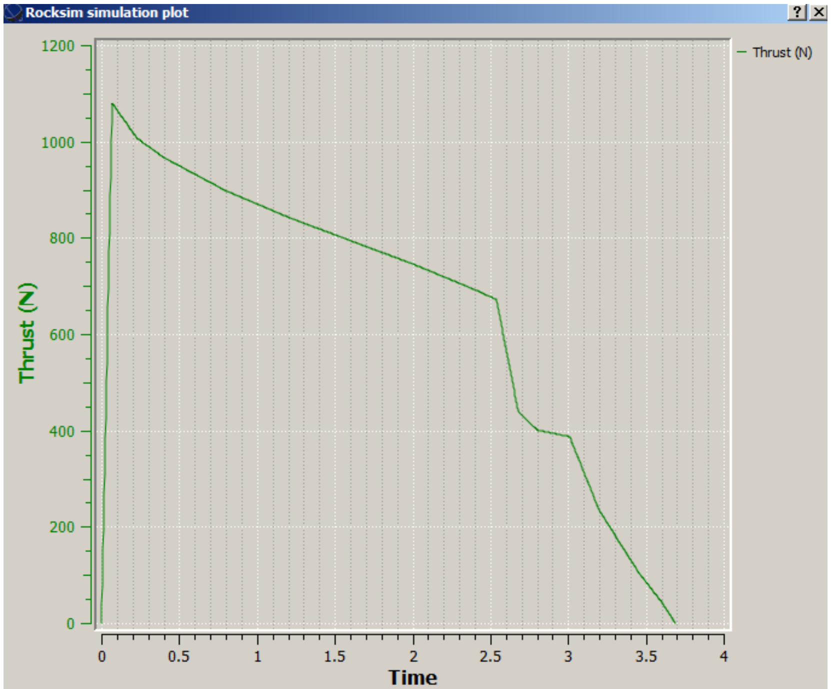
If we change the rail guide angle 10 degrees away from the wind, our predicted altitude increases to 5338.71 feet agl whereas if the guide angle is 10 degrees into the wind direction, the altitude decreases to 5023 feet.

Motor Thrust Curve

Below are the actual and Rocksim thrust curve plots for the CTI K660 Classic reload.



Thrust Curve from the Testing Agency



Thrust curve from Rocksim

Drag Assessment

We have worked extensively with Rocksim and changed the Coefficient of Drag to have the simulated launch altitude be very near the actual altitude. We, of course, matched the weather conditions in the simulation as closely as possible to the actual weather conditions of the flight on December 5, 2010.

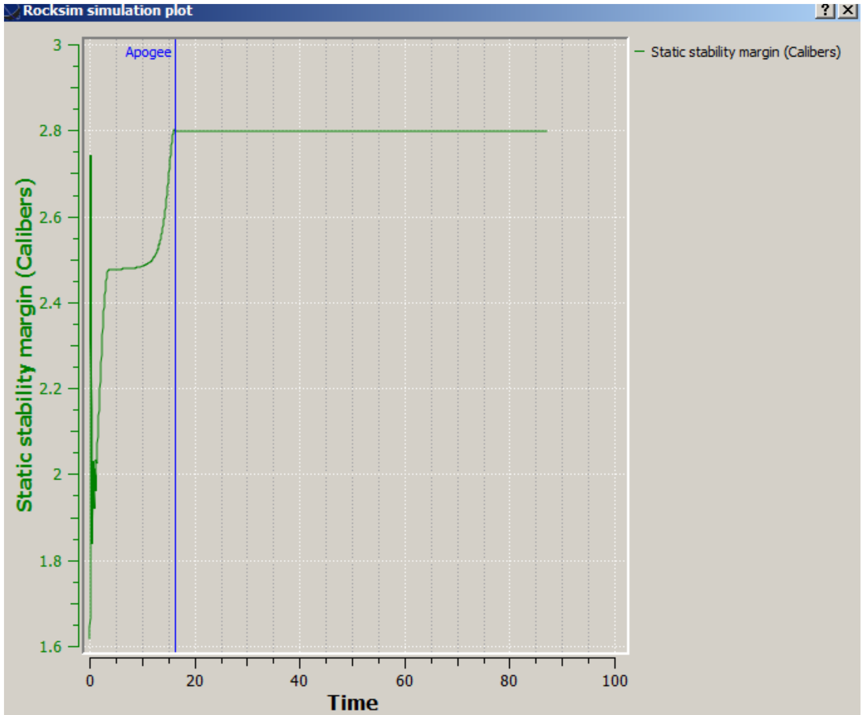
After a series of iterations, the CD has been changed to 0.57, which will override Rocksim's calculated CD. We had planned on verifying this number prior to this report's submission; however, wet weather has delayed our launch schedule.

Stability Margin

Given the actual weights of Frankenstein, Rocsim calculates the static stability margin to be:

Static Stability Margin

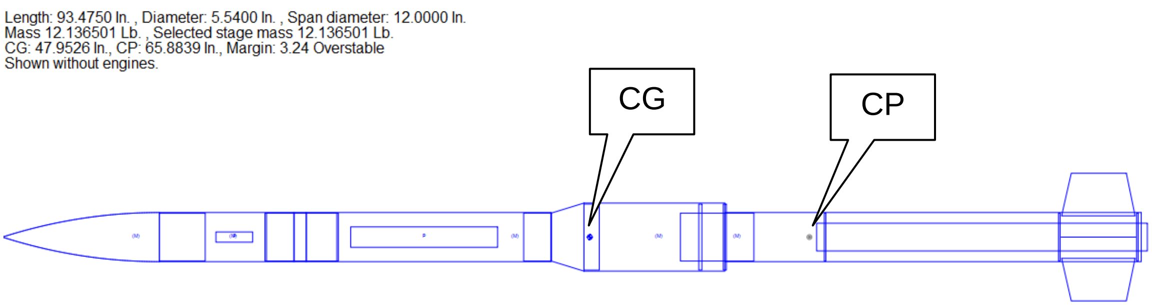
Condition	CG	CP	Margin
No Motor	47.95	65.88	3.24
Motor	56.92	65.88	1.62



Change in Static Stability Throughout Frankenstein's Flight

For the first 0.2 second the launch rail provides stability and the calculated static stability doesn't come into effect until the rocket leaves the launch rail, hence the stability drop on the above graph. After leaving the launch rail, the stability increases due to the forward trend of the center of gravity as the propellant burns off. There is a corresponding leveling off of stability with the leveling off of thrust (see preceding charts) during the 3.5 to 4.0 second after which the stability increases to it calculated static stability (empty motor is not included in the Rocsim calculation).

Below is a visual depiction of the CG & CP in the motorless rocket.



Frankenstein is predicted to be stable throughout its flight.

<u>Payload Integration</u>

The payload is designed to be easily integrated with the other subsystems. The payload team, the airframe team and the recovery team have been working closely together in order to determine the weight of the payload within the rocket. The weight is a crucial parameter to optimize because this determines what size motor and parachutes are needed to reach the target altitude, bring the rocket and its payload safely to the ground as well as perform the science experiments.

Each experiment is self-contained and independent of any other experiment. We designed them in this fashion to give more students an opportunity to be involved in our project and to make the installation more flexible by making it easier to inspect and install several smaller devices rather than an integrated larger one.

The payload is designed so that all of the components can be assembled before launch day and then the instrument package can easily be installed into the rocket science payload bay at any time. On launch day fresh batteries will be checked and installed, and then the payload will be installed onto the rocket. Screws will fasten the science payload bay to the forward part of the rocket and to the fin can.




The individual microcontroller boards are installed on ¼” birch aircraft plywood disks that slide over 1/8” threaded rods and are separated from each other by lengths of phenolic launch lugs. The batteries are housed in the 3.9” tube coupler to keep the center of gravity in its designed place.

Launch Operation Procedures

Launch System and Platform

Our launch controller has a continuity check light and switch, a key-locked power switch, and two independent normally open push buttons to close the circuit to the igniters. We have two sets of launch cables; one set is 100 feet long and the other is 200 feet long.

Ground Support Equipment

Our launch pad base is constructed of 1 inch black pipe. The base has three 36” long legs that are connected to a manifold that supports a 72 inch long T-Slotted Aluminum Extrusion Framing, 70 inches which are available for rocket guidance. The blast shield is a 1/16 x 18 x 12 inch steel plate mounted between the launch rail and the launch pad legs.


Rail size
The launch rail is 72” x 1” x 1” 80/20 1010 T-slotted aluminum. It is mounted to a 3-legged stand constructed from ¾” black pipe and t-connectors. An eye-bolt passes through each leg six inches from the end so that a length of 250 lb breaking strength can be fastened between each leg. This prevents the legs from separating under load.

The calculated maximum g-force for a fully loaded Frankenstein is 13.539 g’s (224 pounds). According to Rocksim, the maximum acceleration is reached 0.0575 seconds after ignition and Frankenstein departs the rail guide at 0.203 seconds.

We’ve had two students with a combined weight of 300 pounds stand on the launch pad and lean about 15 degrees in multiple directions without the launch pad exhibiting any instability. We are very confident that the launch pad can withstand the weight and thrust of Frankenstein.

On December 5, 2010 we launched our original design Frankenstein, no weight except the Garmin Astro 220 DC20 in the nose. Rocksim calculated acceleration at 21 g’s. Video of the launch did not indicate any instability of our launch pad. On that launch we hadn’t installed the chains for stability. We installed the chains after our PDR presentation when one of the observers asked us to, “Be sure that the pad design is adequate to handle a rocket of that size with the chosen motor”.

First Aid kits, a fire extinguisher, 4 foot rebar stakes and “Do Not Cross” tape, and a portable sound system round out our ground support equipment at our local launches.

Final Assembly and Launch Procedures

Launch operations follow a very strict policy with safety being paramount. This accomplished by following a set routine which involves using a series of check lists. Each launch begins with a Safety review meeting and is followed by meticulously using supporting documents and the following checklists which are in the appendices. A summary of routine is as follows:

1. Prepare and install the ground support equipment
2. Prepare the electronics
3. Assemble the rocket
4. Pre-launch check list
5. Final launch check list
6. Post recovery
7. Clean up

Documents

- FAA/CAA Contact Schedule
- Liability Waiver
- HPR Safety Rules
- Flight Card

Checklists

- Ground Support Equipment
- Science Payload Assembly
- Final Assembly Check List
- Pre-Launch Preparation
- Final Launch Preparation
- Post Recovery

Individual Documents and Checklists are in the Appendices

Safety

Safety Officer

Responsible Person: Justin is the safety officer for the team. He is responsible for ensuring that all safety procedures, regulations, and risk assessments are followed. Justin is a member of the National Association of Rocketry and holds his Level 1 certification.

The Northwest Indian College Space Center has a 3000 foot waiver from US and Canadian aviation agencies that permits us to fly from 8:00am to 12:00pm on Saturday's and Sundays.

Safety Rules and Regulations

1. All members of the team shall adhere to the NAR High Powered Safety Code. The NAR HPSC is attached as Appendix G.

2. All members of the team shall adhere to the National Fire Protection Association (NFPA) 1127: “Code for High Powered Rocket Motors”.
3. All members of the team shall be aware of Federal Aviation Regulations 14 CFR, Subchapter F Subpart C “Amateur Rockets”.
4. 4. All team members shall read and sign the "Range Safety Regulations" (RSR) statement. The RSR is attached as Appendix H.

This is a list of current team members and their respective National Association of Rocketry (NAR) or Tripoli Rocketry Association (TRA) certification levels. The two advisors are currently level 2 certified, which will allow us to use the appropriate motor, and Bill Munds, team mentor, shall be the designated owner of the rocket for liability purposes.

Bill Munds	Mentor	NAR L2
Dave Oreiro	Faculty	TRA L1, NAR L2
Gary Brandt	Faculty	NAR L2
Mariya Williams	2nd year	TRA L1
Michael Wright	1st year	TRA L1
Kyle Koos	3rd year	TRA L1
Justin Johnny	3rd year	NAR L1
Patrisha Lane	2nd year	NAR L1
Gordon Kelly	Tribal Elder	NAR L1
Paul Ballew	1st year	NAR
Nick Jefferson	1st year	NAR L1
Krissy Jefferson	1st year	NAR L1
Thomas Doyle	1st year	NAR Junior
Cathy Balew	2nd year	
Kiya Gorman	1st year	
Kinen Gorman	1st year	
Tad Enholm	1st year	

All team members are periodically briefed on the NAR High Power Rocket Safety Code and the risks involved with high power rocket launches. The latest briefing was December 4, 2010

Hazard Awareness and Mitigation

Construction

1. The Airframe Lead has the final say while constructing any designs, subsystems, or sections of the rocket.
2. The safety officer is responsible for having all MSDS for hazardous materials. Also, the safety officer shall inform the team of any material or substance hazards before use. A sample MSDS sheet and hyperlinks to the MSDS sheets are located on our website: http://blogs.nwic.edu/usli
3. All team members are required to wear appropriate Personal Protective Equipment. The equipment includes, but is not limited to, safety glasses, gloves, ear plugs, and breathing masks. The safety officer will notify team members when materials that require PPE are

being used. If additional PPE is required, it is the safety officer's responsibility to obtain the additional equipment.

4. Safety glasses shall be worn when any member is using a tool that may create fragments of a material (Dremmel tool, hammer, band saw, etc.)
5. Power tool use requires at least two members be present. All team members shall wear the appropriate PPE.
6. Safety is the responsibility of all team members. The safety officer shall make all team members aware of any hazards, but individual team members shall be responsible for following all regulations and guidelines set forth by the safety officer.

Payload

Proper static grounding shall be utilized while handling sensor modules. Soldering requires adequate ventilation and safety glasses. None of the payload modules use electrical power greater than 9 volts.

A summary of safety hazards include adequate fastening together the science payload bay halves and the science payload bay itself to the rocket airframe. Details of the steps for safely working with the science payload bay and its contents are in Appendix C

Motors and Black Powder

1. All explosive materials shall be kept in the appropriate storage magazine located off-site on the property of Gary Brandt, the Team Official.
2. All extra black powder, e-matches, igniters, and any unused ejection charges will be stored in the magazine.
3. Any explosives being handled during launch day will be monitored by the safety officer.

Launch Operations

1. The area surrounding the launch pod shall be cleared of all flammable materials, such as dry vegetation, for a radius of at least 50 feet. The launch control box will be located at least 100 feet from the launch stand.
2. The launch rail shall not be inclined greater than 30 degrees from the vertical position.
3. An amplified audio system will be employed during launches.
4. Once everyone is a safe distance from the launch stand, the Range Safety Officer (RSO) will permit the Launch Control Officer (LCO) to connect the launch control system to the power source.
5. The RSO shall contact the appropriate aviation agencies 5-10 minutes prior to launch for clearance to launch.

6. After the RSO has received clearance and agrees that conditions are safe for launch, the system will be checked for continuity and then armed by the LCO.
7. The LCO shall check for aircraft and any other potential hazards and then commence counting down from 5 seconds.
8. The LCO shall activate the launch system when the countdown reaches zero.

Environmental Safety at the Northwest Indian College Launch Complex

1. All hazardous materials, such as black powder and epoxy, brought onto the field must be removed.
2. All trash will be removed prior to leaving the launch complex.
3. Motor remains must be disposed of properly.
4. All rockets shall be recovered. If a rocket is lost, the team will work with the appropriate Tribal office for further assistance.
5. The launch complex will be left as clean, or cleaner than it was prior to launching.

Recognition of Tribal, Federal, State, and Local Laws

The Northwest Indian College Space Center USLI team recognizes and adheres to all Tribal, state, federal, and local laws relating to the use of high power rockets. Each team member is required to sign a Range Safety Regulations (Appendix H) form acknowledging that they are aware of these laws and regulations. All team members are briefed on safety hazards and risks that will be present at any build sessions or rocket launches. The RSO shall conduct a safety meeting before any launch day. This meeting will include information about predicted risks, weather conditions, minimum distances from launch pad, and any changes in the launch waiver.

The RSO or her designee shall contact the proper authorities at the appropriate times to activate the waiver for launching. Appendix I lists the time frame and contacts for waiver activation.

Each team member understands and fully complies with the following safety regulations. These regulations will be enforced by the Safety Officer.

- FAA- Federal Aviation Regulations 14 CFR, Subchapter F, Part 101, Subpart C
- NAR High Powered Rocketry Safety Code
- NFPA 1127 “Code for High Power Rocket Motors”
- NAR High Powered Safety Code
- CFR Title 27 “Commerce in Explosives”

Interaction with Rocket Motors

Motors will be purchased by either Bill Munds or one of the appropriately certified officers. After motors are received they will be placed in the team’s motor magazine which is located off-site on the property of the Team Official, Gary Brandt. This magazine is an ATF-approved Type 4 container. A second, smaller magazine box is an ATF-approved Type 3 container and will be used to transport motors to and from the launch.

Arrangements for purchase, delivery, and storage of our motors for the USLI launch in April at Huntsville, AL will be performed by our NAR Mentor, Bill Munds.

IV) Science Payload

Selection, Design, and Verification of Payload Experiment

We are going to do the NASA Science Mission Directorate's scientific payload that monitors several weather and atmospheric phenomena. We are adding two additional measurements to the required list. The measurements that we'll be monitoring are:

- Barometric pressure
- Atmospheric temperature,
- Relative humidity
- Solar irradiance
- Ultraviolet radiation

Additional Experiments

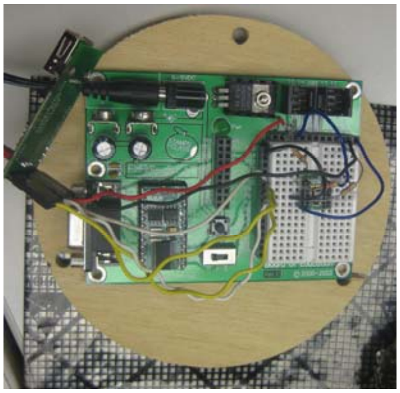
- Science payload bay temperature
- Rocket roll detection and measurement

The measurements shall be made at least every 5 seconds during descent and every 60 seconds after landing. Furthermore, surface data collection operations will terminate 10 minutes after landing. Data from the payload shall be stored onboard and transmitted to the ground station after completion of surface operations.

The secondary mission requires recording at least two pictures during descent and three after landing. The pictures need to portray the sky toward the top of the frame and the ground toward the bottom of the frame.

We will be dedicating a microcontroller, power supply and data logger for each sensor. Having a dedicated system for each sensor ensures that some data will be collected in the event of a single or multiple sensor malfunctions. A totally catastrophic failure is the only reason that we wouldn't be able to collect meaningful data.

There will be a stack of three BASIC Stamp microcontroller boards and their respective data logger electronics and power supplies. The microcontroller boards are 4 x 3 x 1 inches in size. A fourth layer will support the solar irradiance and ultraviolet radiation processing units.



Prototype temperature sensor, data logger, and microcontroller board being fitted to science bay mounting platform

Our redesign of the science payload bay decreases the diameter to 5.54 inches and 10 inches long. It will have to descend as vertically as possible for some of the atmospheric measurements and for the photography. The science payload bay will be constructed from 5.54 inch diameter kraft phenolic airframe tubing from LOC Precision. The payload bay will slide over the instrument package and be secured by #8 5/8 screws. Both the drogue and main parachutes deploy above the science payload bay thus ensuring a vertical orientation.

Vents will permit atmospheric equilibrium for the barometric pressure sensor. The relative humidity, atmosphere temperature, and the roll detection sensors will be mounted vertically on the science payload bay walls.

The Memory Stick Data logger is a USB host bridge which creates a connection between a USB mass storage device, such as a Thumb Drive, to the BASIC Stamp microcontroller. The data can be transferred to a computer via the USB mass storage device. Each of the three BASIC Stamp controlled sensors will have a memory stick data logger and each is independent of each other.

Barometric Pressure

The VTI SCP1000 is an absolute pressure sensor which can detect atmospheric pressure from 30-120 kPa (30,000 to -5000 feet). The pressure data is internally calibrated and temperature compensated. Its resolution is 1.5 Pascals. Pressure equalization between the interior of the science payload bay and the external atmosphere is via vents in the bottom transition cone. The SCP1000 will be mounted on its own Propeller microcontroller board and have its own power supply and data logging capabilities. Data collection will start five seconds after liftoff which is triggered by an accelerometer.

Atmospheric Temperature

The DS1620 is a digital thermometer. It can measure temperature in units of 0.5° Centigrade (C) from –55° C to +125° C, Fahrenheit (°F), units of 0.9° F and a range of –67° F to +257° F. The fastest the DS1620 can generate new temperature data is once per second. The sensor unit will be mounted on its own BASIC Stamp microcontroller board and have its own power supply and data logging capabilities. The sensor itself will be mounted on the vertical wall of the lower half of the science payload bay. Data collection will start five seconds after liftoff which is triggered by an accelerometer.

Relative Humidity

The Sensirion SHT11 Sensor Module measures relative humidity from 0% to 100%. It has a 3.5% range of accuracy. This module has a heater that in high humidity applications, the heater can be switched on briefly to prevent condensation. The sensor will be mounted on the vertical wall of the science payload's top section and have access to the external atmosphere. The sensor will be mounted on its own BASIC Stamp microcontroller board and have its own power supply and data logging capabilities. Data collection will start five seconds after liftoff which is triggered by an accelerometer.

Solar Irradiance

The solar irradiance unit determines how much available sunlight (solar insolation) there is at a location. The silicon pyranometer is based on a PIC16F88-I/P microcontroller and will have its own data logger and power supply. Its probe will be mounted in the forward transition cone so that the probability of it receiving sunlight is higher than if it were mounted on the vertical side. The irradiance range it from 0 to 1520 watts per meter squared (W/m^2). The resolution is 1.5 W/m^2. Readings are taken every 10 seconds. Data collection will start five seconds after liftoff which is triggered by an accelerometer.

Ultraviolet Radiation

The UV radiation sensor will be mounted on the top layer of the electronics stack. Its probe will be located in the forward transition cone so that the probability of it receiving sunlight is higher than if it were mounted on the vertical side. The UV range is from 0 to 30 milliwatts per square centimeter (mW/cm^2). The recording level is one reading per second. Data collection will start five seconds after liftoff which is triggered by an accelerometer.

Science Payload Bay Temperature

The MLX90614 infrared thermometer modules is an intelligent non-contact temperature sensor. The sensor is designed for non-contact temperature measurements of objects placed within a sensor's 90 degree cone of detection. The temperature output data, ranges from -70 to +380 °C. The sensor will be mounted on its own BASIC Stamp microcontroller board and have its own power supply and data logging capabilities. Data collection starts when the altimeter is armed and continues throughout the flight.

Rocket Roll Detection and Measurement

The Texas Advanced Optical Systems (TAOS) TSL230R measures light intensity using an array of photodiodes and outputs a square wave whose frequency is proportional to light intensity striking the surface of the chip. We want to collect roll data because we hypothesize that the rocket's rolling will affect the solar irradiance and ultraviolet readings and perhaps we can use the roll data in conjunction with analyzing the UV and solar irradiation data. The probe will be mounted on an 8 to 10 inch cable and located in the vertical side of the science payload pay. The change in light intensity should allow us to determine the roll rate and how long the sensor was aimed in the sun's direction. The sensor will be mounted on its own BASIC Stamp microcontroller board and have its own power supply and data logging capabilities. Data collection will start immediately after liftoff which is triggered by an accelerometer.

Photography

We will be using multiple cameras for redundancy. Two side-mounted cameras, 0.5 x 0.75 x 2.75 inches will be mounted on the side wall of the science payload bay. Three rear-facing cameras will be mounted in the aft end of the science payload bay transition. They will be aligned with the fins which ensure that at least one of them will be in an upright or near upright position upon landing.

In the past, the recovery area at Huntsville has been a cleared farmer's field. We speculate that it will be relatively flat which indicates that our science payload should land in a nearly horizontal or horizontal position. This will place on of the three cameras in proper orientation for the images.

Data Recovery

Data retrieval will take place after recovery. The USB data storage drives will be removed from their appropriate sensor modules and the data downloaded to the team's laptop computer. The data will be downloaded to at least two computers for data safety. Camera data will be treated the same. Figure 8 illustrates the science bay payload construction and layout concept.

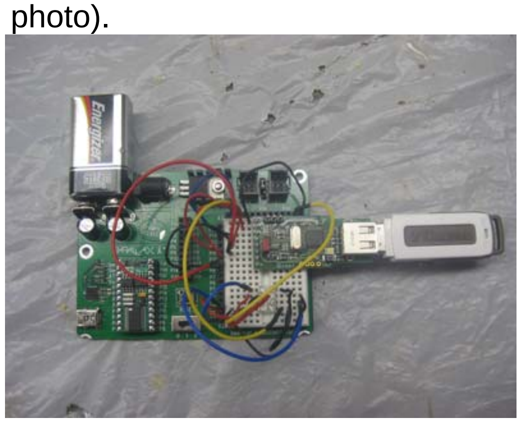
Payload Concept Features and Definition

Creativity and Originality

None of the team members has any electronic or microcontroller programming experience. This learning experience is taking place because the students believe that they can learn enough in a timely manner to construct and test the sensors and to install them in the rocket in such a fashion that the data collected will be meaningful to them as well as to the USLI panel of scientists and engineers.

Uniqueness or Significance

Each sensor or probe will have its own microcontroller and associated electronics. Sensors and microcontroller circuitry will have to be constructed and then programmed to do the measurements and data logging. The microcontrollers are entirely independent of one another, including their power supplies. This photo is of a representative sensor module; this one utilizes a light-to-frequency converter to measure changes in light intensity and then records the data to a data logger that houses a mini-usb drive (full size USB in photo).



Suitable Level of Challenge

This is a totally new process for most of us. We've had a little experience since January 2010 in building, and flying high powered rockets. We've had little to no experience in developing electronic experiments. We've had little to no experience working on a project of this magnitude. That being said, RezRiders are confident that we can pull this off. Our advisors, Gary and Dave, are totally supportive and help us find answers, figure out how to find solutions to our challenges. This is true of our mentor, Bill, as well.

Science Value

Payload Objectives

RezRider's intention is two faceted: 1) gather atmospheric data and present it in a meaningful format; and, 2) gather data from the rocket itself to learn more about our rocket.

The first objective involves building sensor and probe modules to sample atmospheric temperature, humidity, and pressure. Also we will be building an ultraviolet radiation sensor and a solar irradiance sensor. All six of the experiments are independent of one another.

The second objective will gather and analyze rocket data from additional sensors. One will convert light frequency to digital data in order that we can measure the longitudinal roll of our rocket. The second sensor will measure and record the temperature within the science payload bay.

Our major reasons for doing this with individual sensor modules is to not only satisfy the SMD goals, but to enhance the learning and knowledge of our team members, none of whom have had any electronic or microcontroller experience prior to this project.

Payload Success Criteria

Can we build the modules? Can we make them work? Can we program them to do what we want? Can we integrate the sensors and data loggers? Can we collect data? And lastly, can we analyze and report the data gathered in a meaningful manner?

A, "Yes" to all of the previous questions is our goal. The team realizes that there are varying degrees of acceptable performance for each of the modules and an overall payload success criteria falls in the range of total failure to perfection, 0% to 100%. Furthermore, each module has its own degree of difficulty in building, programming, mounting, and sensor/data logging requirements.

Module	Construction		Programming		Mounting	
	Prototype	Competition	Prototype	Competition	Prototype	Competition
Atmospheric Temperature	1.0	2.0	2.0	2.0	1.0	3.0
Barometric Pressure	3.0	1.0	2.0	2.0	1.0	1.0
Humidity	2.0	1.0	2.0	2.0	1.0	1.0
Solar Irradiance	3.0	3.0	3.0	3.0	1.0	3.0
UltraViolet Radiation	2.0	3.0	2.0	2.0	1.0	3.0
Rocket Roll	1.0	3.0	3.0	3.0	1.0	3.0
Science Payload Bay Temperature	1.0	1.0	2.0	2.0	1.0	1.0
Averages	1.9	2.0	2.3	2.3	1.0	2.1

Module	Sensor Integration		Data Logging Integration		Averages	
	Prototype	Competition	Prototype	Competition	Prototype	Competition
Atmospheric Temperature	1.0	3.0	2.0	2.0	1.4	2.4
Barometric Pressure	1.0	3.0	2.0	2.0	1.8	1.8
Humidity	1.0	2.0	2.0	2.0	1.6	1.6
Solar Irradiance	3.0	3.0	3.0	3.0	2.6	3.0
UltraViolet Radiation	3.0	3.0	3.0	3.0	2.2	2.8
Rocket Roll	2.0	3.0	3.0	3.0	2.0	3.0
Science Payload Bay Temperature	1.0	2.0	2.0	2.0	1.4	1.6
Averages	1.7	2.7	2.4	2.4	1.9	2.3

Difficulty Scale: Easy=1, Medium=2, Difficult=3

Experimental Logic, Approach, and Investigation Method

RezRiders logic and approach is to meticulously build everything, provide a thoughtful approach to reaching our goals, be acutely aware of safety, put the rocket into the air and analyze the data that we retrieve.

Test and Measurement, Variables, and Controls

We will be evaluating our atmospheric sensor modules by comparing the sensor results with standard scientific measuring tools such as laboratory quality thermometers, barometers, and hygrometers. We are creating a device to rotate the science payload at a fixed rpm in order to calibrate our roll detection sensor. Prior to the competition flight, we will have a baseline for each of the sensors that we have developed from a controlled environment.

Relevance of Expected Data and Accuracy/Error Analysis

Since the sensor modules are under programming logic, we should be able to programmatically correct any consistent discrepancies between our sensors and standard scientific measurement tools. What will interesting is how much, if any, the data collected through actual flights differs from static data collection. If there are significant differences, that will be a challenging task to evaluate the differences and to be able to compensate for accuracy.

Preliminary Experimental Procedures

After having built and tested the prototype sensor modules, we will be building robust modules that will be able to withstand the rigors of a high powered rocket flight. The competition modules will then be mounted in the science payload bay and a series of static tests will be developed and carried out for each of the sensors. Data collection and analysis will allow us to make any programming changes or other modifications necessary to obtain consistent and accurate results. Test, evaluate, modify, and repeat as necessary.

V) Activity Plan

Activities and Schedule Status

As of December 24, 2011, we are nearly on schedule and have built in enough high-altitude launch days to be successful in our activity plan. We had hoped to fly our competition rocket at least one more time prior to filing this report.

January 2011:

- *15 ~~launch competition rocket~~*
- *22 – ~~23 launch competition rocket~~ (1/21 more rain and flooding!!)*
- *24 Critical Design Review (CDR) reports and CDR presentation slides posted on the team Web site.*
- *25 Finalize competition team*
- *28 All science experiments complete and tested*
- *29-30 launch competition rocket with J300G*

February 2011:

- *2-8 Critical Design Review Presentations (tentative)*
- 19 Hi altitude launch competition rocket w/o science payload

March 2011:

- 12 Hi altitude launch competition rocket with science payload
- *21 Flight Readiness Review (FRR) reports and FRR presentation slides posted on the team Web site.*
- 28-31 Flight Readiness Review Presentations (tentative)

April 2011:

- 13 Travel to Huntsville
- 14-15 Flight Hardware and Safety Checks (tentative)
- *16 Launch Day*

May 2011:

- *9 Post-Launch Assessment Review (PLAR) posted on the team Web site.*
- 20 Announcement of winning USLI team

Budget Plan

RezRiders are within our budget parameters. An unanticipated expenditure may be additional motors for more flight tests. Our budget will allow this, if necessary.

Qty	Description		Total Price
	Scale Model Rocket		
2	3.90" (98mm) Airframe Tubing	$10.45	$20.90
1	7.51" Airframe Tube - 2x30" + TC	$26.95	$26.95
1	3.90" (98mm) Plastic Nose Cone	$20.95	$20.95
1	54mm Motor Mount Tube	$7.35	$7.35
3	Tube Coupler 3.90" (98mm) Tube	$4.50	$13.50
2	Centering Ring CR-7.51-3.90	$10.50	$21.00
6	1/4" Plywood	$6.99	$41.94
3	Pair of Centering Rings CR-3.90-2.14	$8.10	$24.30
2	3.90" (98mm) Bulkhead Assembly	$4.05	$8.10
			$184.99

	Competition Rocket		
2	3.90" (98mm) Airframe Tubing	$10.45	$20.90
~~1~~	~~7.51" Airframe Tube - 2x30" + TC~~	~~$26.95~~	$26.95
1	12" 5.54 Airframe Tube + Coupler	$35.00	$35.00
1	54mm Motor Mount Tube	$7.35	$7.35
3	Tube Coupler 3.90" (98mm) Tube	$4.50	$13.50
~~2~~	~~Centering Ring CR-7.51-3.90~~	~~$10.50~~	$21.00
6	1/4" Plywood	$6.99	$41.94
3	Pair of Centering Rings CR-3.90-2.14	$8.10	$24.30
1	5.54" x 4" balsa transition	$12.95	$12.95
2	3.90" (98mm) Bulkhead Assembly	$4.05	$8.10
			$211.99

	Motors		
2	Aerotech J500G	$54.99	$109.98
1	RMS-54/1706 MOTOR	$72.99	$72.99
3	CTI K660 Classic	$148.99	$446.97
1	CTI 6 Grain Motor and Closure	$135.99	$135.99
			$582.96

	Miscellaneous Parts		
1	Misc Construction Supplies - paint, glue	$200.00	$200.00
1	Misc hardware - bolts, nuts, links	$50.00	$50.00
			$250.00

Recovery System			
1	Recovery materials, nomex, nylon, kevlar	$60.00	$60.00
1	Black Powder	$40.00	$40.00
1	78" Parachute	$59.95	$59.95
1	18" Parachuge	$7.25	$7.25
1	RDAS-Tiny altimeter	$300.00	$300.00
2	MAWD Altimeter	$99.95	$199.90
2	Safety switches for electronics	$15.00	$30.00
			$697.10

Payload and Tracking System			
1	GPS Unit	$495.00	$495.00
5	Payload cameras	$13.95	$69.75
1	Science Payload	$1,200.00	$1,200.00
			$1,764.75

Travel			
6	travel to Mansfield for 3000'+ launches	$75.00	$450.00
6	travel to Atlanta	$412.00	$2,472.00
6	lodging Atlanta	$200.00	$1,200.00
			$4,122.00

Project Income			
	NASA SMD		$5,000.00
	Outreach		$1,500.00
	Washington State Space Grant		$500.00
	Tribal Support		$3,000.00
			$10,000.00

Budget Summary	
Scale Rocket	$184.99
Competition Rocket	$211.99
Propulsion	$582.96
Construction Supplies	$250.00
Recovery	$697.10
Electronics & Payload	$1,764.75
	$3,691.79

Travel & Lodging	$4,122.00

Project Income	
	$10,000.00

Educational Engagement

February 5, 2011	Northwest Indian College Science Department High School students
February 10, 2011	Lummi Nations School Grades 9-12 Demonstration
February 24, 2011	Demonstration to Northwest Indian College students
March 12-13, 2011	NAR Convention in Seattle, WA

VI) Conclusion

The RezRiders are confident in the design that we have created to meet the overall mission requirements in the USLI competition. Any design flaws or improvements, subtle or otherwise, will be addressed well before the final launch in April; this will ensure that the mission safe as well as successful.

The payload presents many challenges to the RezRiders. The team involvement in such a challenging environment can't help but make us better students.

Safety is our greatest priority. We insure this by creating and following rigorous launch checklists. Testing, testing, and more testing add to the safety margin. Our mentor plays an important role in following our course of action and stepping in where necessary to challenge our assumptions.

The overall success of the RezRiders is dependent upon dedication, hard work, and the excitement of doing something that none of us as previously done.

Appendices

Appendix A - Northwest Indian College Space Center (NWIC-SC) Rocket Launches

As consideration for the opportunity to participate in NWIC-SC launches, I hereby release and forever discharge the National Association of Rocketry (NAR), the Tripoli Rocketry Association (TRA) and their officers, members, administrators, agents and assigns; Northwest Indian College Space Center and its officers, members and agents; the launch site's landowners, administrators and caretakers including the state of Washington and all other persons attending NWIC-SC launches from suits of any kind or nature whatsoever resulting from attending NWIC-SC events. This release and discharge includes but is not limited to suits involving injury and/or property loss or damage resulting from accidents which might happen to me and/or to those who accompany me to Northwest Indian College Space Center launches.

When attending NWIC-SC launch events, I hereby agree to fly high power rocket motors of "H" impulse and above only if I possess a valid NAR or TRA High Power Certification. I affirm that I possess valid copies of all permits and paperwork required to legally fly high power rocket motors. Further more, I will never fly rocket motors more powerful than my certification will allow except when engaged in a formally supervised NAR or TRA certification flight attempt. I also agree that I will fly only commercially manufactured rocket motors that are certified for use by NAR and/or TRA.

I am fully aware of the risks involved in traveling to and participating in rocketry events and hereby assume all of those risks. I agree further that I have completely read, fully understood the terms of and voluntarily accept this agreement. Furthermore, I agree to follow the NAR and TRA Safety Codes as well as all local, state and federal laws, regulations and rules that apply to NWIC-SC launches.

Name (Please print) ____

Signature & Date____

Parent/Guardian (17 and younger)_________________________________

Address ____

City State Zip____

Email address____

Phone (   ) ____

NAR Membership ______________________ Cert Level __________ Expires______

TRA Membership ______________________ Cert Level __________Expires ______

Appendix B - GSE Check List

- ☐ Fire Extinguisher
- ☐ 1st Aid Kit
- ☐ Launch Legs
- ☐ Restraining chains
- ☐ Launch Rail
- ☐ Launch Leg Connector
- ☐ Launch Blast Shield
- ☐ Control Box
- ☐ Igniter Cables
- ☐ Launch Batteries
- ☐ Igniter Clips
- ☐ Weather Station
- ☐ Compass/Direction Recorder
- ☐ Cell Phone
- ☐ Phone Numbers
- ☐ Writing Pad
- ☐ Pencils/Pens
- ☐ Sandpaper
- ☐ Flight Cards
- ☐ Liability Waivers
- ☐ Flight Data Sheets
- ☐ Mosquito Repellant (seasonal)
- ☐ FSR Radios w/fresh batteries
- ☐ Video/Still Camera
- ☐ Clipboard
- ☐ Stakes for establishing viewing area
- ☐ “Do Not Go” tape for establishing view area
- ☐ Bullhorn

Appendix C - Final Assembly Check List

Pre Launch Assembly Steps

- ❑ Check all “fresh” batteries for 8.5 v or higher

Altimeter ebay preparation

Electronics

- ❑ Replace both batteries in altimeter ebay
- ❑ Connect primary drogue wires to primary drogue electric match connecting posts
- ❑ Connect primary drogue wires to secondary drogue electric match connecting posts
- ❑ Connect primary drogue wires to primary main electric match connecting posts
- ❑ Connect primary drogue wires to secondary main electric match connecting posts
- ❑ Check connection terminals for security
- ❑ Slide altimeter sled onto ebay rails
- ❑ Insert fail-safe power switch rods through ebay and altimeter power switches
- ❑ Insert top and bottom bulkheads and secure with wing nuts

BP Canisters

- ❑ Connect electric matches to both drogue connecting posts
- ❑ Fill primary drogue BP canister with primary BP grams
- ❑ Fill secondary drogue BP canister with secondary BP grams
- ❑ Insert e-matches and fill remaining canister space with “fire proof” material
- ❑ Secure the top of both BP canisters with tape
- ❑ Connect electric matches to both main connecting posts
- ❑ Fill primary main BP canister with primary BP grams
- ❑ Fill secondary main BP canister with secondary BP grams
- ❑ Insert e-matches and fill remaining canister space with “fire proof” material
- ❑ Secure the top of both BP canisters with tape

Connect to airframe

- ❑ Insert ebay into airframe
- ❑ Secure main parachute bay with nylon shear pins
- ❑ Secure drogue parachute bay with nylon shear pins
- ❑ Check vent holes are clear

Science payload bay preparation

Pre insertion into science payload bay

- ❑ Replace all batteries in science payload bay
- ❑ Download control programs to each module
- ❑ Check sensors and probes secured in position
- ❑ Check sensor and probe connections to respective science module
- ❑ Check power connections from each module to power bus
- ❑ Check motion detect/master power switch is off
- ❑ Check power bus switch is on
- ❑ Check all module switches are on
- ❑ Check science modules fastened securely to mounting brackets

Insert Into Science Bay

- ❑ Slide science payload bay top section over bottom section and secure with screws
- ❑ Secure science payload bay to main parachute bay and to fin can
- ❑ Check vent holes are clear

- ❑ Check sensors and probes have clear access to the exterior

GPS tracking system preparation

- ❑ Charge tracking transmitter the night before launch
- ❑ Replace receiver batteries with AA batteries greater than 1.4 volts
- ❑ Check tracker mounted securely to nose cone board
- ❑ Power tracker on
- ❑ Insert nose cone board into nose cone
- ❑ Fasten with screws
- ❑ Insert nose cone into drogue recovery bay and fasten with screws

Secondary tracking system preparation

- ❑ Check on for “screamer” sound and then turn off
- ❑ Fasten to drogue parachute-shock cord intersection
- ❑ Pack drogue parachute
- ❑ Turn on
- ❑ Pack with drogue parachute

Pre-Launch

- ❑ Prepare motor according to manufacturer’s directions
- ❑ Insert motor into motor mount
- ❑ Secure motor with motor retainers
- ❑ Report to LCO/RSO
- ❑ Move rocket to launch pad and continue with Pre-Launch Preparation check list

Appendix D - Pre-Launch Preparation Checklist

Motor Preparation and Installation

- ❑ Prepare motor per packaged instructions for launch.
- ❑ Check motor casing for snug fit in motor tube, tape if necessary.
- ❑ Install motor.
- ❑ Install motor retaining devices.
- ❑ Insure all electronic deployment devices are in the non-dischargeable safe mode.

Recovery System Preparation

Recovery System, Drogue Chute:

- *Check all connections. Insure all devices are in good condition and properly secured:*

- ❑ Aft bay shock cord to drogue
- ❑ Booster shock cord to drogue

- *Pack drogue chute in deployment bag, keep lines even and straight.*

- ❑ Fold drogue chute per manufacturer's instructions.
- ❑ Insure shroud lines are free from tangles.
- ❑ Insure all quick links are secure.
- ❑ Insert ejection charge protection.
- ❑ Insert drogue bag/chute into drogue recovery compartment.

Recovery System, Main Chute

- *Check all connections. Insure all devices are in good condition and properly secured:*

- ❑ Forward bay shock cord to shock cord mount
- ❑ Forward bay shock cord to main

- *Pack main chute in deployment bag, keep lines even and straight.*

- ❑ Fold main chute per manufacturer's instructions.
- ❑ Insure shroud lines are free from tangles.
- ❑ Insure all quick links are secure.
- ❑ Insert ejection charge protection.
- ❑ Insert main bag/chute into forward recovery compartment

EBay & Black Powder Ejection Charges

Prepare avionics #1

- ❑ Be sure all arming switches are off.
- ❑ Install battery in altimeter.
- ❑ Secure battery in place with positive battery retention system.
- ❑ Altimeter properly programmed and verified.
- ❑ Connect aft pyrotechnic leads to electronic deployment device.
- ❑ Connect forward pyrotechnic leads to electronic deployment device

Prepare avionics #2

- ❑ Be sure all arming switches are off.
- ❑ Install batteries in altimeter.
- ❑ Secure batteries in place with wire ties and tape.
- ❑ Flight computer properly programmed and verified.
- ❑ Connect aft pyrotechnic leads to electronic deployment device.
- ❑ Connect forward pyrotechnic leads to electronic deployment device

Black Powder, drogue

- Prepare drogue deployment pyrotechnic device and ready for installation into rocket.
- Load drogue charges into rocket, insure at all times the devices are safed until final launch readiness.
- Utilizing external disarming mechanisms to insure all electronically discharged pyrotechnics are disabled until final launch readiness.

Black Powder, main

- Prepare main deployment pyrotechnic device and ready for installation into rocket.
- Load main parachute charges into rocket, insure at all times the devices are safed until final launch readiness.
- Utilizing external disarming mechanisms to insure all electronically discharged pyrotechnics are disabled until final launch readiness.

Insure all black powder electronic devices are in disarmed mode during EBay final installation.

Install avionics

- Install EBay in rocket.

Note: All pyrotechnic devices must remain in an unarmed mode until rocket is on pad ready to launch.

Appendix E - Final Launch Preparation Checklist

Load Rocket on Pad

- ❑ Take rocket to assigned pad
- ❑ Prepare launch pad.
- ❑ Verify pad will hold rocket properly
- ❑ Mount proper rod/rail onto pad
- ❑ Tilt pad, slide rocket onto rod/rail
- ❑ Tilt pad/rocket upright
- ❑ Activate and final check electronics
- ❑ Verify pad power is OFF

Prepare Igniter

- ❑ Assure that key IS NOT in remote device and that arming switch is off.
- ❑ Insert igniter. Be sure it is positioned correctly
- ❑ Secure igniter in position
- ❑ Assure that launcher is not hot. Assure that key IS NOT in remote device and that arming switch is off.
- ❑ Be sure all connectors are clean.
- ❑ Attach leads to ignition device.
- ❑ Be sure they don't touch each other or that circuit is not grounded by contact with metal parts.
- ❑ Check tower's position and be sure it is locked into place and ready for launch.

Final Launch Sequence

- ❑ Insure Flight Witnesses are in place and ready for launch.
- ❑ Arm all devices for launch.
- ❑ Return to Safe Area
- ❑ Ready cameras
- ❑ Signal LCO & RSO that rocket is ready for launch.
- ❑ Countdown and launch

Misfire Procedures

- ❑ Wait 60 seconds per NAR
- ❑ Safe all pyrotechnics to pre-launch mode.
- ❑ Remove failed igniter
- ❑ Resume checklist at "Final Launch Preparations/Prepare Igniter."

Appendix F - Post-Recovery Checklist

Normal Post Flight Recovery

- Check for non-discharged pyrotechnics.
- Safe all ejection circuits.
- Remove any non-discharged pyrotechnics.

Flight Failure Checklist

- Disarm all non-fired pyrotechnic devices.
- Continue Normal Post Flight Recovery procedures.
- Fall on ground and cry.

Appendix G - High Power Rocket Safety Code

1. **Certification.** I will only fly high power rockets or possess high power rocket motors that are within the scope of my user certification and required licensing.
2. **Materials.** I will use only lightweight materials such as paper, wood, rubber, plastic, fiberglass, or when necessary ductile metal, for the construction of my rocket.
3. **Motors.** I will use only certified, commercially made rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer. I will not allow smoking, open flames, nor heat sources within 25 feet of these motors.
4. **Ignition System.** I will launch my rockets with an electrical launch system, and with electrical motor igniters that are installed in the motor only after my rocket is at the launch pad or in a designated prepping area. My launch system will have a safety interlock that is in series with the launch switch that is not installed until my rocket is ready for launch, and will use a launch switch that returns to the "off" position when released. If my rocket has onboard ignition systems for motors or recovery devices, these will have safety interlocks that interrupt the current path until the rocket is at the launch pad.
5. **Misfires.** If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher's safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.
6. **Launch Safety.** I will use a 5-second countdown before launch. I will ensure that no person is closer to the launch pad than allowed by the accompanying Minimum Distance Table, and that a means is available to warn participants and spectators in the event of a problem. I will check the stability of my rocket before flight and will not fly it if it cannot be determined to be stable.
7. **Launcher.** I will launch my rocket from a stable device that provides rigid guidance until the rocket has attained a speed that ensures a stable flight, and that is pointed to within 20 degrees of vertical. If the wind speed exceeds 5 miles per hour I will use a launcher length that permits the rocket to attain a safe velocity before separation from the launcher. I will use a blast deflector to prevent the motor's exhaust from hitting the ground. I will ensure that dry grass is cleared around each launch pad in accordance with the accompanying Minimum Distance table, and will increase this distance by a factor of 1.5 if the rocket motor being launched uses titanium sponge in the propellant.
8. **Size.** My rocket will not contain any combination of motors that total more than 40,960 N-sec (9208 pound-seconds) of total impulse. My rocket will not weigh more at liftoff than one-third of the certified average thrust of the high power rocket motor(s) intended to be ignited at launch.
9. **Flight Safety.** I will not launch my rocket at targets, into clouds, near airplanes, nor on trajectories that take it directly over the heads of spectators or beyond the boundaries of the launch site, and will not put any flammable or explosive payload in my rocket. I will not launch my rockets if wind speeds exceed 20 miles per hour. I will comply with Federal Aviation Administration airspace regulations when flying, and will ensure that my rocket will not exceed any applicable altitude limit in effect at that launch site.
10. **Launch Site.** I will launch my rocket outdoors, in an open area where trees, power lines, buildings, and persons not involved in the launch do not present a hazard, and that is at least as large on its smallest dimension as one-half of the maximum altitude to which rockets are allowed to be flown at that site or 1500 feet, whichever is greater.
11. **Launcher Location.** My launcher will be 1500 feet from any inhabited building or from any public highway on which traffic flow exceeds 10 vehicles per hour, not including traffic flow related to the launch. It will also be no closer than the appropriate Minimum Personnel Distance from the accompanying table from any boundary of the launch site.
12. **Recovery System.** I will use a recovery system such as a parachute in my rocket so that all parts of my rocket return safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

13. **Recovery Safety.** I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places, fly it under conditions where it is likely to recover in spectator areas or outside the launch site, nor attempt to catch it as it approaches the ground.

MINIMUM DISTANCE TABLE				
Installed Total Impulse (Newton-Seconds)	**Equivalent High Power Motor Type**	**Minimum Diameter of Cleared Area (ft.)**	**Minimum Personnel Distance (ft.)**	**Minimum Personnel Distance (Complex Rocket) (ft.)**
0 -- 320.00	H or smaller	50	100	200
320.01 -- 640.00	I	50	100	200
640.01 -- 1,280.00	J	50	100	200
1,280.01 -- 2,560.00	K	75	200	300
2,560.01 -- 5,120.00	L	100	300	500
5,120.01 -- 10,240.00	M	125	500	1000
10,240.01 -- 20,480.00	N	125	1000	1500
20,480.01 -- 40,960.00	O	125	1500	2000

Note: A Complex rocket is one that is multi-staged or that is propelled by two or more rocket motors

Appendix H - Range Safety Regulations

I , ______________________________________, have fully read and fully understand the following regulations relating to operating high powered rockets:

1. The National Association of Rocketry High Powered Rocketry Safety Code
2. The National Fire Protection Association (NFPA) 1127: “Code for High Powered Rocket Motors".
3. The Federal Aviation Regulations 14 CFR, Subchapter F Subpart C “Amateur Rockets”.

Also, I understand that the Range Safety Officer has the right to deny any rocket from launch. Before launch I will check with the RSO about:

1. Safety inspection of my rocket
2. Checking the stability of my rocket (center of pressure and center of gravity locations).
3. Weather conditions at the launch pad and predicted altitude
4. Electronics such as altimeters, timers, flight computers, etc.
5. Best recovery options including: Descent rates, launch pad inclination, etc.

Safety is the number one priority for the NWIC Space Center. I hereby reaffirm my commitment to keeping myself, my teammates, launch participants, and the environment safe from risk, harm, and damage.

Signed:
____

Appendix I - Launch Wavier Activation

Date	Time	Initials	Agency	Phone	Timing
			NOTAM	877-487-6867	24-72 hrs
			BLI ATC	360-734-2745	24-48 hrs
			Vancouver ACC	604-586-4560	24-48 hrs
			BLI ATC	360-734-2745	30-45 min
			Vancouver ACC	604-586-4560	5-10 min
			NOTAM	**877-487-6867**	**Operations Concluded**
			BLI ATC	**360-734-2745**	
			Vancouver ACC	**604-586-4560**	

Latitude 48.47.38.44 N Longitude 122.38.26.09 W 3000' MSL
1/2 nautical mile (nm) radius from Whatcom, WA VOR (HUH) 175 degree rdial at 9 nm

High Power Flight Card

Northwest Indian College Space Center

Date:

RSO Initials __________

Rod/Rail # ________

Rocketeer's Name: ___________________________

Tripoli / NAR# ___________ Current Cert Level: ___

Rocket Manufacturer: _________________________

Rocket Name: _______________________________

Source: ☐ Kit ☐ Custom Color: _______________

Length: ______________ Diameter: _____________

Weight: ______________ First Flight of Rocket?: ___

Modifications: ________________________________

Launching on: Rod ☐ Rail ☐

Motor(s): ☐ Single ☐ Clustered ☐ Staged ☐ Air Starts

Main Motor: _________________________________

More than one motor? If YES, see back: __________

Recovery: ☐ Motor Eject ☐ Electronics ☐ Dual Deploy

Recovery via: ☐ Chute ☐ Streamer ☐ Other _______

Electronics: ________________________________

Other Payload: ______________________________

I certify that the assembly and installation of this motor is per the manufacturer's printed instructions and that the construction, deployment and recovery system of this rocket is per the NAR/Tripoli Safety Code. I certify that I have a current, signed NWIC Space Center Liability Waiver and Participation Agreement on file for this launch date.

Signed: ____

Good Flight ☐

Failed Flight Reason

☐ Cato ☐ Hard impact

☐ Shred ☐ Recovery Failed

☐ Certification Flight: ☐ L1 ☐ L2 ☐ L3 Certifier: ____________________________________

☐ Special Flight Info: ____

Instructions

Fill in all the information on the front of the card. If you need help or have questions, please ask the RSO or LCO. She/he will gladly help!

Other Information Box

1. If you have clustered, multiple stage or a complex engine configuration, you must fill in the total combined impulse of your motors in this box.
2. Use this space to indicate any other special notes about the flight.

Other Information:

Appendix J - HPR Flight Card

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