NORTHWEST INDIAN COLLEGE
Xwlemi Elh>Tal>Nexw Squl

2522 Kwina Road
Bellingham, Washington
98226

Northwest Indian College Space Center USLI Team

2010-2011 NASA USLI Flight Readiness Review

March 21, 2011

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Northwest Indian College Space Center
RezRiders

Flight Readiness Review Report

I) Summary

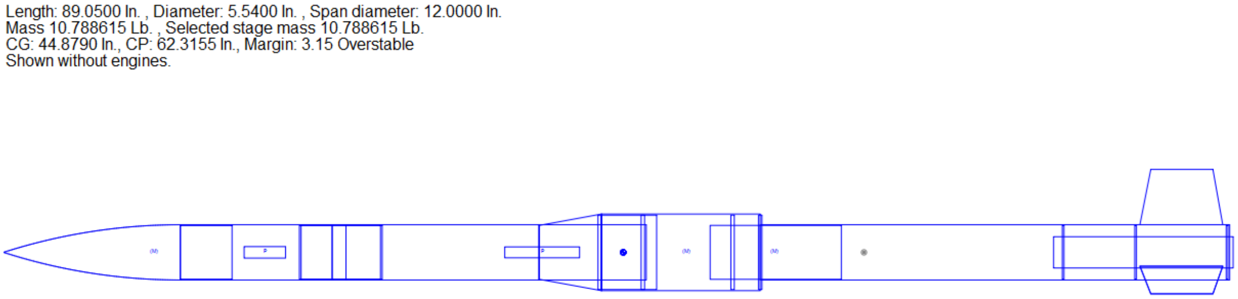
Team name: RezRiders
Rocket Name: ***Frankenstein 2***

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



Size:

89.48 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
44.87 Inches Center of Gravity
62.32Inches Center of Pressure
1.45 Static Margin with CTI K660

Motor choice: CTI K660 Classic

Recovery system: Redundant dual deployment parachutes using a Perfectflite MWAD altimeter and an RDAS-Tiny altimeter. Each are 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 CDR

Changes made to vehicle criteria

High stress areas of Frankenstein have been redesigned and newly constructed as a result of the catastrophic flight event of March 5, 2011. Details are presented in Section III, Vehicle Criteria. We have changed the altimeter configuration from two PerfectFlite MAWDs to one PerfectFlite MAWD and one RDAS-Tiny altimeter.

Changes made to payload criteria

None

Changes made to activity plan

Weather has been a very limiting factor. We have been able to have only one launch since December 5, 2010, and that was on March 5, 2011. March 5 involved traveling 5 ½ hours to Mansfield in eastern Washington. There we flew Frankenstein on a CTI K660 with disastrous results.

We are currently rebuilding Frankenstein as Frankenstein II, the REZerrection (FIIR). An analysis of Frankenstein I’s demise is an addendum to the FRR.

We are exactly on schedule, if today’s date were January 12 and not March 12! Frankenstein II is 95% complete as of this writing and weather permitting, we will be able to do a test launch on March 20 and a high-altitude launch on March 26, after this report is due. A data analysis report will be presented by April 1, 2011.

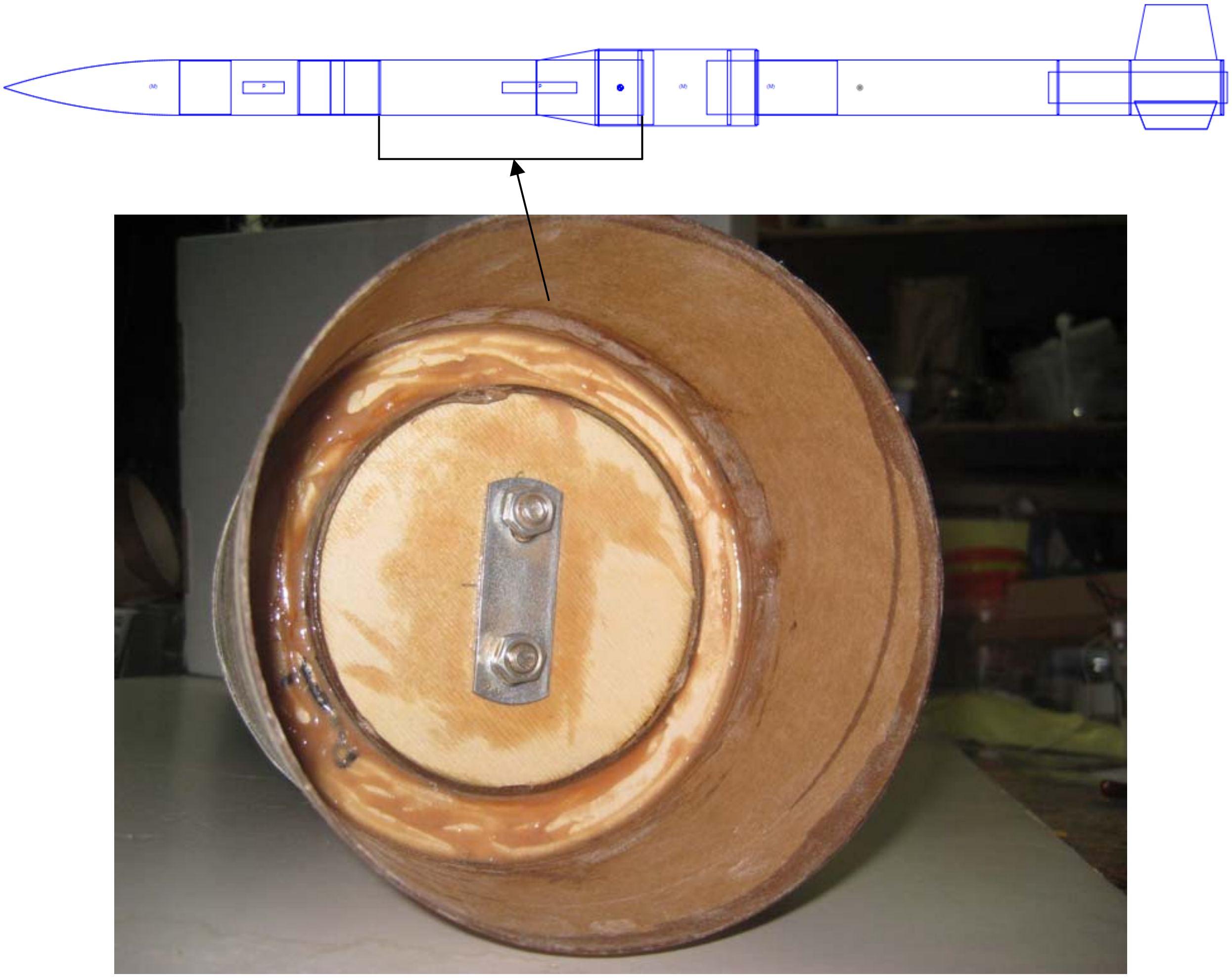
III) Vehicle Criteria

Testing and Design of Vehicle

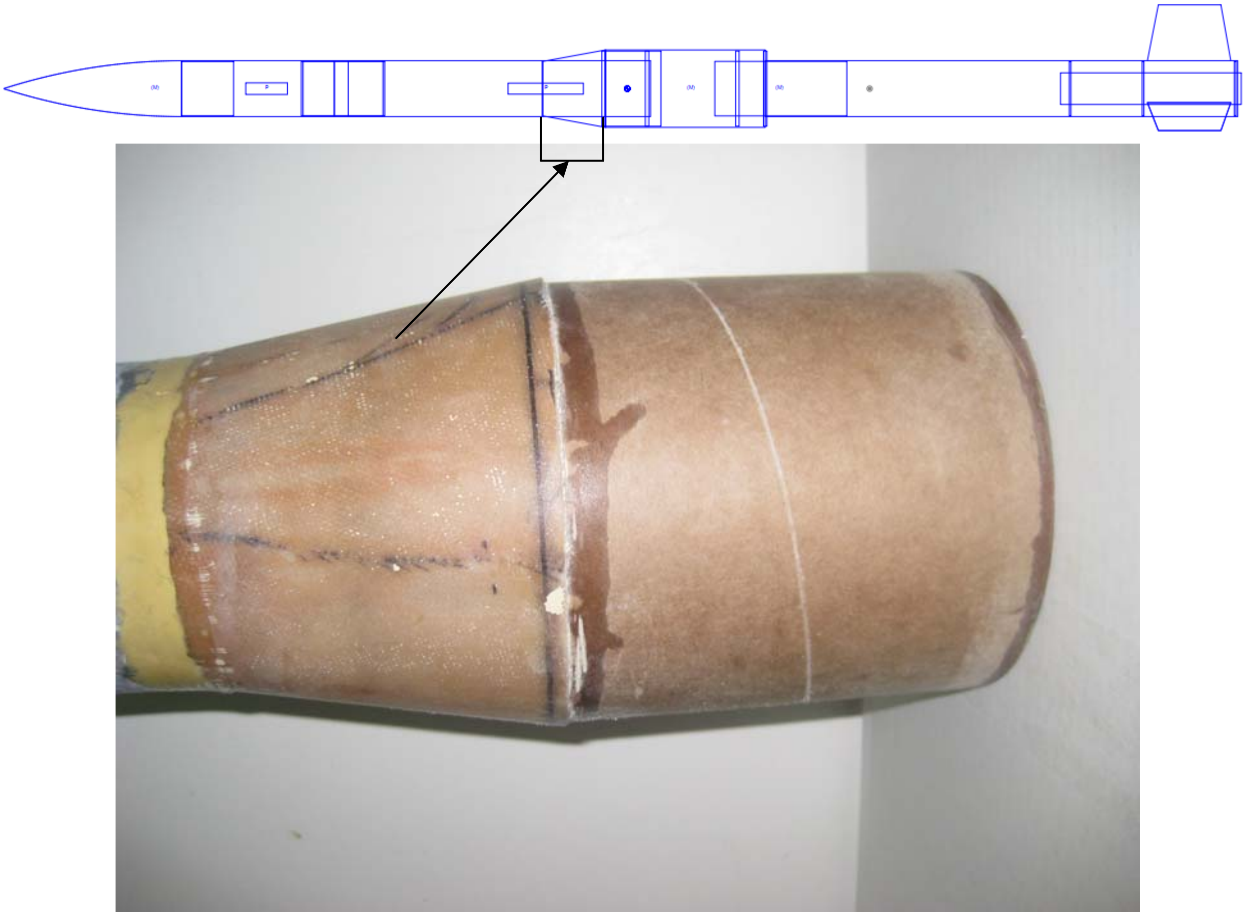
Discuss flight reliability confidence. Demonstrate that the design can meet mission success criteria.
Frankenstein I launched and recovered successfully using an Aerotech J500G reload on December 5, 2010. On March 5, 2011, Frankenstein launched successfully and flew straight until about 4 seconds into the flight when a catastrophic event occurred destroying the vehicle at about 2000 feet above ground level. We are confident that the design is reliable. We are confident that our analysis of the event has resulted in a stronger vehicle that will minimize the chances of a catastrophic repeat.

We have rebuilt Frankenstein as Frankenstein II and have flown it on March 20, 2011 using a CTI J330. It flew and recovered successfully. The modifications that have been implemented have strengthened key joints significantly.

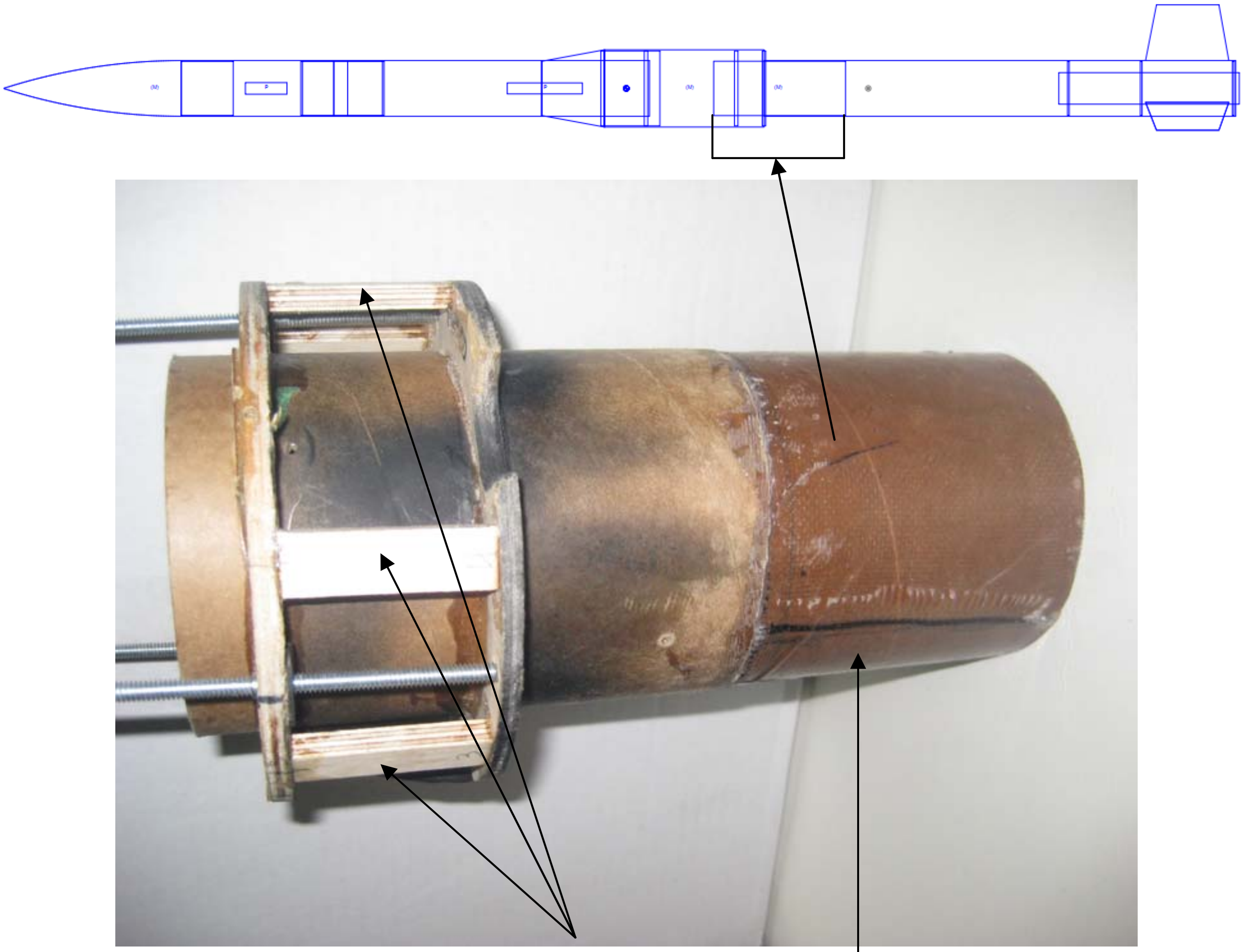
Key Modifications



1. Main parachute bay has been extended through the forward transition into two centering rings resulting in Frankenstein being shorted by 4 inches



2. The solid balsawood forward transition has been replaced with a hollow fiberglass transition. Its length has been increased from 3 to 4.5 inches.



3. The aft transition has six ¼ inch plywood stringers mounted between the two centering rings. A t-bolt is mounted in each, and,
4. The aft transition has its length increased by 5 inches to provide more support when it slides into the fin can. ¼ inch plywood backing has been mounted where each of the six screws fasten the aft transition to the fin can.

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

After careful examination of the remains of Frankenstein I and comments and suggestions from our NAR mentor, Bill Munds, the Range Safety Officer from the 3/5 launch, Carl Hamilton and others on the Rocketry Northwest listserve, we have tightened our pre-flight checklist and have made the aforementioned structural changes.

We have static tested Frankenstein II, the REZurrection (FIIR) by suspending five pounds from its center of gravity will it was supported at the nosecone, drogue bay joint and at a point where the leading edge of the fins enter the fin can. No deflection was observed.

We further tested the solidity of the airframe by subjecting it to shaking to see if there was any obvious deflection anywhere along its length. None was observed. We are confident that the structural changes incorporated has resulted in a significantly stronger airframe.

Describe proper use of materials in fins, bulkheads, and structural elements.
All wooden components, fins, bulkheads, centering rings, rail button standoffs, and support stringers are constructed of ¼ inch birch aircraft plywood. All components have been fastened with West Systems epoxy resin. The fins and standoffs have been reinforced with fiberglass.

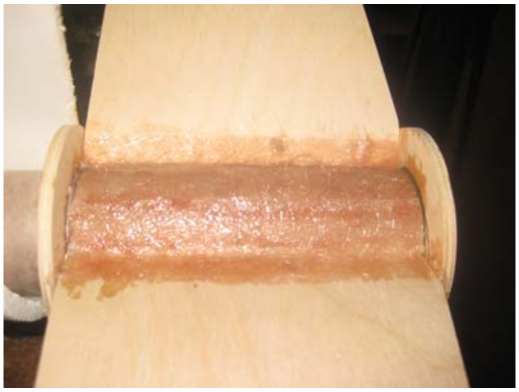
All edges and any fastener holes through the airframe of the Kraft Phenolic tubing have been reinforced with CA glue to help diminish distortion and fraying, particularly at the slip joints.

The extended aft coupler has been reinforced with two layers of fiberglass cloth impregnated with epoxy resin.

Explain composition and rationale behind selection.
Materials have been selected based upon:

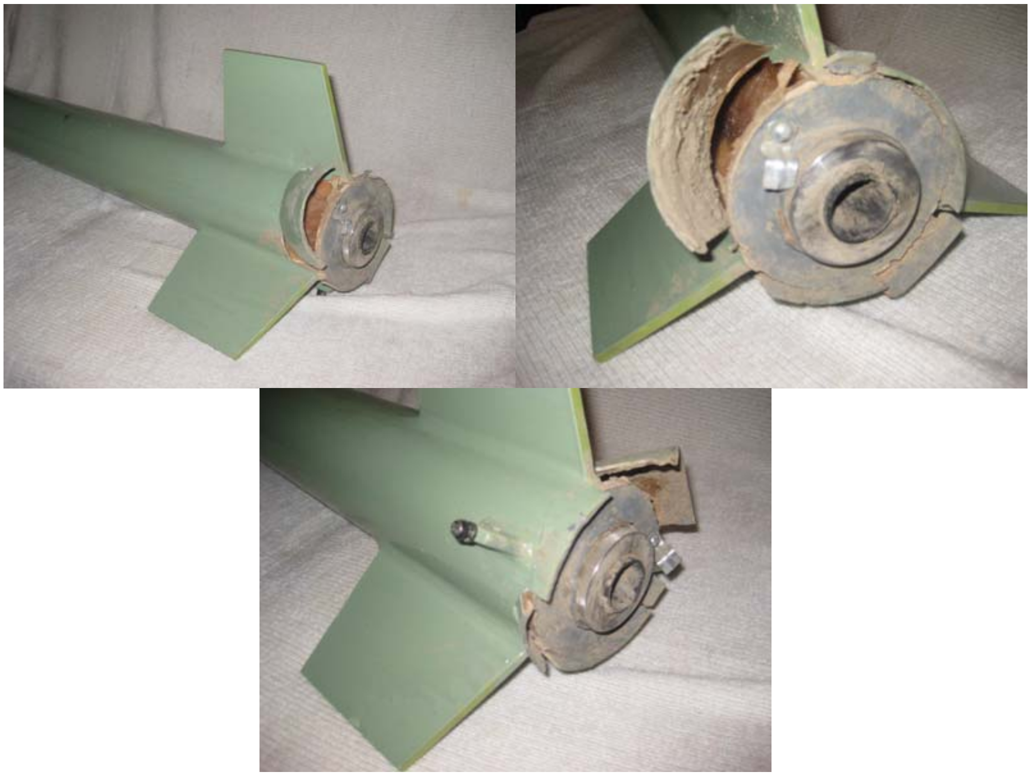
1. Availability
2. Cost
3. Ease of manufacturing
4. Recommendations from experienced HPR builders

Explain strength of assembly, proper attachment and alignment of elements, solid connection points, and load paths. (Looking for optimum assembly quality.) Show sufficient or exemplary motor mounting and retention.
We have had to rely upon readings and the advice of our NAR mentor in constructing FIIR.



The ¼" birch aircraft plywood fins are sandwiched between two ¼" plywood centering rings. The fins and the rail button stand off are then fiberglassed in place with West Systems epoxy resin and fiberglass cloth. A third centering ring is fastened to the forward end of the motor mount. Two ¼" t-nuts are drilled into the aft centering ring to provide a fastening point for motor retention. The fins/motor mount unit are then slid into the airframe and fastened with epoxy resin. Epoxy fillets surround the fins and the rail button standoff.

A testimonial to our fin/motor mount construction is that Frankenstein I's fin can fell approximately 2000 feet, motor first, into the ground. The only damage from ground impact was some peeling of the phenolic airframe tubing and the 54mm motor mount had been pushed in about 1/16 inch from the impact of the CTI 6-grain casing and the ground. The fins, motor mount, and rail button standoff received absolutely no damage.



Discuss the integrity of design and that you have used analysis to improve design. Demonstrate the suitability of shape and fin style for mission.
The breakup of Frankenstein I (FIR) under the acceleration and speed of the CTI K660 reload vividly demonstrated the forces involved during the flight and our lack of understanding those forces. Since we have no materials test facilities, we have to rely on readings and suggestions from our mentor. We now have a much better understanding of those forces and have rebuilt accordingly. We have redesigned key structural components and strengthened joints and other potential failure points, based upon examining FIR's collected pieces.

Specify approach to workmanship as it relates to mission success, including neatness of workmanship, quality of appearance, and attractiveness.
Workmanship is tidy and neat as can be seen by close examination of the fin can in the photos above. Fillets are smooth and symmetrical. The painting and color scheme are a work in progress. We are waiting upon successful test flights before committing a great deal of time to a "professional" paint job.

Provide a safety and failure analysis, including a table with failure modes, causes, effects, and risk mitigations.
Discuss full scale launch test results.

- 12/05/1 – Aerotech J500G reload. Successful flight; however, altitude considerably lower than predicted. Analysis dictated that we need to redesign the science payload bay from 7.67 inch diameter to 5.54 inch diameter because no 54 mm reload would allow Frankenstein I to reach desired altitude. Rocksim also showed that a blunt aft transition, rather than a cone-shaped one, would significantly increase our altitude.

- 3/05/11 – CTI K660 reload. Frankenstein I broke up 4 seconds into the flight. Analysis of the altimeter data, onboard video footage, and the rocket’s remains indicated that a structural design change was necessary. Frankenstein II was created between 3/6/11 and 3/19/11 with significant changes as mentioned previously.
- 3/20/11 – CTI J330 reload. Frankenstein II flew to an altitude of 2389 feet and had a successful recovery. The gee forces and maximum velocity are slightly more than half of what can be expected from the CTI K660 reload. Another launch with the K660 is scheduled for March 26, after which an FRR update will be submitted prior to April 1, 2011

Recovery Subsystem

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

To ensure a successful flight and recovery, the rocket will be equipped with a redundant recovery system consisting of a PerfectFlite MAWD altimeter and an RDAS-Tiny altimeter that are independent of each other. The PerfectFlite altimeter will provide primary parachute deployment functionality. The RDAS-Tiny 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 a SkyAngle 52” in diameter. The descent rate after the main is deployed is calculated to be 21 feet per second.

PARACHUTE SIZE CALCULATION		
Rocket Weight: 10.85 pounds		
Parachute Drag Coefficient: 1.5		
Vastsas Chute Calculator Program		
	Drogue (50-100 f/s)	**Main (17-22 f/s)**
Descent Rate	85 f/s	21.3 fps
Diameter	18.01 inches	53 inches
Shroud line length	12 inches	50 inches

SkyAngle 52"	
Tested Load Capacity for 17-25 fps descent (lbs)	6.8 -14.8
Surface Area (sq. ft.)	29.5
Suspension Line Length (inches)	52"
Cd at seal level	1.46
Net Weight (oz.)	13.32

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

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!.	70%
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.	5%
Incorrect parts or supplies are purchased.	Delay in build sessions, and possible milestones.	Ensure all orders are verified by team officers.	0%
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.	0%

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.	0%
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.	5%
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.	5%
Parachute deploys too early or too	High-speed deployment causes the shock cord to produce a “zippering"	Test the altimeter for drogue deployment at	10%

late in flight.	effect.	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.	10% 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.	0%
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%

Mission Performance Predictions

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

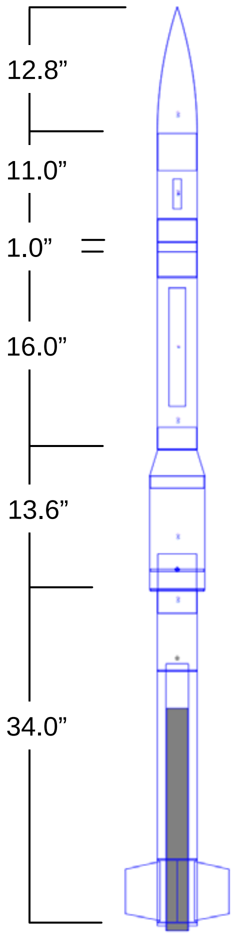
Provide flight profile simulations, altitude predictions with real vehicle data, component weights, and actual motor thrust curve. Include real values with optimized design for altitude. Include sensitivities.

Component Weights

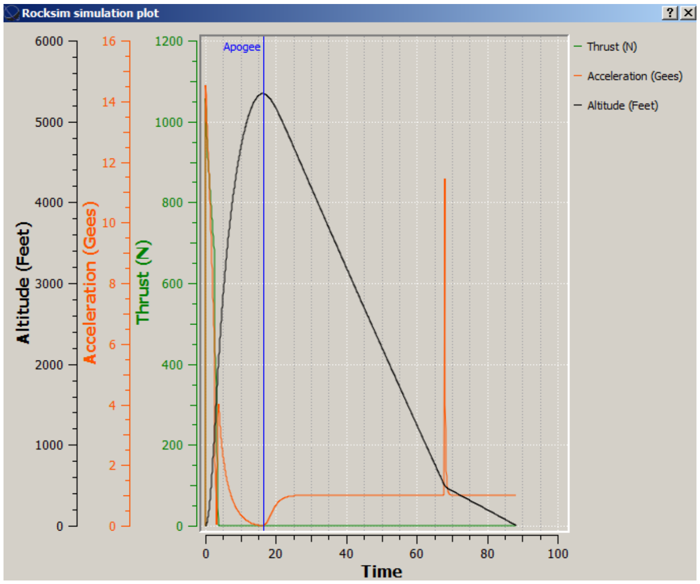
	Air Frame Wgt	
	g	oz
Nose Cone	180	6.35
DC20 & Mount	270	9.52
Drogue Parachute Bay	95	3.35
Drogue Shock Cord	100	3.53
Drogue Quick Link	**In Ebay Total**	
Drogue Parachute	14.07	0.50
Ebay & Electronics	597	21.06
Primary Altimeter 1	**In Ebay Total**	
Main Black Powder	1.9	0.07
Drogue Black Powder	1.1	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

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Wind starts at altitude: 0.00000 Ft.
Launch guide angle: 0.000 Deg.
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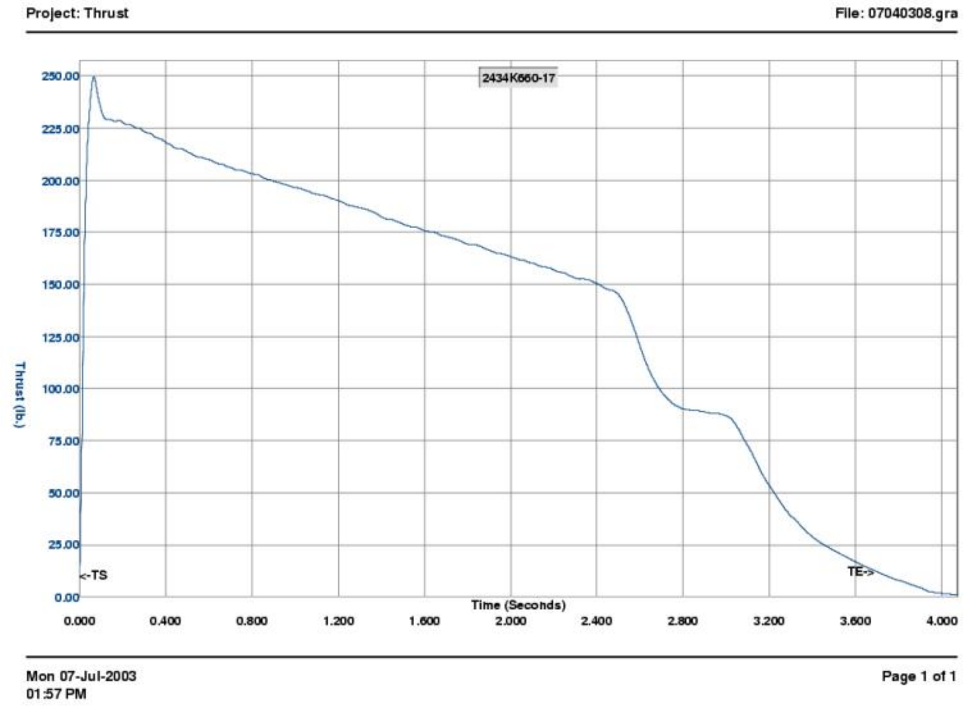
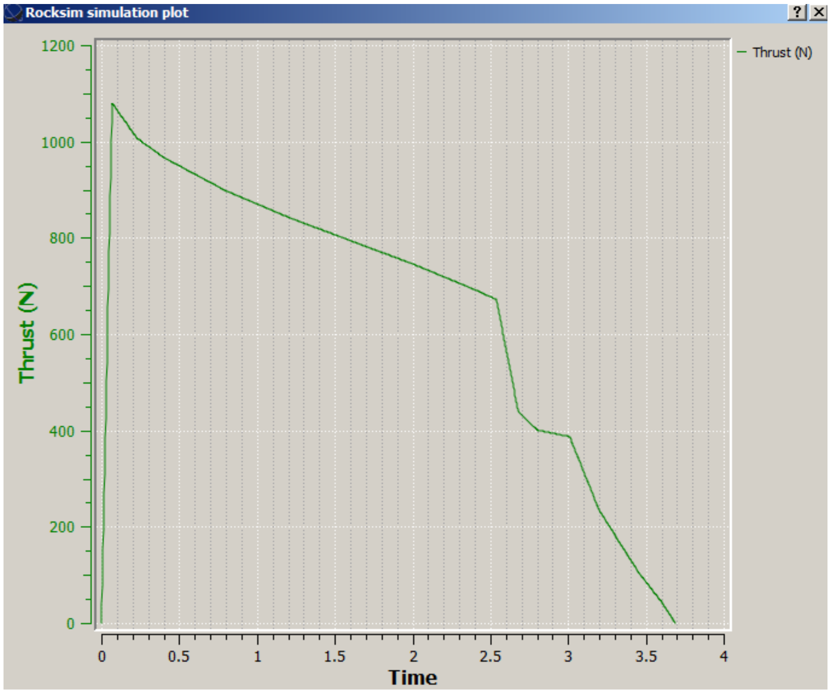
If we change the rail guide angle 10 degrees away from the wind, our predicted altitude increases to 5338.71 feet agl whereas if the guide angle is 10 degrees into the wind direction, the altitude decreases to 5023 feet.

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 March 20, 2011.

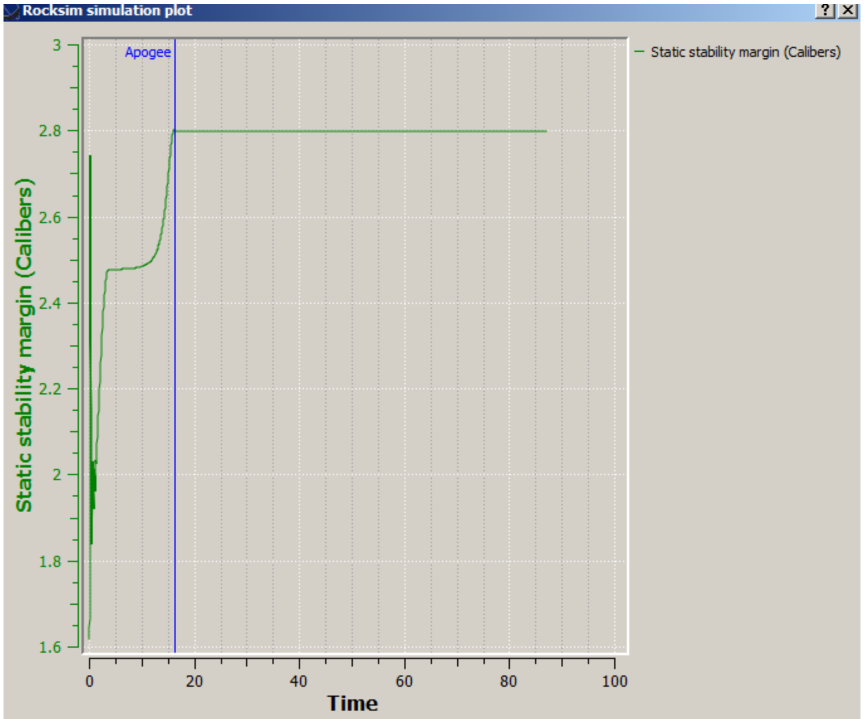
After a series of iterations, the CD has been changed to 0.50, which will override Rocksim's calculated CD. We will add additional data after the launch on March 26..

Stability Margin

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

Static Stability Margin

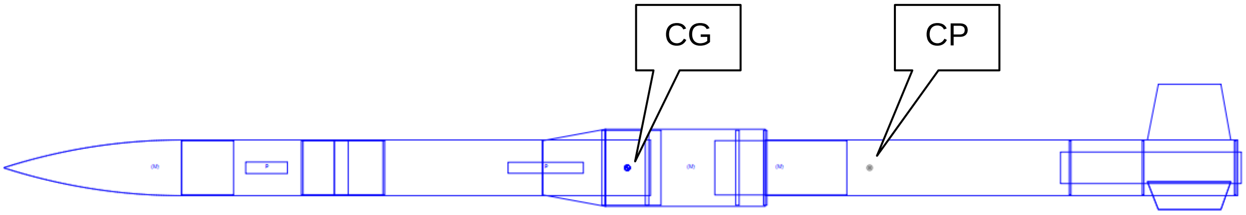
Condition	CG	CP	Margin
No Motor	44.88	62.32	3.15
Motor	54.26	62.32	1.45



Change in Static Stability Throughout Frankenstein II'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 II is predicted to be stable throughout its flight.

Safety and Environment (Vehicle)

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 A.
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. All team members shall read and sign the "Range Safety Regulations" RSR) statement. The RSR is attached as Appendix B.

Hazard and Safety 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 glasses shall be worn when working with black powder.
7. 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 instructions for attaching the science payload bay to the rocket airframe.

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 B) 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 C 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

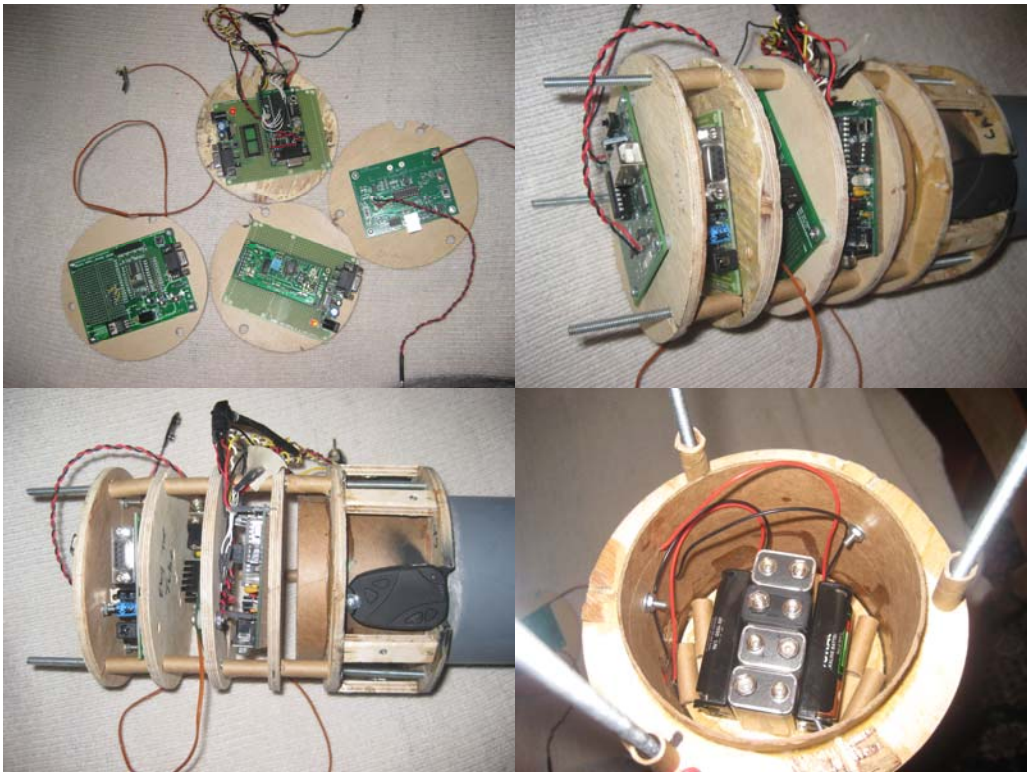
Motors will be purchased by either Bill Munds or one of the appropriately certified officers. After motors are received they will be placed in the team’s motor magazine which is located off-site on the property of the Team Official, Gary Brandt. This magazine is an ATF-approved Type 4 container. A second,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

Payload Integration

Each of our experiment is totally self contained in power source, data logging and sensor deployment. They are mounted on ¼” birch aircraft plywood disks which, in turn are mounted on three ¼ all-thread. The all-thread rods are mounted to the lower and bottom centering rings. The volume between the centering rings houses the batteries required to power the experiments.

The housing is a 11.5 inch section of 5.54 inch airframe. It is mounted via six #8 ½” screws into the forward transition and by an additional 6 10-54 ½” screws through the housing into t-nuts mounted in the vertical stringers between the bottom centering rings.



IV) Payload Criteria

Experiment Design of Payload

- Review the design at a system level, describe integration plan, and demonstrate that the design can meet all mission goals.
- Provide information regarding the precision of instrumentation and repeatability of measurement. (Include calibration with uncertainty.)
- Discuss the application of engineering, functionality, and feasibility.
- Provide flight performance predictions (flight values integrated with detailed experiment operations).
- Discuss flight preparation procedures.
- Specify approach to workmanship as it relates to mission success.
- Discuss completed component, functional, or static testing

Assembly

- Clear details of how the rocket is assembled.
- Integration and compatibility simplicity
- Structural integrity for flight
- Quality of construction

Safety and Environment (Payload)

This will describe all concerns, research, and solutions to safety issues related to the payload.

- Identify safety officer for your team.

- Update the preliminary analysis of the failure modes of the proposed design of the rocket, payload integration, and launch operations, including proposed and completed mitigations.
- Update the listing of personnel hazards, including data demonstrating that safety hazards have been researched, such as material safety data sheets, operator's manuals, and NAR regulations, and that hazard mitigations have been addressed and enacted.
- Discuss any environmental concerns.

Experiment Concept

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.

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 6 #8 5/8 screws into t-nuts that are fastened to ¼" birch aircraft plywood. 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.

Aft camera photo, 3/20/11

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.

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.

Mission 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.

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 have built robust modules that will be able to withstand the rigors of a high powered rocket flight. The competition modules are mounted in the science payload bay and a series of static tests are being developed (about 60% complete) 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) Launch Operations Procedures, Safety and Quality Assurances

Justin Johnny is our Safety Officer and is responsible for the upkeep of the checklists.

Checklists

Science Bay and Experiment Preparation

- ☐ Check all batteries for 8.5v or better – replace if necessary
- ☐ Check batteries in UV sensor (1.3v or better)
- ☐ Check power switches off
    - UV
    - IR
    - Humidity/Temp
    - Roll
    - Pressure
- ☐ Connect batteries to experiment boards
    - Roll
    - Pressure
    - Humidity/Temp
    - IR
- ☐ Mount experiment platforms on retaining rods
    - Roll
    - Pressure
    - Humidity/Temp
    - UV/IR
- ☐ Connect sensors to respective boards
    - UV to UV sensor
    - IR to IR sensor
    - Roll to roll sensor
    - Temp to temp sensor
- ☐ Turn on the two vertical cameras
- ☐ Slide science bay housing over experiments
- ☐ Fasten science bay housing with 6 10/24 screws
- ☐ Check sensor ports are clear – adjust if necessary

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

Wear eye protection whenever working with Black Powder!

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

- ☐ Trim electric match to an appropriate length.
- ☐ Remove at least an inch of insulation from each lead
- ☐ Short electric match leads
- ☐ Insert electric match into BP cup
- ☐ Pour measured amount of BP into BP cup
- ☐ Fill remaining space with dog barf

- ☐ Tape over the BP cup with tape to make certain that no BP escapes while filling the other cups.
- ☐ Repeat for the secondary BP cup
- ☐ Insert external disarming mechanisms to insure all electronically discharged pyrotechnics are disabled until final launch readiness.
- ☐ Connect electric match leads to appropriate connecting posts for each altimeter

Black Powder, main

- ☐ Trim electric match to an appropriate length.
- ☐ Remove at least an inch of insulation from each lead
- ☐ Short electric match leads
- ☐ Insert electric match into BP cup
- ☐ Pour measured amount of BP into BP cup
- ☐ Fill remaining space with dog barf
- ☐ Tape over the BP cup with tape to make certain that no BP escapes while filling the other cups.
- ☐ Repeat for the secondary BP cup
- ☐ Insert external disarming mechanisms to insure all electronically discharged pyrotechnics are disabled until final launch readiness.
- ☐ Connect electric match leads to appropriate connecting posts for each altimeter

Mount ebay into rocket, checking external disarming mechanisms are in place.

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

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

Motor preparation

- ☐ Be sure that motor is clean
- ☐ Open reload package
- ☐ Read the instructions
- ☐ Identify all of the parts to make certain that they are all there. If not, contact the Safety Officer
- ☐ Grease motor liner
- ☐ Insert propellant grains
- ☐ Tighten nozzle
- ☐ Remove black powder for forward end of reload
- ☐ Seal ejection charge hole with grease
- ☐ Insert reload into motor
- ☐ Fasten retaining devices
- ☐ Tape igniter to rocket airframe
- ☐ Discard trash properly

Launch team transports rocket to assigned launch pad

Tools to launch pad

- ☐ Multi bit screwdriver
- ☐ Sandpaper
- ☐ Wire strippers
- ☐ Masking tape
- ☐ Small screwdriver for switching on aft cameras
- ☐ Razor knife

Setup on launcher

- ☐ Verify pad power is OFF
- ☐ Slide rocket on to rail guide
- ☐ Turn on all electronics – check for appropriate lights and sounds
- ☐ Remove both safety restraints from altimeter switches
- ☐ Altimeters – beeping
- ☐ Power switches to experiments on
  - o UV
  - o IR
  - o Humidity/Temp
  - o Roll
  - o Pressure
- ☐ Aft Cameras on
  - o Cam 1
  - o Cam 2
  - o Cam 3

Igniter installation

After rocket is on the launch rail and after the altimeters are turned on then,

- ☐ Strip at least an inch of insulation from the igniter leads
- ☐ Make certain that igniter leads are shorted out to prevent accidental ignition
- ☐ Straighten igniter leads
- ☐ Insert igniter through the nozzle to the top of the motor
- ☐ Retain with plastic nozzle cap
- ☐ Short alligator clips to check for unpowered igniter wires
- ☐ Clamp clip of igniter lead and wrap excess igniter lead wire around alligator clip
- ☐ Repeat for second igniter lead.
- ☐ Make certain that there is no tension on the igniter leads that might cause it to fall from the rocket.
- ☐ Check continuity
- ☐ Fasten igniter into position
- ☐ Dispose of trash properly

Final Launch Sequence

- ☐ 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."

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.

Troubleshooting

- ☐ Failed igniter – replace

Post flight inspection

- ☐ Turn off electronics
- ☐ Check for damage
- ☐ Remove motor after it's cool
- ☐ Clean motor
- ☐ Download any data

VI) 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:
5 Hi altitude launch competition rocket with partial science payload
20 Launch Frankenstein II competition rocket without science payload
26 Hi altitude launch competition rocket with partial 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:
5-8 Flight Readiness Review Presentations (tentative)
13 Travel to Huntsville
14-15 Flight Hardware and Safety Checks (tentative)
16 Launch Day
17 Launch Day (backup)

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- Frankenstein II			
1	3.90" (98mm) Airframe Tubing	$10.45	$10.45
1	54mm Motor Mount Tube	$7.35	$7.35
			$17.70
Competition Rocket- Frankenstein I			
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
	CTI J330	$54.95	$54.95
			$647.91

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
15	travel to Huntsville	$412.00	$6,472.00
15	lodging Atlanta	$495.00	$2,200.00
			$9,122.00

Project Income			
	NASA SMD		$5,000.00
	Outreach		$1,500.00
	Washington State Space Grant		$3,000.00
	Tribal Support		$3,000.00
			$20,000.00

Budget Summary	
Scale Rocket	$184.99
Competition Rocket	$301.99
Propulsion	$647.91
Construction Supplies	$250.00
Recovery	$697.10
Electronics & Payload	$1,764.75
	$3,846.74

Travel & Lodging	$9,122.00

Project Total	$12,968.74

Project Income	
	$12,000.00

Educational Engagement

- Climate Change Workshop: November 11, 2010
- Northwest Indian College Science Department High School students: February 5, 2011
- Lummi Nations School Grades 9-12 Demonstration: February 10, 2011
- Demonstration to Northwest Indian College students: February 24, 2011
- NAR Convention in Seattle, WA: March 12-13, 2011

VII) 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.

Demise of Frankenstein I – Damage Analysis

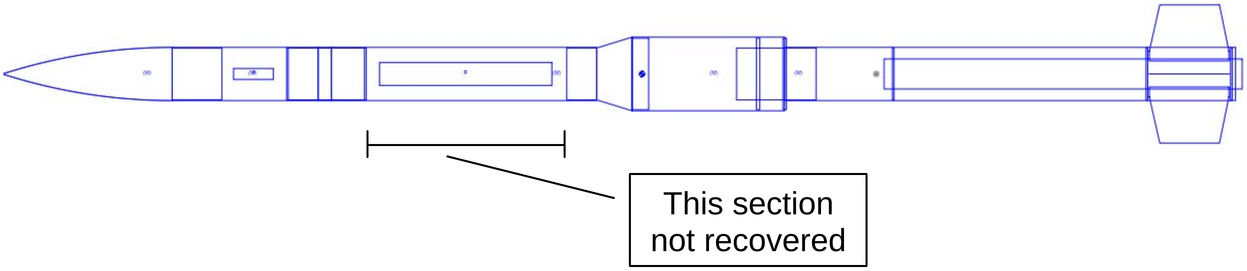
The Death of Frankenstein

March 5, 2010
Mansfield, WA
Sunny, patchy fog & low clouds, 40-45 degrees F, 0-2 Kts NE
CTI K660
RDAS – Tiny, drogue 1 and main 1
PerfectFlite MAWD, drogue 2 and main 2
52” SkyAngle parachute wrapped in blue fire blanket
18” Blue parachute wrapped in red fire blanket

Lifted off straight and flew very stably until about 4seconds into the flight when Frankenstein came apart. The Ebay and parachutes tumbled down, the fin can continued upward out of sight.

Sections Recovered or Not

Nose cone with GPS unit, recovered
Drogue parachute bay, recovered
Ebay with parachutes, recovered
Main parachute bay, **not recovered**
Payload bay, recovered
Fin can, recovered
Main parachute, recovered and severley damaged
Drogue parachute, recovered undamaged



This section not recovered

Damage Report

Nose cone:

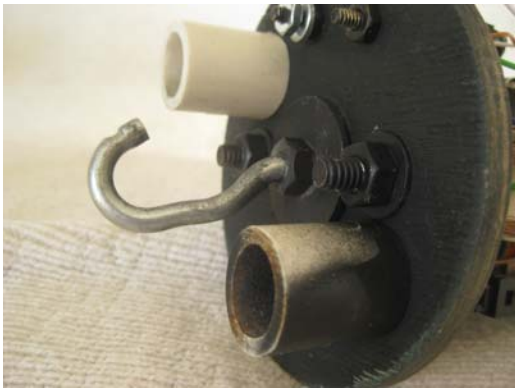
- undamaged
- GPS unit: undamaged, flight data recovered
- GPS retainer platform: base separated from bulkhead

Drogue bay:

- section failed at Ebay coupler end

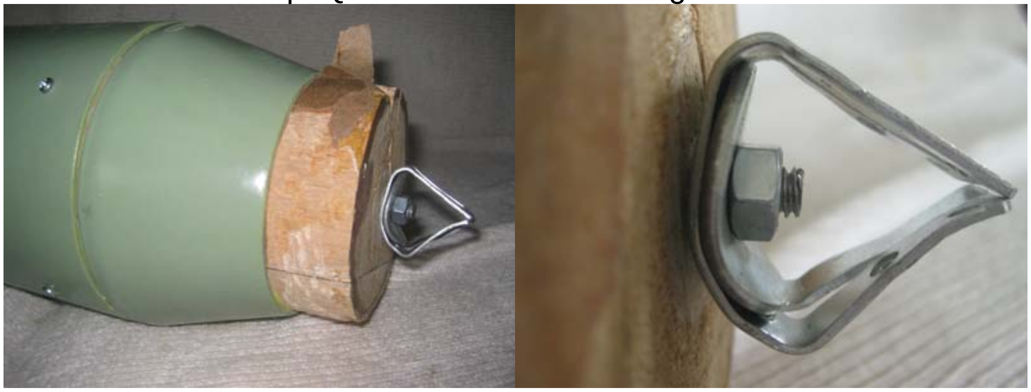
Ebay:

- drogue screw bolt straigtned
- RDAS – Tiny: undamaged and data recovered successfully
- PerfectFlite MAWD: undamged; however battery was disloged and no data recovered



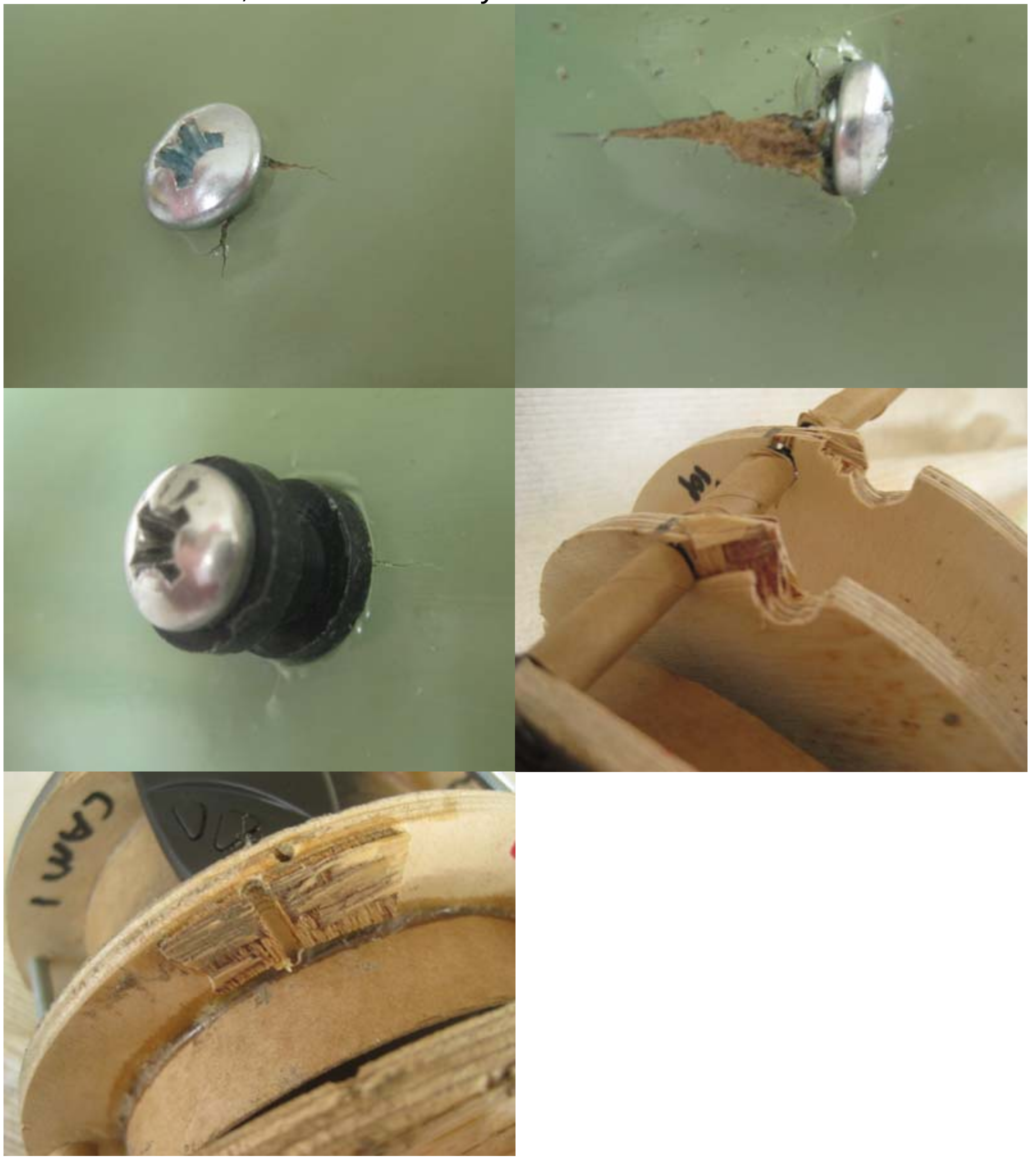
Main bay: Not Recovered

- Wasn’t aware that this section was missing because of all of the other pieces.
- Section separated at Ebay/main bay coupler end and forward transition end
- Main shock cord connection to aft section of rocket was distorted from the forch of the breakup. Quick link was not damaged



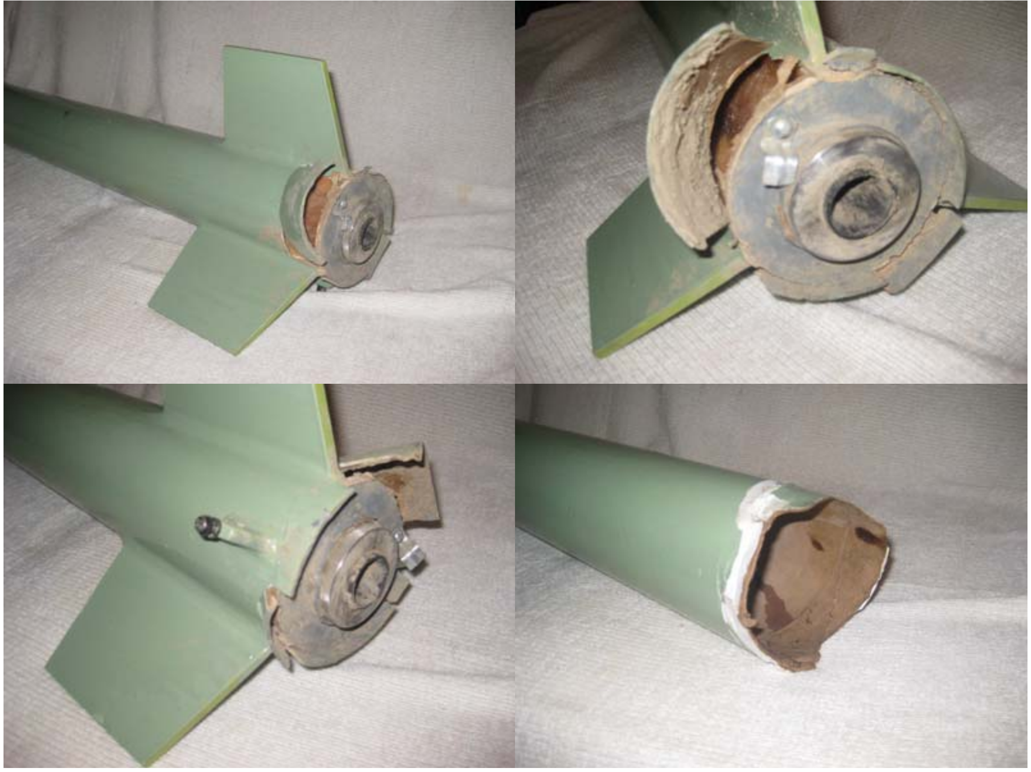
Payload bay:

- 5 1/2” body tube: suffered screw hole distortion damage at lower section where it screws into the science bay/fin can coupler.
- No rail button damge
- Electronics platforms suffered some damage
  - Notch for rail button damaged upon catastrophic separation
  - All 3 retaining screw mounts separated from centering ring that connects the 5 ½” science bay to scienc bay/fin can coupler
- Cameras 2 & 3, no damage and date recovered successfully
- Camera 1, no data recovery



Fin Can:

- Top 3” damaged from separation with payload bay.
- Base of rocket had some of the phenolic ripped and pushed forward as a result of ground impact.
- 54 mm motor jammed about 1/16“ into motor mount tube.
- Absolutely no damage to any of the fins or to the rail button offset mount.



Other Data

Video

Camera 2:

Fin can is passing wrapped drogue(?) parachute

- Camera shows time from ignition to event to be about 3.5-4.0 seconds
- After the event, the payload bay took 30.72 seconds to hit the ground
- The weight of the balsa transition allowed the cameras to continue to point upward while descending to the ground.

Camera 3:

Wrapped drogue(?) parachute

Fin can still going

Parachutes & Ebay Descending

- Lift off to event is 3.25 seconds

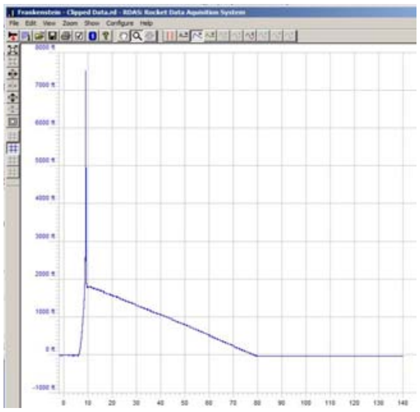
Altimeters

PerfectFlite MAWD

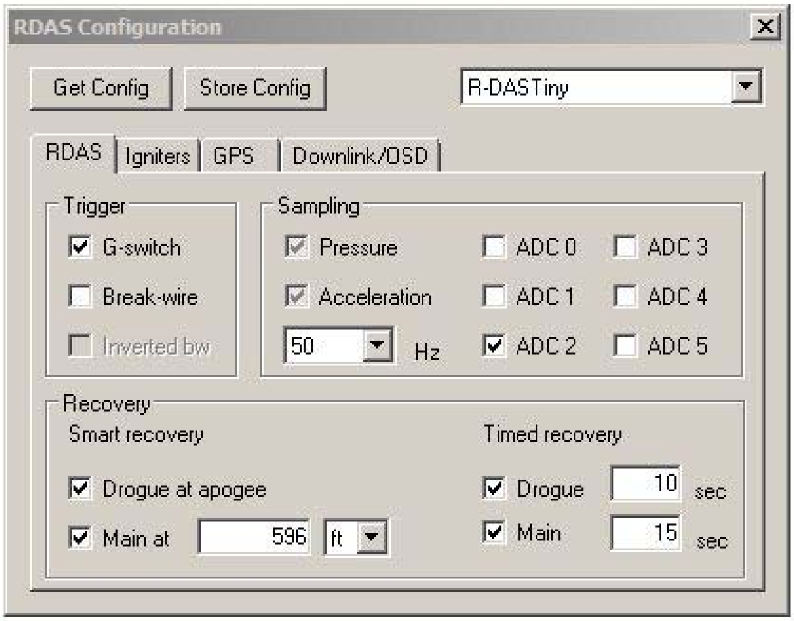
- Battery disconnected
- No Data recovered
- Drogue electric match not fired
- Main electric match not fired

RDAS-Tiny

- Data recovered
- Drogue electric match fired
- Main electric match not fired
- Altimeter data shows anomaly near 10 seconds after liftoff
- Altimeter data shows altitude at time of anomaly to be about 1800 feet
- Configuration indicates potential problem



Altitude Data from RDAS-Tiny



R-DASTiny

Trigger

☑ G-switch

☐ Break-wire

☐ Inverted bw

Sampling

☑ Pressure

☑ Acceleration

50 Hz

☐ ADC 0

☐ ADC 1

☑ ADC 2

☐ ADC 3

☐ ADC 4

☐ ADC 5

Recovery

Smart recovery

☑ Drogue at apogee

☑ Main at 596 ft

Timed recovery

☑ Drogue 10 sec

☑ Main 15 sec

The RDAS-Tiny allows for Smart Recovery (altitude-based) and Timed Recovery. We ground tested using the Timed Recovery mode which was set for Drogue, 10 seconds, and Mina, 15 seconds. A mistake (Gary's actually) was to not clear the timed recovery when we set the Smart recovery for the actual flight.

We are speculating that the drogue was ejected at an airspeed sufficient enough to cause Frankenstein's breakup. Additional supporting evidence is the nearly straightened Ebay eyebolt that fastens the drogue shock cord to the Ebay, drogue and nose cone.

Other Data

We used a frame from Camera 2 and matched the size of the race track located at the Mansfield site to one from Google Earth. We determined that the altitude was approximately 1700 feet agl at the time that that frame (camera still pointing down) was recorded and that the altitude was approximately 1800 feet agl when the rocket started to breakup..

Conclusion:

One remote possibility is that the timed drogue and main ejection in the RDAS-Tiny may have caused the igniter to fire 10 seconds into the flight where Frankenstein was traveling approximately 220 f/s according to Rocksim. RDAS data is suspect since maximum predicted speed by Rocksim is about 788 f/s. However the 10 seconds does not match the 4 seconds of the video, or, if one were to discount the 6 seconds of the RDAS-Tiny before liftoff; therefore, this conclusion is rejected.

The other possibility is that the joint between the aft end of the science bay and the fin can failed. It is difficult to analyze this with any certainty. This theory makes sense because we tried to have Frankenstein I as light as possible to help us achieve the target altitude.

We have settled on the failed-joint possibility of failure and have rigorously strengthened the connections between the aft transition and the fin can, the science bay cover to both the forward and the aft transitions. And, we have built a new forward transition from fiberglass for a more robust structural component

Afterward:

Frankenstein II launched and recovered successfully on March 20, 2011 using a CTI J330 reload.

Appendices

Appendix A - 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 B - 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 C - 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