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# Northwest Indian College Space Center – Team Sky Walkers Preliminary Design Review Report

## **I) Summary of Preliminary Design Review Report**

### **I.1 Team Summary**

#### **I.1.1 Team Name**

Northwest Indian College Space Center – Team Sky Walkers  
Project Sky Bolt

#### **I.1.2 Location**

Northwest Indian College, 2522 Kwina Road, Bellingham, Washington, 98226,

#### **I.1.3 Team Officials and Mentor**

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

### **I.2 Launch Vehicle Summary**

#### **I.2.1 Dimensions without motor (inches)**

Length	112.625	Diameter	4.025
Weight	25.318 lbs	Fin Span	12.025
Center of Gravity	62.157	Center of Pressure	76.287
Static Stability	3.51		

#### **I.2.2 Motor Choice**

Full-scale motor: Cesaroni Technology Inc L935-RL  
Sub-scale motor Aerotech G80

#### **I.2.3 Recovery System**

To ensure a successful flight and recovery, the rocket shall be equipped with a redundant recovery system consisting of two PerfectFlite MAWD altimeters that are independent of each other. Each will have its own power supply and ejection charges. The drogue will be deployed at apogee and the main will be deployed at 700 feet. Landing will have a maximum kinetic energy of 75 ft-lbf.

#### **I.2.4 Launch Vehicle Fly Sheet**

Please see Appendix A

### **I.3 Payload Summary**

The scientific payload contains systems to measure temperature, humidity, pressure, ultra-violet radiation, and solar irradiance. Measurements will be taken and recorded on descent and after landing whereupon the data will be transmitted to our ground station. The payload also contains multiple cameras used to take pictures and video throughout the flight and after landing.

## ***II) Changes Made Since Proposal***

### **II.1 Changes made to Vehicle Criteria**

The length has been increased 112 inches, to accommodate the science payload, the power management system and the data transmission system. The remaining dimensions are the same.

After having limited success with the horizontal recovery plan on our scale rocket, we have decided to have each of the connected separate sections of the rocket descend in a more conventional vertical orientation. A different recovery separation arrangement is being considered where the science payload remains connected to the fin can and will remain vertical throughout the descent.

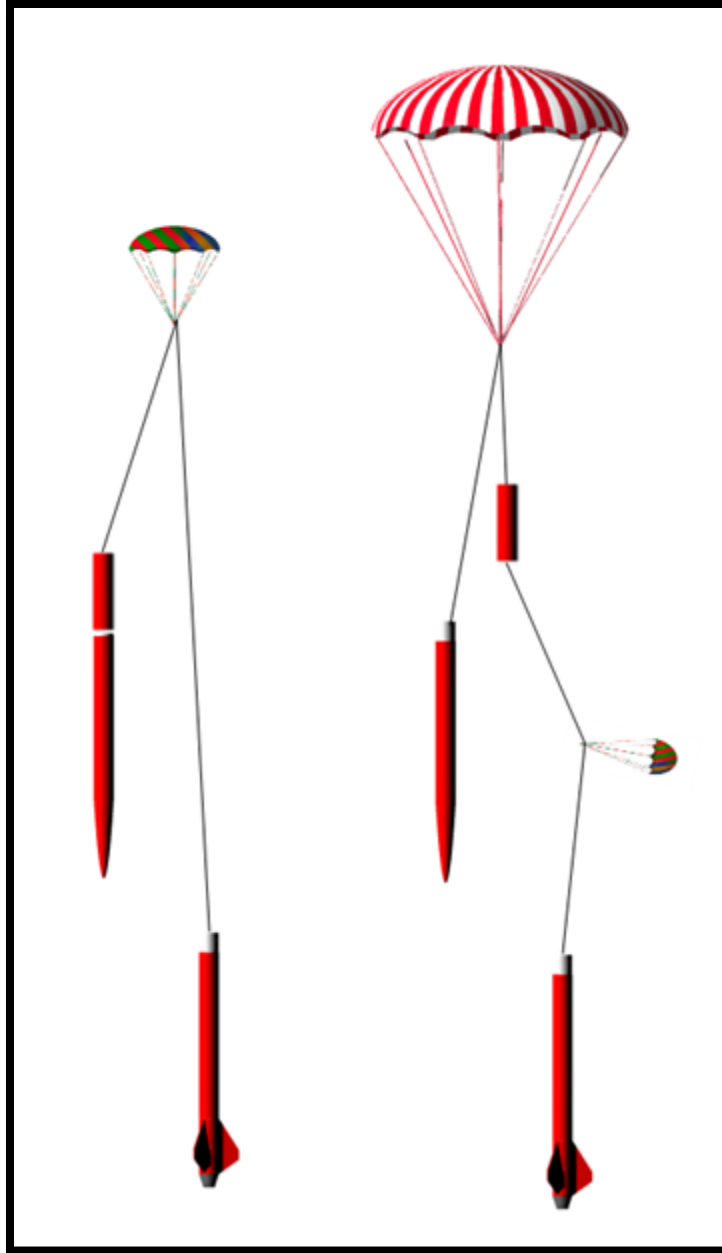
The power management system has been modeled successfully using an Arduino microcontroller operating two high-torque servos that extend and retract speed brakes. The rocket is slightly overpowered to an altitude of 5,460 feet agl based upon Rocksim, and an in-house modified trajectory numerical simulation program. When and for how long the brakes will be operated is determined by altitude and speed measurements being used to calculate forward-looking altitude and speed to reach 5,280 feet at zero airspeed. A parachute will deploy at 5,280 feet as a precautionary measure to ensure that the rocket stays within the competition parameters.

### **II.2 Changes made to Payload Criteria**

The science payload is continuously being refined as team members improve their programming and construction skill. We have shifted from the BASIC Stamp microcontroller to the Arduino microcontroller because of cost, size, and increased performance.

### **II.3 Changes made to Activity Plan**

Our full-scale flight schedule missed the first two attempts. Other than that, no changes have been made at this time regarding the activity plan. It is still progressing as listed in the proposal.



*Figure 1, Deployment Scheme*

### **III) Vehicle Criteria**

#### **III.1 Selection, Design, and Verification of Launch Vehicle**

##### **III.1.1 Mission**

##### **III.1.1a Mission Statement**

1. Through the USLI program, the Northwest Indian College Space Center's Sky Walkers Team enhances its involvement in science, math,

engineering and technology and encourages others in Tribal communities to do the same. (We are taking a considerable amount of credit for encouraging Haskell Indian Nations University to make a USLI proposal this year.)

2. Furthermore, we plan to:
  - a. design and build a recoverable, reusable rocket
  - b. carry a science payload to an altitude of no more than one mile
  - c. collect and analyze in-flight data from the science payload
  - d. achieve the 5280 foot altitude via a power management system

This objective will be achieved by thorough design and testing of the rocket and its scientific payload.

### **III.1.1b Mission Requirements**

Sky Walker's Rocket will, in addition to the USLI competition requirements:

- Build a rocket that will be water resistant
- Build a rocket whose electronics will be protected from water
- Use a power management system that will ensure the target altitude requirement is met
- Test atmospheric conditions and use the information as part of the Native Environmental Science Degree environment data collection plan.

### **III.1.1c 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:*

- rocket launches as designed
- attain an altitude within .01% of 5280 feet with the power management system
- 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
- rocket and electronics sustain no damage from a damp landing

#### *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

### III.1.2 Schedule and Time Line (Key Events)

Team Sky Walkers Major Milestone Schedule			
Proposal Submitted	Completed	9/6/11	
Scale Rocket	Design Complete	10/5/11	
Scale Rocket	Construction Complete	10/17/11	
	Completed Flight Test	11/12/11	
Selection Notification	Selected!	10/17/11	
USLI Team Teleconference	Completed	10/21/11	
Web Presence Established	Completed	11/4/11	
Competition Rocket	Initial Design Considerations	9/9/11	
Competition Rocket	Design Finalized	10/20/11	
	Construction Started	10/28/11	
	Construction Complete	11/22/11	
	Recovery System Ground Test	11/23/11	
	Test Flight	12/3/11	
	Power Management Test Flight	1/14/12	
	Test Flights as needed		1/28/12
			2/4/12
			2/18/12
			3/3/12
			3/17/30
			3/31/30
Science Payload	Initial Design Considerations	9/6/11	
Science Payload	Design Finalized	10/31/11	
	Construction Started	11/1/11	
	Construction Complete	2/15/12	
	Operational Testing	2/15/12	
	Testing Complete	3/20/12	
	Test Flight	3/31/12	
Preliminary Design Review Submitted		11/27/11	
Preliminary Design Review Presentation		12/14/11	
Critical Design Review Submitted		1/22/12	
Critical Design Review Presentation		2/10/12	
Flight Readiness Review Submitted		4/21/12	
Flight Readiness Review Presentation		4/11/12	
Launch		4/21/12	
Post flight Analysis Review		5/7/12	
Announcement of Winning USLI Team		5/18/12	

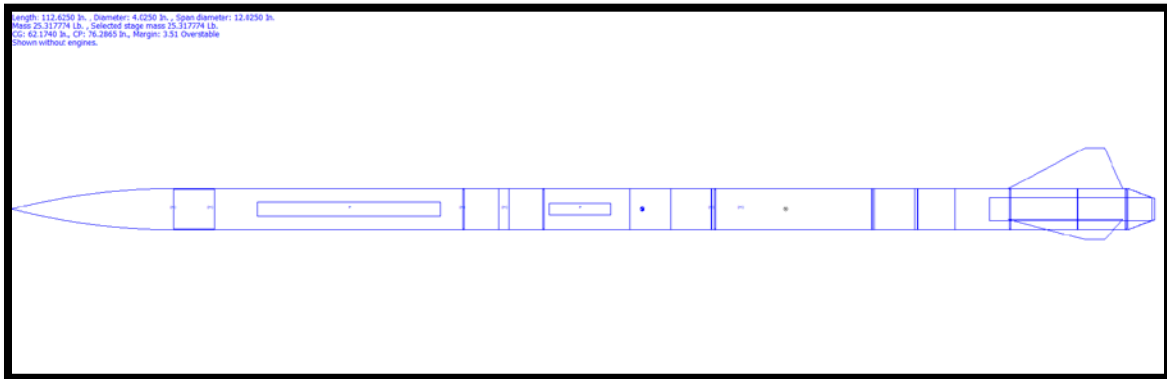
The full time line is in Appendix B.

### III.1.3 Design Review at System Level

The overall vehicle stands slightly over 112 inches tall with an airframe diameter of four inches. The entire rocket is fiberglass, G10 for everything except tail cone. All components, except the tail cone, are from Performance Rocketry. The tail cone is from Aero Pack and is constructed from aluminum. Three fins are attached through the wall to the 54 mm motor tube 1/2 inch above the aft edge of the airframe. The fins are fastened in place with West Systems 2-part epoxy resin and reinforced with a fiberglass inlay across the inside. Table 1 and Figure 2 list the dimensions.

Length	112.625	Diameter	4.025
Weight	25.318 lbs	Fin Span	12.025
Center of Gravity	62.157	Center of Pressure	76.287
Static Stability	3.51		

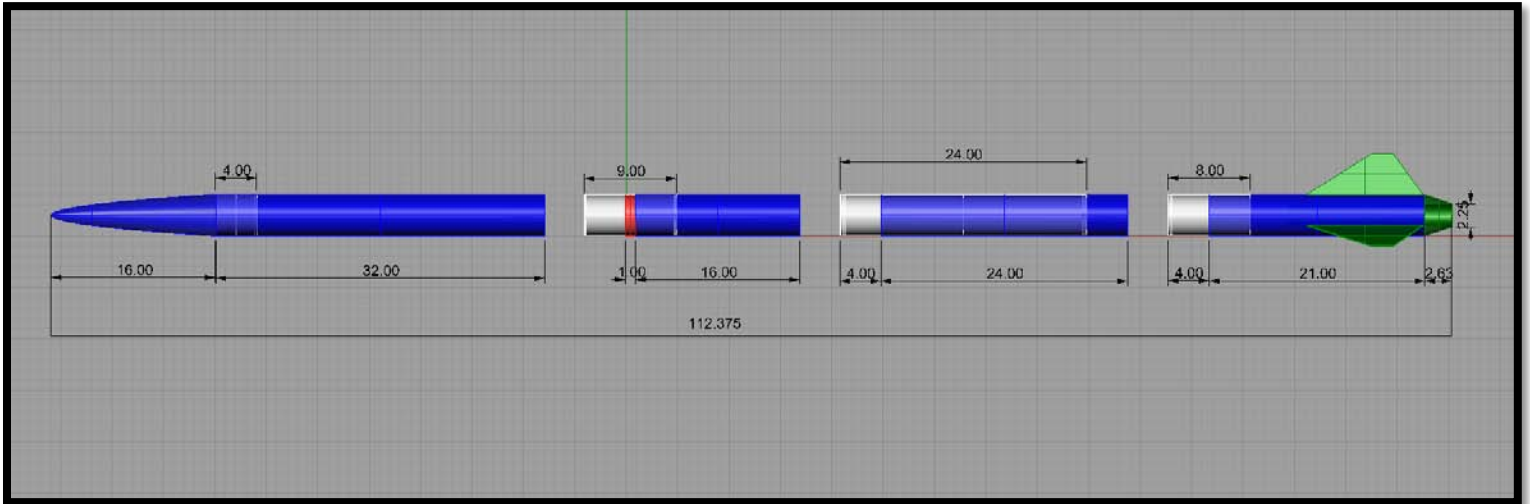
*Table 1, Rocket Dimensions*



*Figure 2, Rocksims 9 Side View*

The airframe houses the parachutes, recovery electronics, science payload, power management system, velocity retardation device, motor and motor mounts, bulkplates, nosecone, fins, and other instruments in an aerodynamic structure. The airframe is constructed from G10 fiberglass manufactured by Performance Rocketry. We chose fiberglass for two reasons: 1) strength to handle the stresses of launching a heavy load, and 2) water resistance because of our often flooded recovery area. The airframe components are illustrated in Figure 3 and will be described in detail.

*Figure 3, Airframe Component View*



### **III.1.3a Nosecone**

The nosecone is a fiberglass commercial 16 inch long 4:1 ogive-shaped nosecone with a 3.75 inch shoulder. The GPS transmitter will be housed here, (Figure 4), well away from all other electronics. A ½ inch aircraft grade birch plywood bulkplate secures the GPS platform in the nosecone.



*Figure 4, GPS Tracker on nose cone insert with hand-held GPS receiver*

### **III.1.3b Main Parachute Recovery Bay**

The main parachute recovery bay is 32 inches long of which 4 inches of either end are allocated for the nose cone shoulder and the altimeter electronics bay connector.

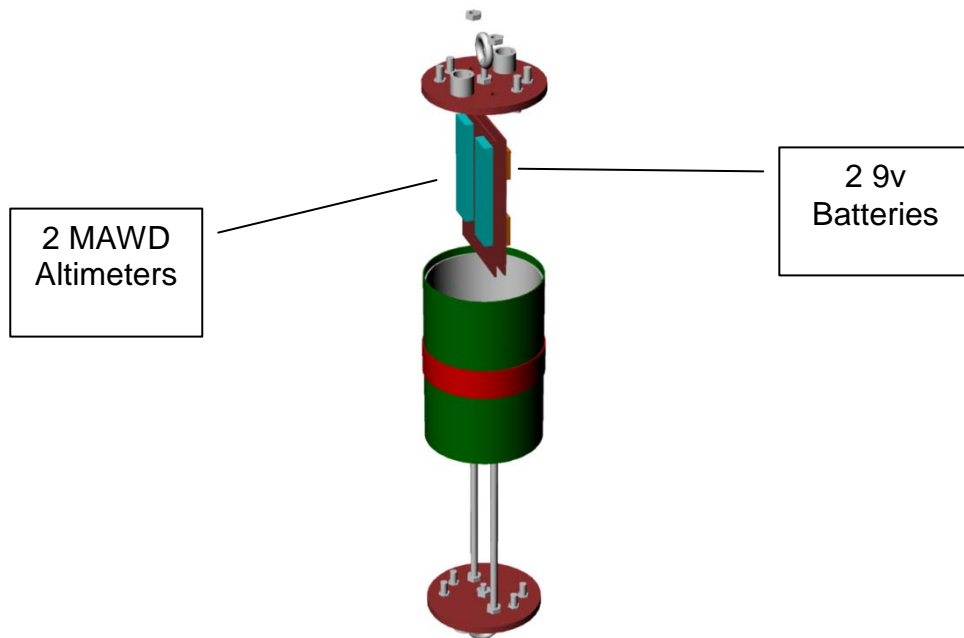
### **III.1.3c Altimeter Electronics Bay (ebay)**

The altimeter electronics bay, **Figure 3**, adds 1 inch to the rocket's length and itself is 9 inches long. It houses the two PerfectFlite MAWD altimeters for redundant dual deployment. It constructed from G10 fiberglass capped with G10 bulkplates. An eyebolt, two black powder cups, and connecting posts for the

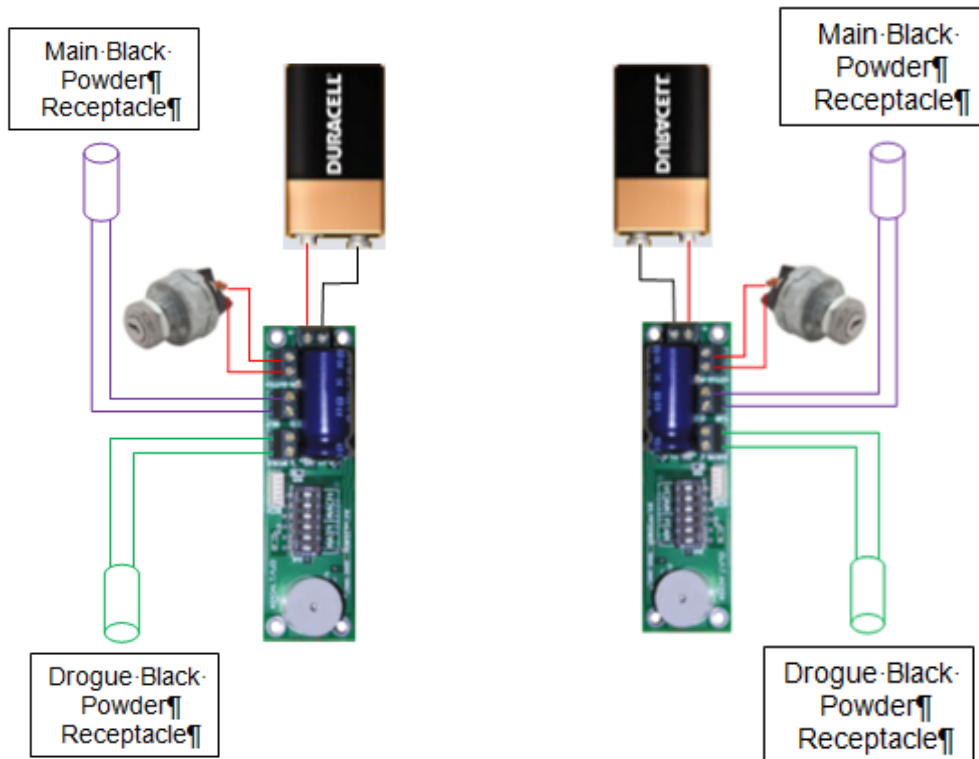
electric match wires finish each end. The two MAWD altimeters and batteries are held in place on a G10 fiberglass sled that slides on two ¼ inch threaded rods. Everything is fastened together by bolts and wing nuts on either end of the threaded rods.

The vent holes connect to flexible tubing that is curled to inhibit water entry should the rocket land in water.

The ebay altimeters will be shield from stray RF signals with a layer of aluminum foil glued to the ebay's interior.



*Figure 5, Ebay Concept*



*Figure 6, Redundant Dual Deploy Avionics Block Diagram*

### **III.1.3d Drogue Parachute Recovery Bay**

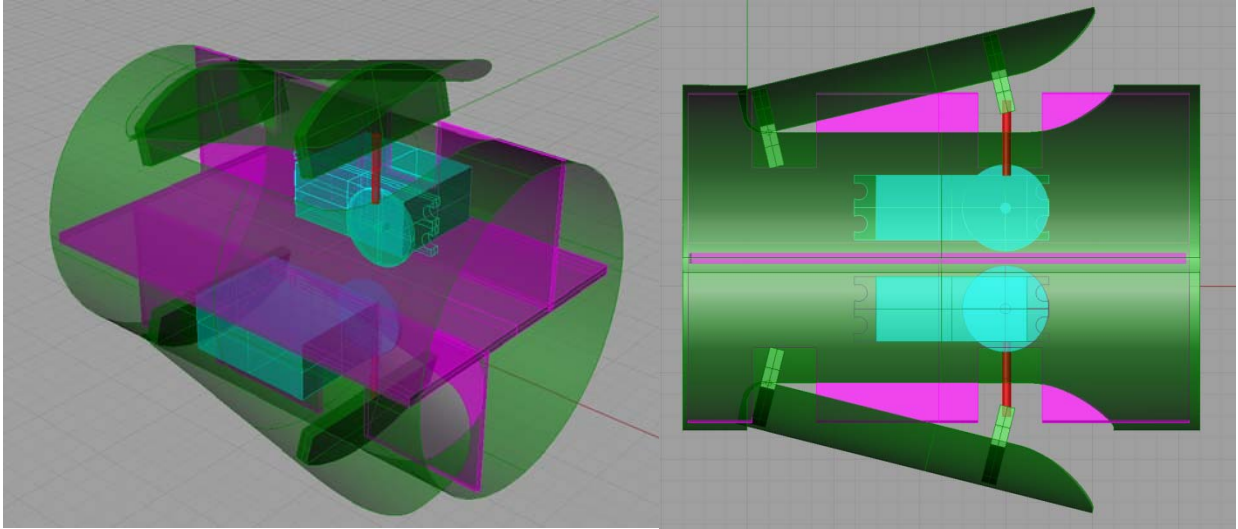
The drogue parachute recovery bay is 16 inches long, of which the upper 4 inches are allocated for the connection to the ebay. This leaves 12 useable inches. The bottom slides over the tube connector between it and the science payload bay. The tube remains hollow for the first 4 inches for recovery harness/drogue chute storage.

### **III.1.3e Science Payload Bay**

The science payload bay contains the sensors and microcontrollers for the atmospheric data gathering, the data transmitter, and the power management system for the velocity reduction system

### **III.1.3f Power Management and Velocity Reduction System**

This system (Figure 4) is located in the after end of the science payload bay. It's comprised of 2 or more high-torque servos that open and close hinged flaps. The opening and closing is controlled by an Arduino microcontroller with a barometric shield that measures altitude, calculates velocity and predicts whether or not and when the flaps need to be deployed.



*Figure 7, Power Management System Concept*

### **III.13g Fin Can**

The fin can, Figure 8, is 21 inches long and houses the 16 inch x 54mm diameter motor mount which is secured in place with epoxy resin and three centering rings, one at either end of the fin tabs and with the mid ring fitting into a notch in each fin. A layer of fiberglass cloth and epoxy resin provides additional connection support for the fins. An Aero Pack combination fin cone/motor retainer finishes the airframe. It provides both drag reduction and secure motor retention.

### **III.1.3h Fins**

Three 1/8 inch G10 fins (Figure 9) are placed 98.25 inches from the nose of the rocket to provide stable flight. The fins have a tab and are mounted through the airframe wall (TWT mounting) 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. The fins have been notched and an additional centering ring placed between the fore and aft centering rings. This provides a larger bonding surface as well as more support for the motor tube.



*Figure 8, Fin-to-Motor Tube Mounting*

### **III.1.3i Bulkplates and Centering Rings**

The bulkplates provide recovery harness mounts, confine the different components, and protect the components and electronics from black powder charges ignited during recovery system deployment. Eye-bolts are used on the bulkplates to provide a connection point for the recovery harnesses. The material for all bulkplates is 3/16 inch G10 fiberglass. This material was chosen because of its high strength, durability, it's relatively easy to shape with woodworking tools. It is suitable for protecting the instruments in the payload and the altimeters from the black powder charges used in the recovery system. The bulkplates are secured in place using West System epoxy resin.

### **III.1.3j Motor Mount, Motor retainers and Couplers**

G10 fiberglass is used for the motor tube and couplers is from Performance Rocketry. The G10 tubing is structurally stable and is used to protect and house the motor, the avionics, the science experiments and to provide a stable structure to contain and constrain the motor. The motor tube is 16 inches long with a 54 mm (2.14 inch) diameter and is located 96 3/8 inches from the tip of the nose cone. Three different connection methods are used:

### **III.1.3k Connecting the Components**

1. Permanent connections use West System epoxy.
2. Those that need intermittent access use 10-24 T-nuts and screws.
3. Temporary connections between the ebay and the two parachute compartments use shear pins. The shear pins prevent the rocket from premature separation due a combination of drag, inertia, and momentum.

The shear pins are, however, designed to fail when the black powder ejection charge is ignited.

An Aero Pack fin cone/motor retainer (Figure 8) provides both drag reduction and secure motor retention. The adaptor portion is bonded to the motor mount with J&B Weld high temperature epoxy.

### III.1.4 Required Subsystems to Accomplish the Overall Mission

<b>Subsystems</b>	
<b>Airframe is G10 Fiberglass and is the complete rocket</b>	
<b>Nose Cone</b>	
Contains the GPS tracking unit used to locate the rocket after landing and to provide flight data.	
<b>Recovery</b>	
<b>Main</b>	Contains the drogue parachute and recovery harness
<b>Ebay</b>	Contains deployment electronics
<b>Drogue</b>	Contains main parachute and recover harness
<b>Science Payload Bay</b>	
Contains the sensor electronics and microcontrollers for atmospheric data collection	
Contains the data transmitter	
Sensors are mounted on the science payload bay	
Contains the cameras	
<b>Power Management</b>	
Contains the electronics and the hardware for the velocity reduction system	
<b>Propulsion</b>	
Contains the engine casing and the reload used for flight.	
<b>Ground Support Equipment</b>	
Launch platform, guide rail and launching electronics	
<b>Safety System</b>	
Check lists, fire suppression equipment, cell phones	

*Table 2, Subsystems*

### III.1.5 System and Subsystems Performance Characteristics

<b>Subscale Rocket</b>		<b>Characteristic</b>			<b>Metrics</b>	
<b>System</b>	<b>Subsystem</b>	<b>Design</b>	<b>Structure</b>	<b>Materials</b>	<b>Evaluation</b>	<b>Verification</b>
Airframe	Nose Cone	Designed in Rocksim	LOC Precision Nose Cone	Polystyrene	Rocksim 9 Simulation	Completed Successful Flight Test

	Forward Airframe	9	LOC Precision Airframe	Phenolic		
	Ebay Ring					
	Aft Airframe					
	Fin Can					
	Fins					
Recovery	Main Bay	Designed in Rocksim 9	LOC Precision Airframe	Phenolic	Rocksim 9 Simulation	Completed Successful Flight Test
	Main Parachute		TopFlight Parachute	Ripstop Nylon		
	Ebay		LOC Precision Airframe	Phenolic		
	Drogue Bay			Phenolic		
	Drogue Parachute		TopFlight Parachute	Ripstop Nylon		
	cs Avionics	Designed to High Power Rocketry standards	Perfect Flight MAWD Altimeter, plywood sled, zinc plated 1/4" threaded rod	Various	Ground Test	
Propulsion	Fin Can	Designed in Rocksim 9	Aerotech Commercial Motor	Aluminum, ACP	Rocksim 9 Simulation	Successful Flight

*Table 3, Subscale Rocket Performance Characteristics*

Competition Rocket		Characteristic			Metrics	
System	Subsystem	Design	Structure	Materials	Evaluation	Verification
Airframe	Nose Cone	Designed in Rocksim 9	Performance Rocketry Airframe	Performance Rocketry G10 Fiberglass	Team & Advisor Visual Inspection, Rocksim 9, OpenRocket Simulations, NAR Mentor Inspection	Successful Test Flights
	Forward Airframe					
	Ebay Ring					
	Aft Airframe		Performance Rocketry Fins			
	Science Payload Bay					
	Fin Can		Aero Pack	Aluminum		
	Fins					
	Tail Cone/Motor Retainer					
Recovery	Main Bay	Designed in Rocksim 9	Performance Rocketry Airframe	Performance Rocketry G10 Fiberglass	Team & Advisor Visual Inspection, Rocksim 9, OpenRocket Simulations, NAR Mentor Inspection	Successful Test Flights
	Main Parachute		Sky Angle parachute	Nylon		
	Ebay	Designed in Rocksim 9	Performance Rocketry Airframe	Performance Rocketry G10 Fiberglass		
	Drogue Bay		TopFlight Parachute	Ripstop Nylon		
	Drogue Parachute				Multiple Ground Tests that demonstrate successful parachute ejection	Successful Ground Tests and Successful Flight
	Avionics	Designed to High Power Rocketry standards	2 Perfect Flight MAWD Altimeter, G10 sled, zinc plated 1/4" threaded rod	Various		
Science	Science Payload Bay	Integration Designed with Rhino 3D	Performance Rocketry Airframe	Performance Rocketry G10 Fiberglass	Team & Advisor Visual Inspection, Rocksim 9, OpenRocket Simulations, NAR Mentor Inspection	Successful Flight
	Atmospheric electronics		Arduino Microcontroller, various manufacturer's sensors	Various	Multiple Ground Tests	
	Cameras		Meritline Mini Camera			
	Power Management		Hi-Torque Servos, Arduino Microcontroller			

Propulsion		Designed in Rocksim 9	CTI Commercial Motors	Aluminum. ACP	Rocksim 9 Simulation	Successful Flight
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*Table 4, Competition Rocket Performance Characteristics*

**III.1.5b Science Payload Bay Subsystem**

An Arduino microcontroller provides all of the data collection from the various sensors and sensor modules. It then transfers the data to an SD card for later analysis as well as to the 900MHz transmitter. The transmitter sends the information to a laptop computer on the ground which has a 900 MHz receiver attached.

**III.1.5c Power Management Subsystem**

A second Arduino microcontroller collects data from a barometric sensor and interacts with the program to determine when to deploy the velocity reduction system. The table below shows the information that is used in the calculations and the first 0.8 seconds of data derived from the calculations. The numbers have been limited to 2 decimal places in order for the table to fit on the page in a readable format.

Appropriate motor information is entered as well as key information about the rocket. With these calculations we are able to determine at what altitude/speed combination to deploy the velocity reduction system in order to reach the target altitude at near 0 velocity.

The Arduino is programmed to activate the servos when the proper combination of velocity and altitude are reached. See figure 7 for a preliminary design.

Rocket	USLI			Chute diam	Dc	2	<p style="text-align: center;">Avg. Thrust 650.59</p> <p style="text-align: center;">True Impulse 2400.66</p>							
Rckt Mass (empty)	Mr	10.99		Time Incr	dt	0.1								
Eng. Case mass	Me	0.772		Mass Decr (propellant burned)	dm	0.31897019								
Propellant mass	Mp	1.177		Grav. Const	gc	9.8								
Diameter, rocket	Dr	0.10244		Area, (widest part)	A	0.00824193								
Impulse, motor(N-sec)	Im	2437		Chute area	A_2	3.14159265								
Thrust (Newtons)	Ta	659		Burn Time	tb	3.69								
Air Density (kg/m^3)	rho	1.2		Eject time	te	17.97					Peak kph	Peak (m)	Peak (ft)	Peak mph
Drag coef	Cd	0.7									148.26	1192.41	3911.10	331.66

Flight Time	Drag Force	Thrust	Net Force	Mass	Acceleration	Velocity (m/s)	Altitude (m)	Rocket Area		Air Density
t	Fd	Ft	F	M	Acc	V	Y	Area	mph	rho
0.0	0.00	0.00	-126.80	12.94	0.00	0.00	0.00	0.01	0.00	1.22
0.1	0.00	1065.32	938.83	12.91	72.74	7.27	1.09	0.01	16.27	1.22
0.2	0.19	1020.05	893.69	12.88	69.41	14.21	2.86	0.01	31.80	1.22
0.3	0.71	990.12	863.54	12.84	67.24	20.94	5.29	0.01	46.84	1.22
0.4	1.54	966.76	839.67	12.81	65.54	27.49	8.37	0.01	61.50	1.22
0.5	2.66	949.45	821.55	12.78	64.29	33.92	12.08	0.01	75.88	1.22
0.6	4.04	932.14	803.17	12.75	63.01	40.22	16.42	0.01	89.98	1.22
0.7	5.68	914.83	784.53	12.72	61.70	46.39	21.37	0.01	103.78	1.22
0.8	7.56	897.52	765.66	12.68	60.37	52.43	26.91	0.01	117.28	1.22

### **III.1.5d Propulsion Subsystem**

The selected motor must provide stable flight for the rocket and reach the desired altitude. An appropriate thrust-to-weight ratio, as well as sufficient lift-off speed are necessary for a safe flight. The thrust-to-weight ratio is an indicator of flight stability by making certain that the motor has the necessary power to accelerate the rocket to a safe lift-off speed. Additional stability is provided by the force that the fins on the rocket provide. Sufficient velocity prior to the rocket leaving the stability-inducing guide rail is necessary to increase the fin force so that the rocket is stable once it has left the guide rail. In general, a minimum thrust to weight ratio of five is recommended for flight, but a higher ratio can be necessary for stronger winds

#### **Environmental Conditions (Toney, AL late April example)**

Altitude: 827 Ft.  
Relative humidity: 77 %  
Temperature: 65 Deg. F  
Pressure: 30.27 In.  
Slightly breezy (8-14 MPH)

#### **Launch Guide Data**

- Launch guide length: 72.0000 In.
- Velocity at launch guide departure: 54.2556 ft/s
- The launch guide was cleared at : 0.246 Seconds
- User specified minimum velocity for stable flight: 43.9882 ft/s
- Minimum velocity for stable flight reached at: 49.0961 In.

#### *III.1.5da Motor Selection Procedure*

Using Rocksim, several motors were analyzed and considered for use. Cesaroni Technology Incorporated (CTI) L size motors will be used for the competition flight. We will use Aerotech motors for low level testing.

The primary considerations for the motors were the average thrust and total impulse. The average thrust was used to determine if the motor would provide the necessary thrust to weight ratio for stable flight. Once that was determined, the motor was tested in Rocksim to find the predicted altitudes. Using a predicted altitude, an estimate of the total impulse was found that would meet our target altitude requirements. The motors that are being considered meet the minimum thrust to weight ratio and have the necessary total impulse to reach the competition altitude. The ratio was derived with this formula:

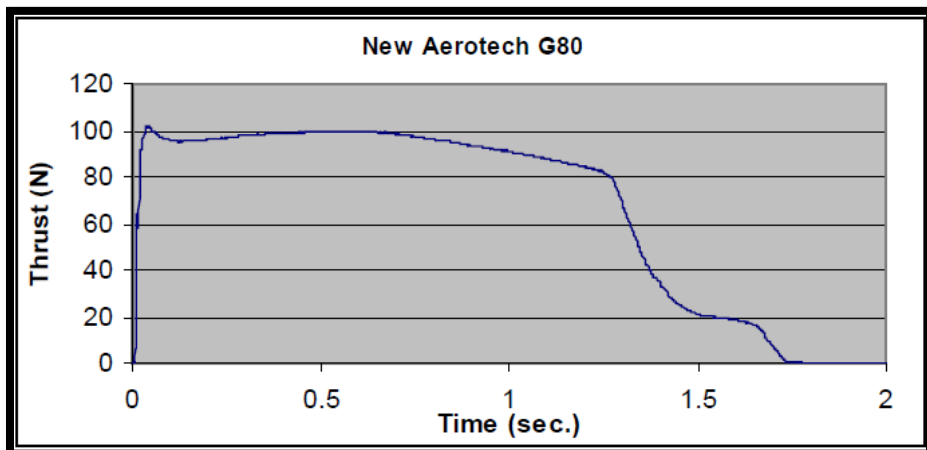
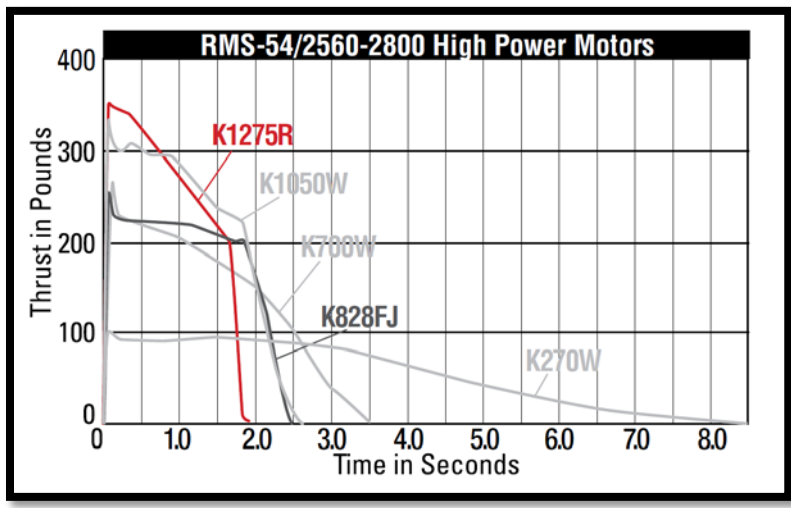
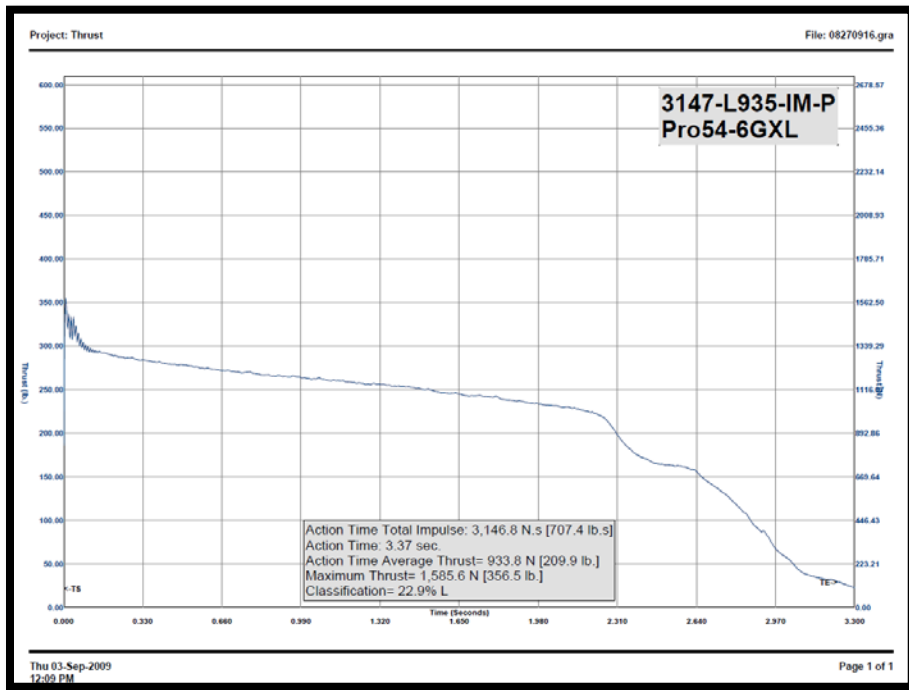
$$\text{Thrust to Weight Ratio} = \text{Pounds of Thrust/Weight of Skybolt}$$

Table 5 illustrates the “best” choices given the information that we have at hand. Test launches will be used to refine the motor selection. The simulation indicates that the motors are big enough to get the rocket safely off the launch rail. We do not and will not know how close the predicted altitude will be to actual altitude. Until we get some actual flight data, our motor choice is based on the Rocksim 9 simulation using the best information that we have available and at this point is the CTI L935.

Selection	Motor	Total Impulse		Average Thrust		Maximum Thrust		Loaded Weight (lbs)	Ratio			RocSim Altitude	Case	Lift Off (fps)
		N	lbs	N	lbs	N	lbs		Total Impulse	Avg Thrust	Max Thrust			
	CTI K300	2546	572.364	304.0	68.342	561.80	126.298	32.80	17.450	2.084	3.851	Small	6GXL	31.21
	CTI K660	2437	547.859	659.0	148.149	1078.90	242.546	32.07	17.083	4.620	7.563	3708	6G	48.93
	CTI K815	2304	517.960	814.9	183.197	1246.50	280.224	32.60	15.888	5.620	8.596	Skidmark	6GXL	
	CTI L1030	2788	626.767	1031.0	231.778	1223.00	274.941	32.93	19.033	7.039	8.349	4742	6GXL	51.52
	CTI L640	2772	623.170	638.4	143.518	1590.00	357.446	32.72	19.046	4.386	10.924	4513	6GXL	58.97
	CTI L730	2765	621.597	733.0	164.785	1214.90	273.120	32.70	19.009	5.039	8.352	4593	6GXL	51.45
<b>Competition</b>	CTI L935	3147	707.474	933.8	209.927	1585.60	356.457	33.38	21.195	6.289	10.679	5554	6GXL	55.11
	CTI L990	2771	622.946	991.0	222.786	1702.70	382.782	32.71	19.044	6.811	11.702	4728	6GXL	54.45
	AT K375	2228	500.897	430.6	96.803	1371.80	308.393	32.42	15.450	2.986	9.512	2885	54/2560	51.52
<b>Low Level Test</b>	AT K828	2052	461.342	828.0	186.142	1510.99	339.685	32.66	14.126	5.699	10.401	2980	54/2560	49.88
	AT K1275	2225	500.177	1275.0	286.631	1554.00	349.353	32.32	15.476	8.869	10.809	3074	54/1760	60.97
<b>SubScale</b>	G80	137	30.799	78.0	17.535	108.00	24.279	2.75	11.200	6.376	8.829	1928	Single	67.27

*Table 5, Motor Selection Criteria*

Below are the thrust curves associated with the competition, low level test, and subscale motor choices



### **III.1.5e Ground Support Equipment Subsystem**

Our GSE consists of the launch pad, the launch control box, the launch cables, a portable sound system, a First Aid kit, a fire extinguisher, and cell phones.

The equipment has been successfully used for twenty three launches.

### **III.1.5f Safety Subsystem**

#### *III.1.5f.1 Plan for storage of Hazardous Materials*

We plan to use a number of hazardous materials in the construction of the rocket. Below is the most current list:

- West System Three epoxy resin
- West System Three epoxy hardener
- Acetone (Epoxy Solvent)
- Isopropyl Rubbing Alcohol (Epoxy solvent/cleaner)
- Krylon Spray Paint
- Cesaroni ProX Reload Kit
- Cesaroni ProFire Igniter
- Black Powder
- Duracell/EveryReady Alkaline Batteries
- 60/40 Rosin Core Solder

All hazardous materials will be stored offsite at one of the team advisor's residence or in a hazardous materials location at Northwest Indian College in accordance with all federal, state, and local regulations.

All flammable materials will be stored away from heat and flame. If required by the MSDS's or any applicable regulations, they will be stored in a shed detached from any occupied room.

### **III.1.6 Verification Plan**

#### **III.1.6a Competition Rocket Verification Plan**

We will verify all components and subsystems for soundness, suitability, and flight worthiness according to our verification plan (Appendix C). We will meticulously examine each system and subsystem prior to either ground testing or flight testing. Our NAR Mentor and NAR L2 Advisors will inspect also. The Rocksim simulations will provide a starting point for safety and flight success probability.

#### **III.1.6b Subscale Verification Status**

We have constructed the entire scale rocket with the exception of the science payload which is still under construction. We have flown the rocket without the science payload and have tested and verified these:

Launch and recovery of scale rocket	successful
Black Powder ejection test without altimeters	successful
Black Powder ejection test with altimeters	successful
Flight test of dual deployment recovery system	successful
Drogue deployment during flight test	successful
Main deployment during flight test	successful
Safe main parachute-to-ground descent rate	successful
Predicted altitude	94% successful
Launch rail and GSE equipment function	successful
Recovery team performance	successful
Range setup	successful
Safety implementation	successful

### **III.1.7 Risks and Risk Reducing Plans**

Native American culture often times necessitates individuals to participate in cultural activities that require absence from school and or work. Therefore our biggest challenge will be to keep the team together and functioning as a unit for the entire duration of this project.

Our design process is build, test fly, evaluate, and make modifications and test fly again. We do not have any engineering, electrical, design, or computer science departments that we can rely on for assistance. We are doing all of this through sheer determination to learn and have fun.

Winter weather in the Pacific Northwest has moderate temperatures, moderate winds and many days of low clouds and precipitation. This definitely impacts our testing ability. Fortunately, our launch area is only 2 miles from the college and we can activate our 5000' FAA and Canadian AA waivers for any Saturday and Sunday mornings from 8:00 am through 12:00 pm. However, flights higher than 5000 feet require a 6 hour drive into Washington's interior which means weather can severely affect our higher altitude test schedule. Given this, we may forego a test flight using the full-scale motor.

<b>General Risks</b>	<b>Probability</b>	<b>Impact</b>	<b>Mitigation</b>
Fluidity in team membership	High	Lack of cohesion resulting in redundant learning/work	Spread the work and ideas among all of the members
Project falls behind	Moderate	Late hours required for task completion	Effective planning
Parts not arriving on time	Low	Incomplete vehicle	Create good relationships with vendors and order early
Design issues	Moderate	More time needed to build a competitive rocket	Make efficient use of time and Mentor
Delayed test flights because of weather	High	Insufficient testing for design validation and data acquisition	Have flexible launch plans for tests

Exceeding budget	Low	Design alterations	Proper budget management and foresight
Lack of expertise	Moderate	Design alterations or outsourcing	Identify needs early and make proper arrangements

<b>Personal Safety Hazards</b>	<b>Potential Effects of Failure</b>	<b>Failure Prevention</b>
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.
Accidental injuries such as lacerations, bruises, etc.	Harm to team members (possible hospitalization).	Be attentive to task at hand. First aid kit is available.
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
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.

<b>Schedule Risks</b>	<b>Potential Effects of Failure</b>	<b>Failure Prevention</b>
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.
Team has difficulties meeting set deadlines.	Deadlines will not be met.	Assign enough time for the completion of tasks.

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 shall also work with members that still have conflicts.
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!.
NWIC sessions changes from fall to winter to spring quarter.	Team members' schedules will change.	Vote by majority for meeting times and plan accordingly.

<b>Financial Support Failures</b>	<b>Potential Effects of Failure</b>	<b>Failure Prevention</b>
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.
Incorrect parts or supplies are purchased.	Delay in build sessions, and possible milestones.	Ensure all orders are verified by team officers.
Problems could arise with space grant funding for the	Delays in purchasing needed supplies and parts.	Adhere to budget guidelines and discuss financial matters

team.		with team advisor.
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<b>Structural Failures</b>	<b>Potential Effects of Failure</b>	<b>Failure Prevention</b>
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.
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.
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.
Parachute deploys too early or too late in flight.	High-speed deployment causes the shock cord to produce a "zippering" effect.	Test the altimeter for drogue 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.
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
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.
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.

<b>Payload Failures</b>	<b>Potential Effects of Failure</b>	<b>Failure Prevention</b>
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 shall also use separate power supplies for each section containing electronic devices

		to prevent the failure of all electronics.
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.
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.
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.
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.
Static discharge to electronics.	Electronic instruments are damaged.	Team members should properly ground themselves before handling electronics.
<b>Ultraviolet (UV) Sensor</b>		
No data logged but data transmitted to ground station	Partial science mission failure	test data logger, ensure battery strength is adequate
Data logged but no data transmitted to ground station	Partial science mission failure	test transmitter and receiver, ensure battery strength is adequate
Erratic data or inconsistent data	Science mission failure	check proper placement, wiring and calibration of sensor, ensure battery strength is adequate. Faulty sensor.
No data logged or transmitted to ground station	Science mission failure	conduct proper ground testing, ensure battery strength is adequate
Damage during transportation or deployment	Science mission failure	pack carefully and ensure rugged construction techniques
<b>Atmospheric Pressure Sensor</b>		
No data logged but data transmitted to ground station	Partial science mission failure	test data logger, ensure battery strength is adequate
Data logged but no data transmitted to ground station	Partial science mission failure	test transmitter and receiver, ensure battery strength is adequate
Erratic data or inconsistent data	Science mission failure	check proper placement, wiring and calibration of sensor, ensure battery strength is adequate. Ensure adequate access to outside atmosphere. Faulty sensor.
No data logged or transmitted to ground station	Science mission failure	conduct proper ground testing, ensure battery strength is adequate

Damage during transportation or deployment	Science mission failure	pack carefully and ensure rugged construction techniques
<b>Relative Humidity Sensor</b>		
No data logged but data transmitted to ground station	Partial science mission failure	test data logger, ensure battery strength is adequate
Data logged but no data transmitted to ground station	Partial science mission failure	test transmitter and receiver, ensure battery strength is adequate
Erratic data or inconsistent data	Science mission failure	check proper placement, wiring and calibration of sensor, ensure battery strength is adequate. Ensure adequate access to outside atmosphere. Faulty sensor.
No data logged or transmitted to ground station	Science mission failure	conduct proper ground testing, ensure battery strength is adequate
Damage during transportation or deployment	Science mission failure	pack carefully and ensure rugged construction techniques
<b>Temperature Sensor</b>		
No data logged but data transmitted to ground station	Partial science mission failure	test data logger, ensure battery strength is adequate
Data logged but no data transmitted to ground station	Partial science mission failure	test transmitter and receiver, ensure battery strength is adequate
Erratic data or inconsistent data	Science mission failure	check proper placement, wiring and calibration of sensor, ensure battery strength is adequate. Ensure adequate access to outside atmosphere. Faulty sensor.
No data logged or transmitted to ground station	Science mission failure	conduct proper ground testing, ensure battery strength is adequate
Damage during transportation or deployment	Science mission failure	pack carefully and ensure rugged construction techniques
<b>Solar Irradiance Sensor</b>		
No data logged but data transmitted to ground station	Partial science mission failure	test data logger, ensure battery strength is adequate
Data logged but no data transmitted to ground station	Partial science mission failure	test transmitter and receiver, ensure battery strength is adequate
Erratic data or inconsistent data	Science mission failure	check proper placement, wiring and calibration of sensor, ensure battery strength is adequate. Faulty sensor.
No data logged or transmitted to ground station	Science mission failure	conduct proper ground testing, ensure battery strength is adequate
Damage during transportation or deployment	Science mission failure	pack carefully and ensure rugged construction techniques

<b><i>Recovery Failures</i></b>	<b><i>Potential Effects of Failure</i></b>	<b><i>Failure Prevention</i></b>
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.
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.
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.
Drogue and main parachutes are packed too tightly to release.	Rocket experiences uncontrolled descent.	Ground test efficiency of the packing technique before launch.
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.
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.

<b><i>Propulsion Failures</i></b>	<b><i>Potential Effects of Failure</i></b>	<b><i>Failure Prevention</i></b>
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.
Igniter fails on the launch pad.	Motor of the rocket will fail to ignite.	Ensure that the igniter is secure before attempting ignition.
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.
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 shall also conduct an inspection of the mounting system prior to launch.
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.

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.
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<b>Launch Operation Failures</b>	<b>Potential Effects of Failure</b>	<b>Failure Prevention</b>
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.
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.
Fault igniter.	Motor will not ignite and the rocket will not launch.	Bring extra igniters to the launch site.
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.

Grass at the launch site catches on fire after launch.	Equipment will be destroyed and people at the launch site may be harmed.	Use a fire-retardant blanket if the grass near the launch site is not excessively dry. Have a fire extinguisher readily available.
Rocket is carried out of range by the wind.	Rocket will be lost.	Don't fly in heavy winds. Use a GPS or other tracking device
Catastrophic motor malfunction on launch pad	Rocket is damaged, possibly destroyed.	Ensure proper fire safety devices are on hand to prevent any injuries to personnel.

### ***III.1.8 Planning***

#### ***III.1.8.1 Manufacturing***

By adhering to our time line, we have been able to focus our attention to accomplishing the myriad of tasks involve in our USLI project.

We are on very good terms with the major component vendors and they have responded very timely to our purchases. Constructing both the subscale and competition rocket have proceeded smoothly. Working with fiberglass airframe and rocket components is new to us. It is surprising how heavy the rocket is, even though our planning and simulation in Rocksim 9 indicated it would weigh this much.

The power management system is proving to be quite a challenge. We have built a working model; however, getting all of the parts to fit into the rocket is a challenge and our programming prototype is just now beginning to show promise.

The science experiments are being built. We have had no issues in building them. Programming is coming along.

### **III.1.8.2 Verification**

Verification is done through multiple inspections by both team advisors and key team members. Each item is verified for strength, construction techniques, neatness, and compliance with instructions.

### **III.1.8.3 Integration**

We verify through design and model building that each component and subassembly will physically fit as planned.

Airframe: all components fit and are soundly constructed.

Recovery: parachutes, parachute bay, and avionics (including BP charges) are designed to function together.

Propulsion: careful simulations, calculations, and prior experience insure that the propulsion subsystem is fully integrated.

Science Payload: this is a stand-alone system that is using the rocket as a means of transportation. The science components are independent of each other in order to increase the likelihood of successful data collection.

Power Management: this is turning out to be the most complicated of all of the subsystems. It has to be carefully integrated with the speed reduction mechanics, the altitude and velocity sensors, and the programming tying all of this together.

### **III.1.8.4 Operations**

Since this is a class, operation planning is straight forward. A majority of the time consensus is reached about who does what when in accordance with our timeline.

### **III.1.8.5 Component Testing**

Stress tests, ground tests, multiple simulation runs, all figure into planning for component testing.

### **III.1.8.6 Functional Testing**

The rocket's functioning will be tested first through simulations and then through actual flights. The avionics and recovery system will be tested through ground testing of the electronics and the black powder charges. The science payload will be tested by gathering and analyzing data on the ground. The power management system's functioning will be through simulations and ground testing.

### **III.1.8.7 Static Testing**

Stress testing of the airframe and fins will be performed. We will do no motor testing other than through test flights. This is a financial decision. All of the sensors and their related programming will be tested on the ground to verify that adequate data acquisition, storage, and transmission take place.

### **III.1.9 Confidence and Design Maturity**

The design phase began with process of identifying and defining the project goals. We elected to choose the SMD project, measuring and obtaining atmospheric data. It was from this point that individual concepts were discussed and ideas formed.

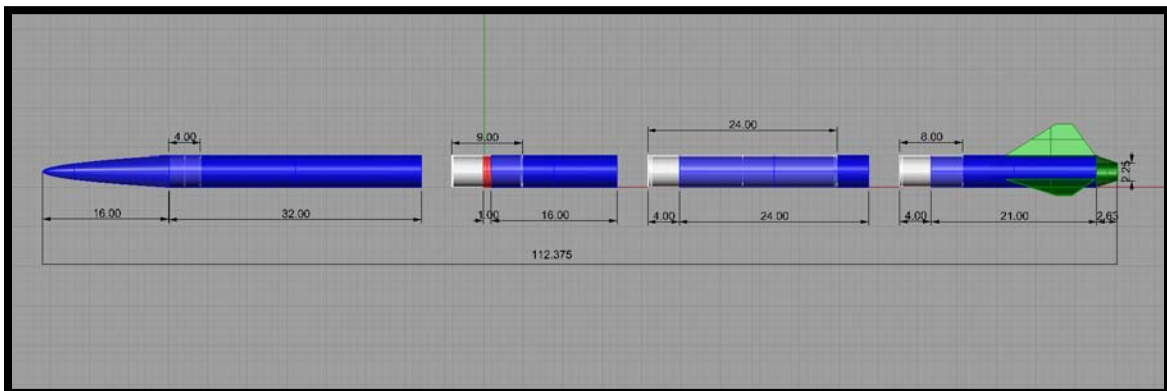
The next step in the design was the choice of materials with which to construct the rocket. We know that we have to deal with a very wet recovery area. This dictated a water resistant rocket. We examined fiberglass, blue tube, and carbon fiber. Fiberglass had the best qualities and was reasonably priced.

Budgetary restraints also affect the design process. We elected to use a 4 inch airframe that was long enough to hold the parachutes, the tracing device, the science payload, and the power management system. Rocksim 9 was then utilized to design the rocket and run simulations based upon estimates of the payload. Motors were “flown” to verify target altitude acquisition. Parachute calculations were run to determine the appropriate sized parachute to meet the USLI design parameters. The proper relationship between the Center of Pressure and the Center of Gravity was maintained throughout the design process.

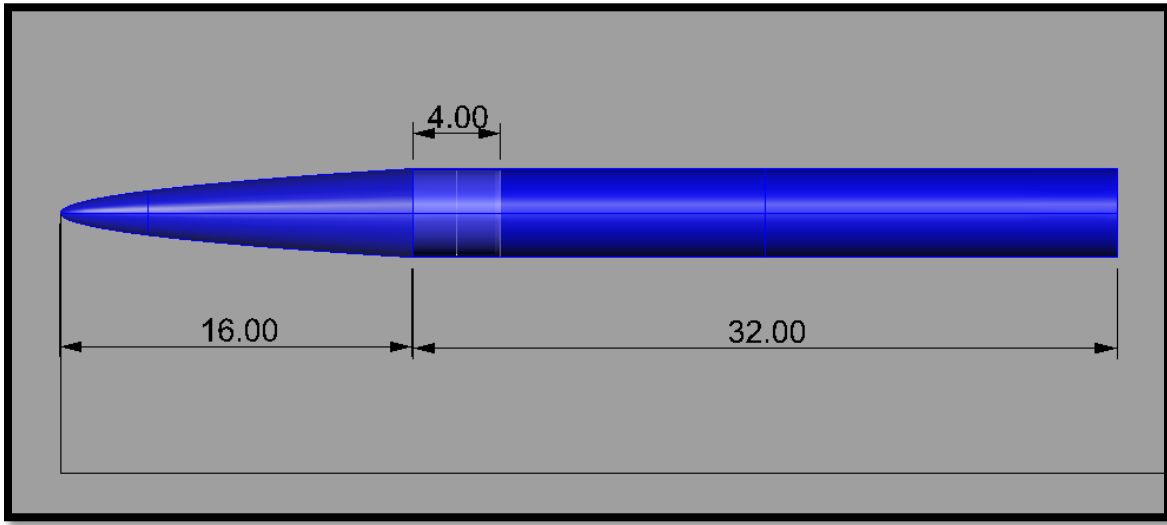
A similar design process was followed when designing the sub-scale launch vehicle. This allowed newer team members to become more integrated into the USLI project and its processes. The goal was to team-build a smaller rocket and to try our “horizontal” recovery system and a dual deploy system.

The design process has given the team confidence in the construction and the reliability of the competition rocket.

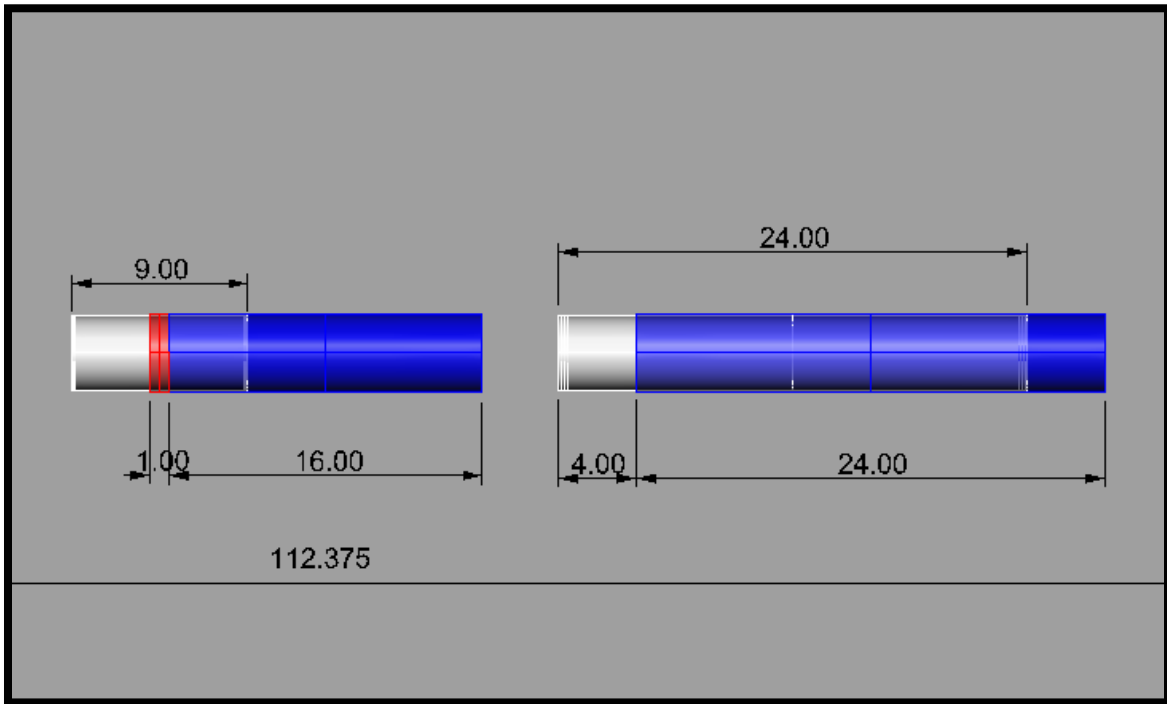
### **III.1.10 Dimensional Drawings**



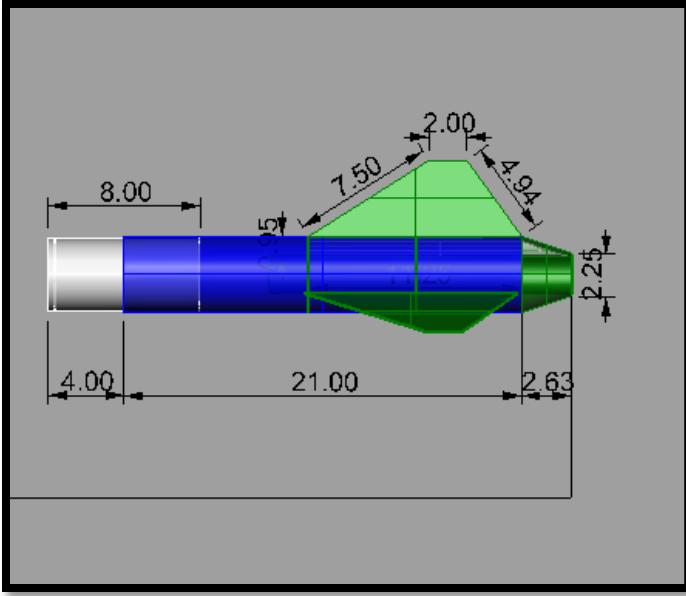
*Figure 9, Entire Rocket with dimensions*



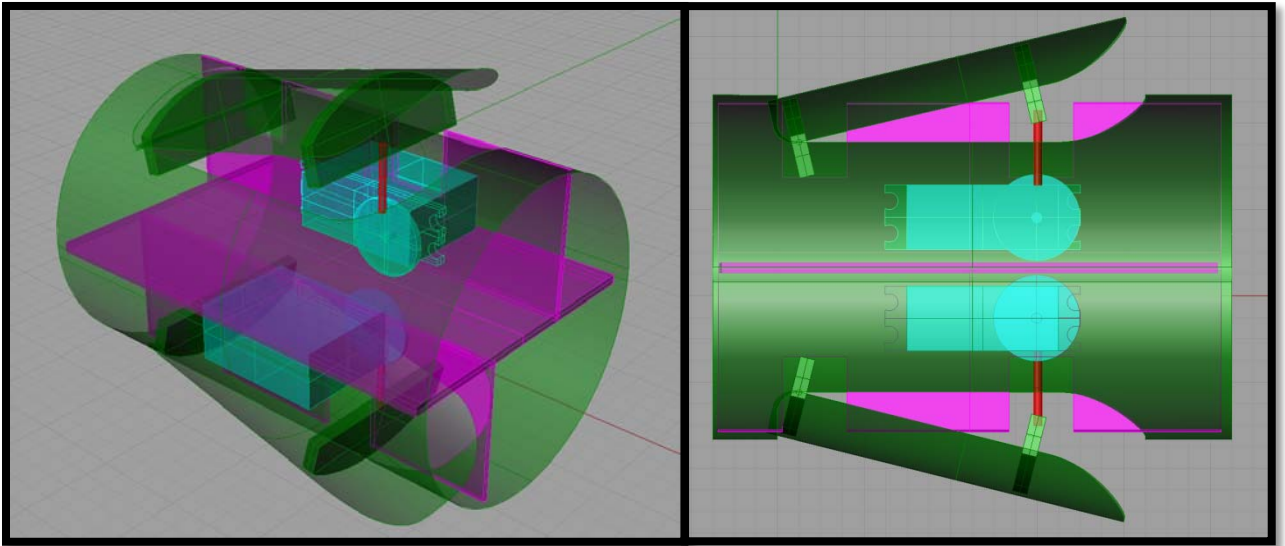
*Figure 10, Nose Cone and Main Parachute Bay*



*Figure 11, Ebay, Drogue Parachute Bay, and Science Payload Bay*

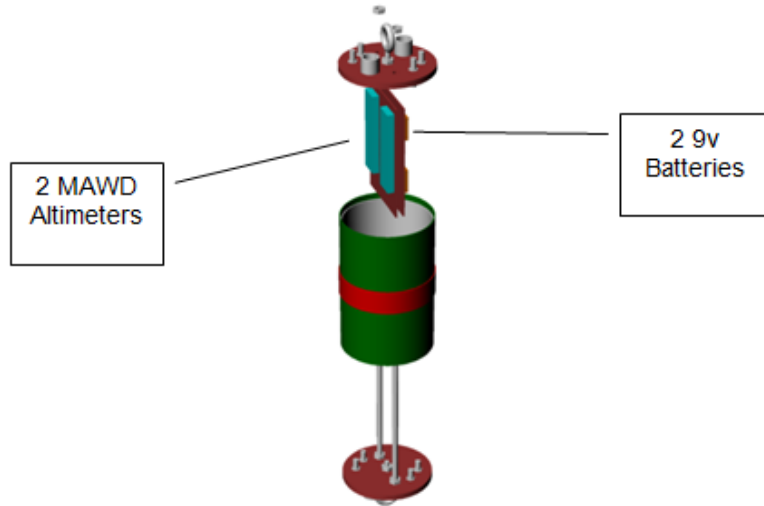


*Figure 12, Fin Can, Fins, and Tail Cone*

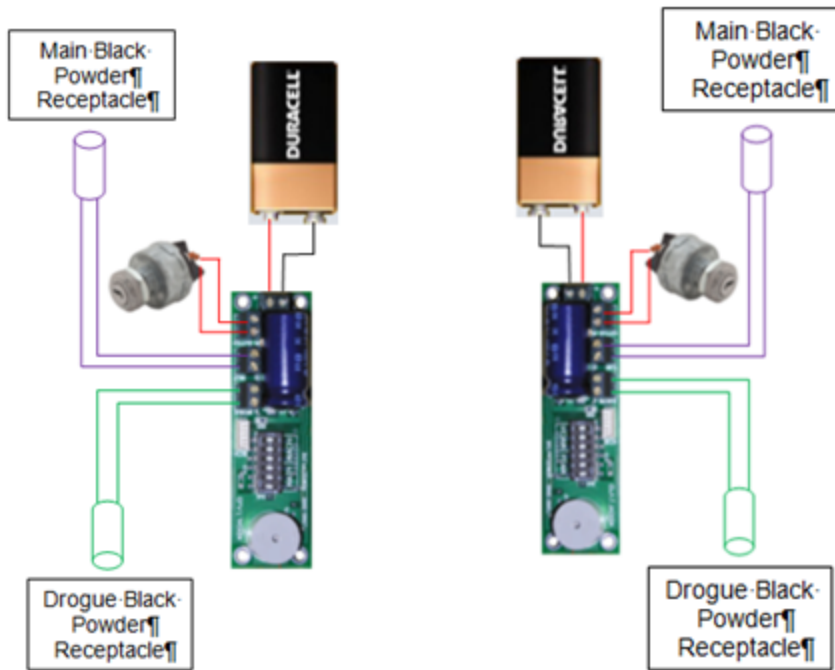


*Figure 13, First Generation Power Management System-Perspective and Top Views*

### III.1.11 Recovery System Electrical Schematics



*Figure 14, Competition Rocket Ebay*



*Figure 15, Recovery Avionics, redundant dual deploy*

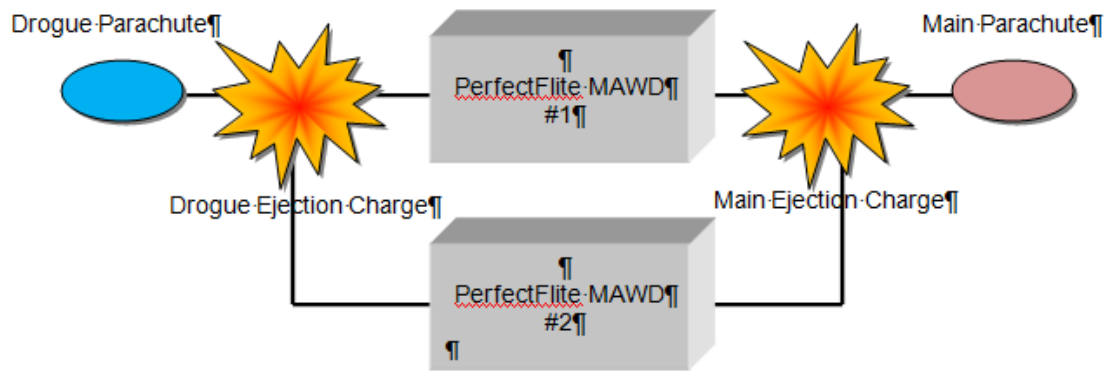
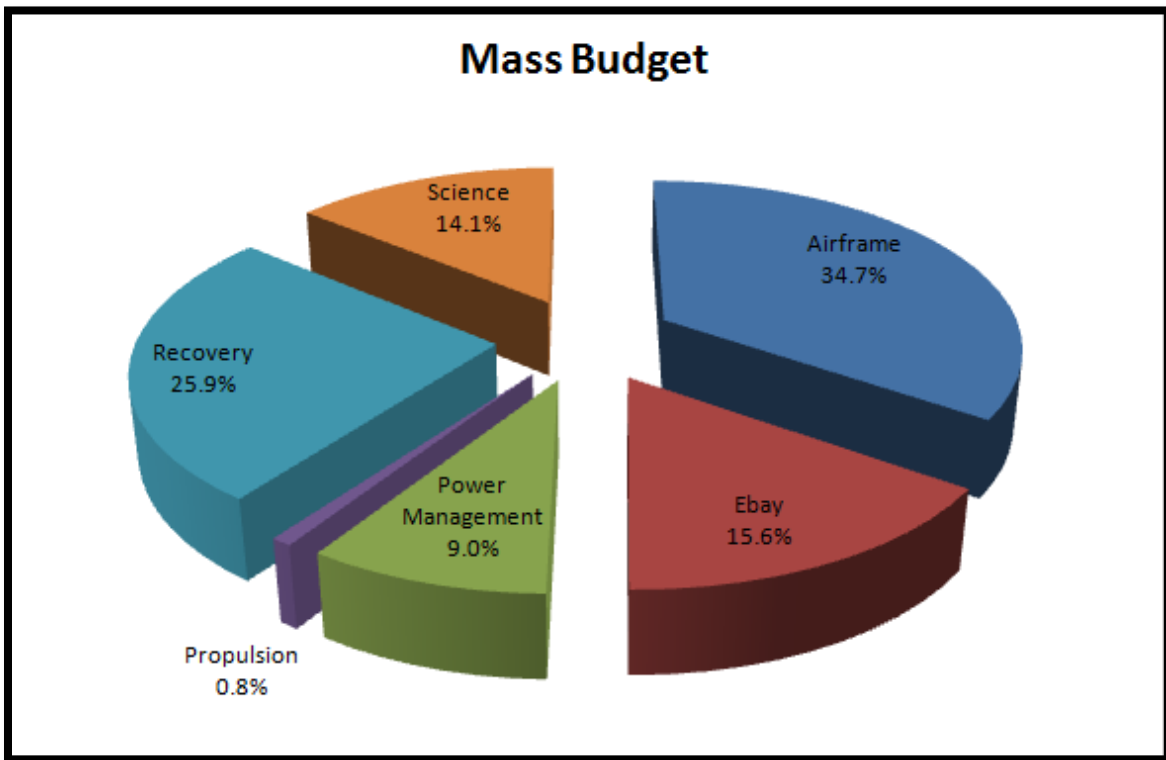


Figure 16, Redundant Dual Deployment System Schematic

**III.1.12 Mass Statement**

Mass Statement		
Material	Component	Mass (lb)
Aluminum	Tailcone	0.170
G10 Fiberglass	Fin Can	1.125
G10 Fiberglass	Aft Airframe	0.857
G10 Fiberglass	Fwd Airframe	1.714
G10 Fiberglass	Nose Cone	0.823
G10 Fiberglass	Science Payload Bay	0.750
G10 Fiberglass	Ebay Ring	0.071
G10 Fiberglass	Fin Can Tube Coupler	0.478
G10 Fiberglass	Science Bay Tube Coupler	0.478
G10 Fiberglass	Ebay Coupler	0.478
Steel	Threaded Rod	0.375
Steel	Nose Cone Eyebolt	0.125
Steel	Fwd Ebay Eyebolt	0.125
Steel	Aft Ebay Eyebolt	0.125
Steel	Fwd Science Bay Eyebolt	0.125
Steel	Aft Science Bay Eyebolt	0.125
Steel	Fin Can Eyebolt	0.125
Nylon	Main Parachute	2.813
Nylon	Drogue Parachute	0.375
	Avionics (altimeters, batteries)	3.000
	Science Payload (sensors, transmitter, cameras)	3.500
Kevlar	Main Recovery Harness	2.000
Kevlar	Drogue Recovery Harness	1.000
	GPS Unit	1.000
G10 Fiberglass	Nose Cone Bulkplate	0.077
G10 Fiberglass	Fwd Ebay Bulkplate	0.077

G10 Fiberglass	Aft Ebay Bulkplate	0.077
G10 Fiberglass	Fwd Science Bay Bulkplate	0.077
G10 Fiberglass	Aft Science Bay Bulkplate	0.077
G10 Fiberglass	Fwd Motor Mount Center Ring	0.075
G10 Fiberglass	Mid Motor Mount Center Ring	0.075
G10 Fiberglass	Aft Motor Mount Center Ring	0.075
	Power Management System	2.500
G10 Fiberglass	Fin Set	0.902
	Epoxy	1.000
	Paint	1.000
	<b>Total Mass=</b>	<b>27.769</b>



*Figure 17, Mass Budget Graph*

All of the masses except the science payload, epoxy, and paint are derived from weighing each of the components. Epoxy and paint used as well as the science payload and power management system are estimates based upon prototypes.

The selected motor has reserve power for three extra pounds, which is about 25% of the designed weight. This extra weight will not adversely affect the stability margin or the target altitude.

## III.2 Recovery Subsystem

### III.2.2 Ebay

This subsystem consists of the parachute bays and the ebay (Figure 5) that contains the avionics that control the parachute deployment. The parachute bays are connected to the ebay using frictional fitting and are secured with nylon #2-56 machine screws that act as shear pins. These screws prevent dynamic separation, premature deployment, of the recovery system. Each screw has an average shear strength of 25 pounds which means the black powder charge needs at least 50 pounds force to shear the screws. Two 3/8" closed eyebolts, are fastened each end of the ebay. These are the fastening points for the recovery harness.

### III.2.2 Recovery Harness

The two recovery harnesses, main and drogue, are 9/16" tubular nylon. The drogue harness is 30 feet long and the main harness is 20 feet long. Each harness is secured to its respective end of the ebay with stainless steel quicklinks. The other end of each harness is connected to its respective airframe component, drogue bay or main bay and their respective 3/8" closed eyebolt with quicklinks.

### III.2.3 Parachutes

Rocksim calculated the weight for the rocket at 23 pounds. USLI requires a 75 lb/ft<sup>3</sup> Kinetic Energy impact for the rocket. We interpreted that to mean that this was the KE for the entire rocket. Of course the KE will be less for each of the three sections. We used Excel and these formulas to calculate a main parachute size of 76 square feet.

KE=Kinetic Energy

m=mass in pounds

V=velocity in feet per second

S=surface area of parachute in square feet

$\rho$ =air density

$C_d$  = Coefficient of drag

$$KE = \frac{1}{2}mV^2$$

$$S = \frac{2m}{\rho V^2 C_d}$$

Kinetic Energy Calculation		Calculate Parachute Size given the KE	
	Ft/lbs	Weight	23
Rocket Mass (m)	24	CD	1.26
Descent Rate (v)	14.25	Descent Velocity	14.25
$KE=1/2mv^2$	74.67546584	KE	0.074675466
$KE=1/2mv^2/32.2$		Parachute Size in Square Feet	
		76	

Drogue parachute size was calculated based upon descent speed. We select a descent speed between 80 and 90 fps and calculated a drogue size of 24 inches.

The Sky Angle Cert-3 XLarge and the Sky Angle Cert-3 Drogue satisfies the parachute requirements.

### III.2.4 Black Powder (BP) Ejection Charge Determination

Factors that affect the amount of BP that will be needed:

- Diameter of airframe (base of nose cone)
- Volume of parachute chamber
- How tightly parts (airframe/coupler) fit
- Leakiness of the airframe

A starting point for determining the amount of BP to use is to determine the amount of desired force on the base of the bay that needs to be separated. Typically 150-200 pounds are used in high powered rockets. The next step is to determine the amount of pressure (pounds per square inch - psi) that will produce the desired amount of force.

#### Shear Pins and Ejection Charges

The use of shear pins avoids the possibility of drag separation during flight. #2 nylon screws (2-56) as shear pins, reliably shear with 35 pounds of force. That force must be generated by the ejection charge. The ejection charge force is calculated by multiplying the cross-sectional area of the body tube by the ejection charge pressure in psi. Divide this force by 35 pounds to get the maximum number of shear pins that can be used. We will not use less than two shear pins because it's possible that the slip joint could cock to one side and jam if only one is used.

The ejection charge equation is:  $Wp = dP \cdot V / R \cdot T$

Where:

- $dP$  is the ejection charge pressure in psi.

- R is the combustion gas constant, 22.16 (ft-lbf/lbm R) for FFFF black powder. (Multiply by 12 in/ft to get in terms of inches)
- T is the combustion gas temperature, 3307 degrees R for black powder
- V is the free volume in cubic inches. Volume of a cylinder is cross section area times length L, or from diameter D,  $V=L \cdot \pi \cdot D^2/4$
- Wp is the charge weight (mass, actually) in pounds. (Multiply by 454 g/lb to get grams.)

Subscale Drogue and Main Parachute Black Powder Calculations

Volume =	56.5	in <sup>3</sup>
Dia =	2	inch
Length =	18	inch

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

Calculate Pressure for a known Quantity of Black Powder		
Mass of BP =	0.70	grams
Pressure =	24.0	psi
Ejection F =	75.3	lbf

$P=mRT/V$
$F=P \cdot \pi \cdot d^2$

Ground testing will reveal the minimum amount needed under **ideal conditions**. We choose to not fly with the minimum amount of BP that works under **ideal conditions**. We did several tests of the black powder ejection charge prior to flying the scale model. The calculated amounts, making certain that we slightly exceeded the minimum force, worked as predicted.

We used 0.7 grams of black powder for the main parachute ejection charge and for the drogue separation charge, we also used 0.7 grams. These amounts resulted in successful separation for both ground tests and actual flight. This amount provided 75 pounds of force which sheared the two #2-56 nylon screws acting as shear pins that held the parachute bays secured to the ebay subsystem.

Competition Rocket Drogue and Main Parachute Black Powder Calculations

**Main Parachute Calculation**

Volume =	402.1	in <sup>3</sup>
Dia =	4	inch
Length =	32	inch

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

Calculate mass of BP for a desired Ejection Force			
Ejection F =	75.0	lbf	
Mass of BP =	3.0	grams	$m=F*(length)/R/T$
Pressure =	15	psi	$P=F/(pi/4*d^2)$

### Drogue Parachute Calculation

Volume =	201.1	in <sup>3</sup>
Dia =	4	inch
Length =	16	inch

Calculate mass of BP for a desired Ejection Force			
Ejection F =	75.0	lbf	
Mass of BP =	1.56	grams	$m=F*(length)/R/T$
Pressure =	15	psi	$P=F/(pi/4*d^2)$

Extensive ground testing of the ejection system is planned prior to any flight.

### ***III.2.5 Recovery Data from Rocksim***

#### ***III.2.5a Launch conditions***

- Altitude: 827 Ft.
- Relative humidity: 77.000 %
- Temperature: 65.000 Deg. F
- Pressure: 30.2683 In.

#### ***III.2.5b Wind speed model: Slightly breezy (8-14 MPH)***

- Low wind speed: 8.0000 MPH
- High wind speed: 14.9000 MPH

#### ***III.2.5c Recovery system data***

- P: Drogue Parachute Deployed at : 19.276 Seconds
- Velocity at deployment: 34.5027 ft/s
- Altitude at deployment: 5530.27686 Ft.
- Range at deployment: -563.35928 Ft.
- P: Main Deployed at : 87.069 Seconds
- Velocity at deployment: 72.4160 ft/s
- Altitude at deployment: 699.98324 Ft.
- Range at deployment: 570.39224 Ft.

**III.2.5d Landing data**

- Successful landing
- Time to landing: 130.614 Sec.
- Range at landing: 791.76922
- Velocity at landing: Vertical: -12.1141 ft/s , Horizontal: 11.9474 ft/s , Magnitude: 17.0145 ft/s

**III.2.5e Launch guide data:**

- Launch guide length: 72.0000 In.
- Velocity at launch guide departure: 55.1189 ft/s
- The launch guide was cleared at : 0.218 Seconds
- User specified minimum velocity for stable flight: 43.9882 ft/s
- Minimum velocity for stable flight reached at: 45.9310 In.

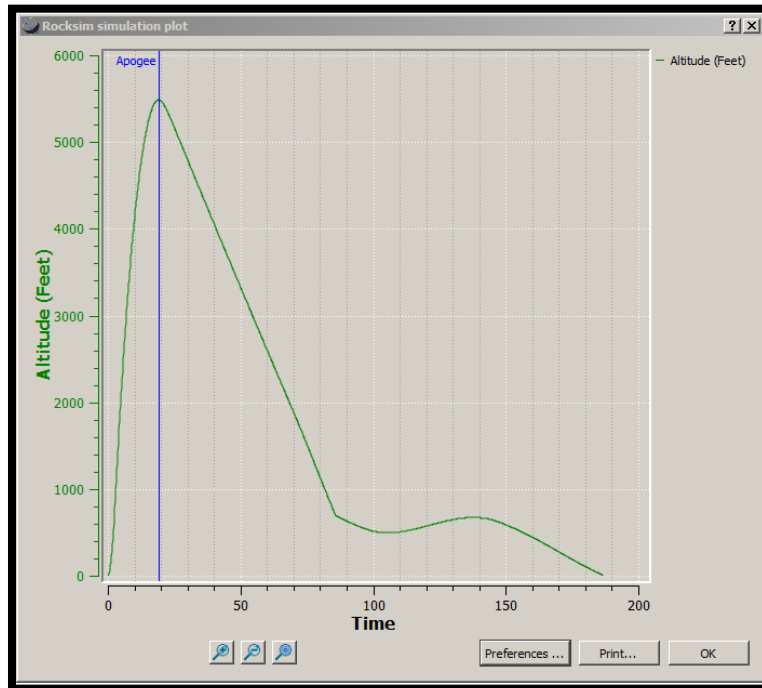
Mission	Ground Operations				Flight Operations		
	Constructed	Test Date	Data Recovery %	Success %	Test Date	Data Recovery %	Success %
Barometric pressure	Yes	10/5	95%	90%	1/15		
Atmospheric temperature	Yes	10/8	100%	100%	1/15		
Relative humidity	No	11/30			1/15		
Solar irradiance	No	12/2			1/15		
Ultraviolet radiation	No	12/2			1/15		
Science payload bay temperature	Yes	11/30			1/15		
Rocket roll detection and measurement	Yes	10/5	100%	90%	1/15		
Photography	Yes	10/5	100%	100%	10/5	100%	100%
Target Altitude	N/A	N/A	N/A	N/A	11/6	100%	72%
GPS Tracking	Yes	10/30	100%	100%	11/6	100%	100%
Launch, Scale	Yes	N/A	N/A	N/A	11/6	N/A	100%
Launch, Full Size	90%	11/30	N/A	N/A	1/15		

### III.3 Mission Performance Prediction

#### III.3.1 Mission Performance Criteria

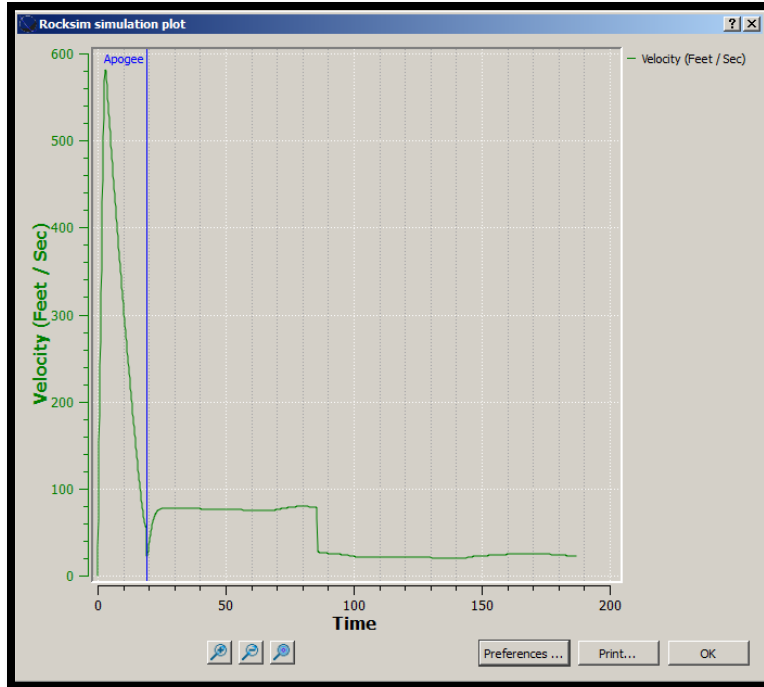
The goals of Team Skywalker's rocket is to safely deliver the payload to 5280 feet (AGL) conduct the science experiments and then safely descend to the earth using the redundant dual deploy recovery system. The following graphs illustrate Rocksim's flight simulations using the launch conditions given in III.2.5 above.

#### III.3.2 Flight Simulations from Rocksim 9



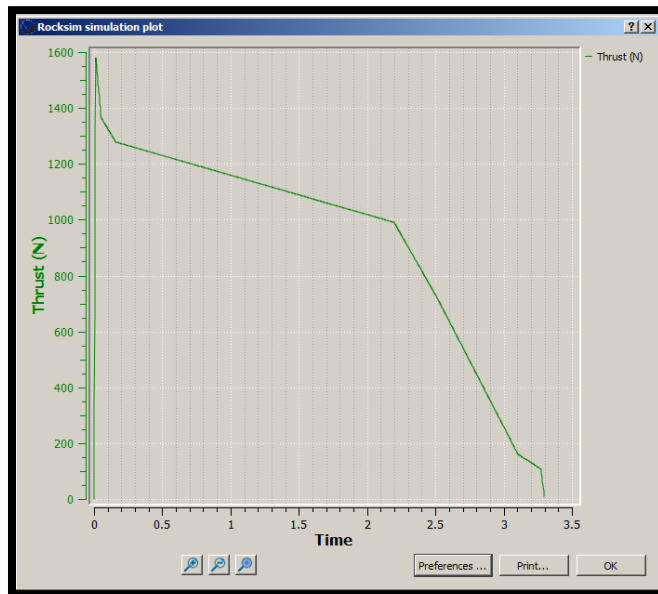
*Figure 18, Altitude*

The altitude plot shows a steady increase in altitude until apogee is reached whereupon the altitude decreases while under the drogue parachute. At the preconfigured 700 foot altitude, the main parachute is deployed. Given the wind conditions, the descent is not as linear as it would be under calm wind.



*Figure 19, Velocity*

This velocity plot shows the change resulting from the thrust phase through the coast phase. After apogee is reached, the rocket descends momentarily while the drogue is deployed. At 700 feet the main is deployed and the rocket descends at a much slower speed until it lands.



*Figure 20, Simulated CTI L935 Motor Thrust Curve*

### III.3.3 Stability Data

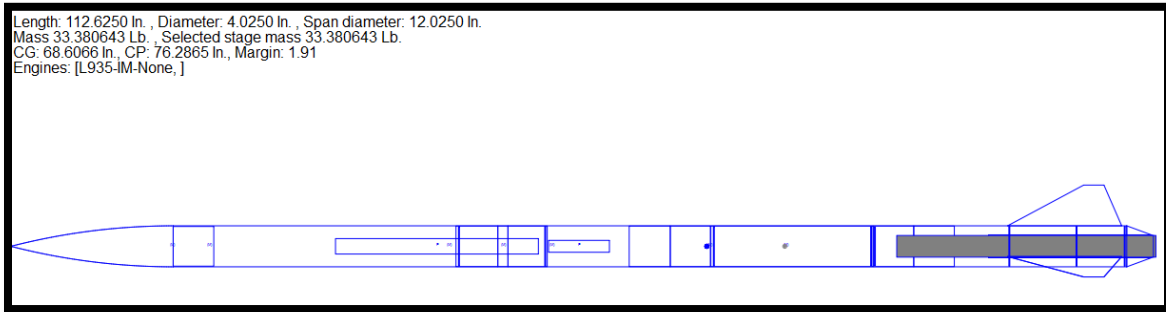


Figure 21, Rocksim CP=76.3, CG=68.6, and Stability Margin at 1.91 with motor loaded

### III.3.4 Kinetic Energy

Rocksim calculated the weight for the rocket at 23 pounds. USLI requires a 75 lb/ft<sup>3</sup> Kinetic Energy impact for the rocket. We used Excel and these formulas to calculate a main parachute size of 76 square feet.

- KE=Kinetic Energy
- m=mass in pounds
- V=velocity in feet per second
- S=surface area of parachute in square feet
- $\rho$ =air density
- $C_d$  = Coefficient of drag

$$KE = \frac{1}{2} m V^2$$

$$S = \frac{2m}{\rho V^2 C_d}$$

Kinetic Energy Calculation

	Ft/lbs
Rocket Mass (m)	24
Descent Rate (v)	14.25
KE=1/2mv <sup>2</sup>	75.67546584
KE=1/2mv <sup>2</sup> /32.2	

Calculate Parachute Size given the KE

Weight	23
CD	1.26
Descent Velocity	14.25
KE	0.075675466
Parachute Size in Square Feet	
76	

Drogue parachute size was calculated based upon descent speed. We select a descent speed between 80 and 90 fps and calculated a drogue size of 24 inches.

The Sky Angle Cert-3 XLarge and the Sky Angle Cert-3 Drogue satisfies the parachute requirements.

### III.3.5 Drift Calculations

Latitude: 34° 38' 50" N  
 Longitude: 86° 33' 11" W  
 Elevation: 827 feet

Relative humidity: 77 %  
 Temperature: 65 Deg. F  
 Pressure: 30.27 In.

Guide Rail Angle	Wind Speed (Kts)				
	0	5	10	15	20
0	0.00	319.96	2521.56	2897.79	3274.01
5	1055.14	-655.32	-8.02	39.83	735.57
10	2064.74	1781.04	-1370.00	-775.48	-117.30
20	3795.24	3707.87	-3247.40	-1819.31	1771.45
30	4963.05	4866.80	-4318.88	-3823.33	1869.44

*Table 6, Drift Distance in Various Wind Speeds and Guide Rail Angles*

## III.4 Interfaces and Integration

### III.4.1 Payload Integration

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 and it is easier to inspect and install several smaller devices rather than a 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 into the rocket. Screws will fasten together the upper and lower halves of the science payload bay.

The science payload will fit into the science payload bay which is an integral part of the airframe. It is connected to the fin can and the ebay with a 9 inch G10 coupler. The coupler is bolted to the science payload bay with 10-24 T-nuts and screws.

The power management system slides into the lower portion of the science payload bay and is connected to the fin can with 10-24 T-nuts and screws.

#### ***III.4.2 Airframe Internal Interfaces***

Each section of the rocket is connected to each other section with a 9" G10 fiberglass tube coupler. This allows for a 4.5" insert for each connecting section.

1. Permanent connections use West System epoxy.
2. Those that need intermittent access use 10-24 T-nuts and screws.
3. Temporary connections between the ebay and the two parachute compartments use shear pins. The shear pins prevent the rocket from premature separation due a combination of drag, inertia, and momentum. The shear pins are, however, designed to fail when the black powder ejection charge is ignited.

#### ***III.4.3 Launch Vehicle and Ground Facilities Interface***

The science payload sensors will be connected to the RDAS-Tiny transmitter which will transmit the data to the ground station. Altitude data is recorded through several altimeters and will be collected and analyzed after ground operations cease. Photos and videos are collected during the flight and also after landing and will be collected and analyzed after ground operations cease. Photos and videos will be taken of the rocket after it has landed and prior to retrieval to help analyze any data anomalies. Furthermore, data will be stored on board and can be analyzed after ground operations cease.

#### ***III.4.4 Rocket and Launch Rail Interface***

Two 0.5 inch rail guide buttons are bolted and fiber glassed to the fin can. These serve to guide the rocket up the 72 inch long T-Slotted Aluminum Extrusion Framing, 70 inches which are available for rocket guidance.

### **III.5 Launch Operation Procedures**

#### ***III.5.1 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.

##### **III.5.1.1 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. See photos and drawing below. The legs of the

launch pad are chained together to help prevent the legs from spreading and tilting the guide rail.



First Aid kits, a fire extinguisher, a portable sound system, 4 foot rebar stakes and “Do Not Cross” tape, and round out our ground support equipment. The recovery crew is equipped with cell phones as is the Range Safety Officer who has to contact Bellingham International Airport, USA and Victoria International Airport, Canada prior to the launch and at the cessation of the day’s operations.

### ***III.5.1.2 Final Assembly and Launch Procedures***

Launch operations follow a very strict policy with safety being paramount. This is 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 checklists which are in the appendices. A summary of the routine is as follows:

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

**III.5.1.2a Documents On Hand at Each Launch**

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

**Checklists**

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

**III.6 Vehicle Safety and Environment**

***III.6.1 Safety Officer***

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 5000 foot waiver from the US and the Canadian aviation agencies. We launch our rockets from 8:00am to 12:00pm on Saturday’s and Sundays.

**III.6.1.1 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 J
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 K.

All team members will have been briefed on the NAR High Power Rocket Safety Code and the risks involved with high power rocket launches. These briefings have taken place prior to submitting the USLI proposal and are repeated prior to each launch.

***III.6.2 Potential Failure Modes and Mitigation***

<i>Structural Failures</i>	<i>Potential Effects of Failure</i>	<i>Failure Mitigation</i>
----------------------------	-------------------------------------	---------------------------

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.
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.
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.
Parachute deploys too early or too late in flight.	High-speed deployment causes the shock cord to produce a "zippering" effect.	Test the altimeter for drogue 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.
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
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.
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.
<b><i>Payload Failures</i></b>	<b><i>Potential Effects of Failure</i></b>	<b><i>Failure Mitigation</i></b>
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 shall also use separate power supplies for each section containing electronic devices to prevent the failure of all electronics.
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.
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.
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.
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.
Static discharge to electronics.	Electronic instruments are damaged.	Team members should properly ground themselves before handling electronics.
<b><i>Recovery Failures</i></b>	<b><i>Potential Effects of Failure</i></b>	<b><i>Failure Mitigation</i></b>

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.
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.
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.
Drogue and main parachutes are packed too tightly to release.	Rocket experiences uncontrolled descent.	Ground test efficiency of the packing technique before launch.
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.
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.

### ***III.6.3 Personnel Hazards and Hazard Mitigations***

#### **III.6.3.1 Construction**

The Airframe Lead has the final say while constructing any designs, subsystems, or sections of the rocket.

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/rocketteam>

All team members are required to wear appropriate Personal Protective Equipment (PPE). 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.



1. 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.)
2. Power tool use requires at least two members be present. All team members shall wear the appropriate PPE.
3. 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.

### **III.6.3.2 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 F.

### **III.6.3.3 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.

### **III.6.3.4 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.

### **III.6.3.5 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 K) 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 L 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”

### **III.6.3.6 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.

### **III.6.4 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.

#### ***IV) Payload Criteria***

##### **IV.1 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. The measurements that we'll be monitoring are:

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

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. We are going to transmit some of the data during the descent.

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 use a microcontroller, power supply and data logger controlling the sensors and recording and transmitting the data. We will have a second microcontroller, power supply and data logger acting as backup and providing system redundancy. Having a redundant system ensures that some data will be collected in the event of a microcontroller malfunction. A totally catastrophic failure is the only reason that we wouldn't be able to collect meaningful data.

The main part of the payload will be the Arduino Uno. The Arduino Uno will be tasked with collecting data from all of the sensors and sending the data to the Adafruit Data Logger and to the 900 MHz transmitter. The Adafruit Data Logger will in turn store the data in an SD card, which will be easily accessible upon landing.

The payload system will easily fit into our 4" science payload bay. The UV and IR sensors will be located on a horizontal bulkplate that will maintain a vertical orientation during descent. Vents will allow atmospheric equilibrium for the

barometric pressure sensor as well as allow atmospheric access for the humidity and temperature sensors.

We are exploring the possibility of installing a 3" Plexiglas section fitted with mirrored upper and lower surfaces for the UV and IR sensors. If this proves feasible, we will be extensive ground testing with the sensors both in and out of the science payload bay.

#### ***IV.1.1 System's Function***

##### **IV.1.1a 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.

##### **IV.1.1b 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.

##### **IV.1.1c 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.

##### **IV.1.1d 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.

**IV.1.1e 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.

**IV.1.1f Photography**

The camera, 0.5 x 0.75 x 2.75 inches will be mounted on the airframe near the nose cone. It will be mounted in an inverted position so that it will record with the sky at the top of the picture frame after the drogue parachute has deployed and is descending. We are still brainstorming on how to ensure that the camera is up right while the rocket is lying on the ground and taking pictures for the requisite 10 minutes. The camera will start recording when the altimeters are armed.

**IV.1.1g Data Recovery**

Data retrieval will take place during descent, while on the ground for 10 minutes, and after recovery. The data will be transmitted to our ground station during descent and while on the ground during the 10 minute competition parameters. The USB data storage drive will be removed 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.

**IV.1.2 Payload Subsystems**

Payload Subsystem Description		
Sensors	silicon photo detector	These will be used to take readings on descent and after landing.
	temperature/humidity sensor	
	UV sensor	
	pressure sensor	
Controllers	Arduino Uno Microcontroller	This will be used to activate the devices and integrate the data collected.
Data Logger	Adafruit Data Logger	The data logger collects the data directed through the micro controller from the sensors. It stores this data for retrieval after landing.

Power Management	Arduino Pro Mini	This takes the readings from the barometric sensor and velocity and calculates when to deploy the velocity reduction system flaps.
	HiTec HS 645MG Ultra Torque Servo	This controls the velocity reduction system flaps.
	BMP 085 Barometric Sensor	

### IV.1.3 Performance Characteristics

We cannot at this time provide data for this section. We need to build and test our payload system and see what the limitations and specifications for each sensor.

Extensive testing of the individual sensors as well as the integrated package will be done. Data transmission testing will be done throughout the construction and testing phases.

### IV.1.4 Verification Plan and Status

Requirement	Design Feature	Verification	Status
The payload shall gather data for studying the atmosphere during descent and after landing. Measurements shall include pressure, temperature, relative humidity, solar irradiance and ultraviolet radiation. Measurements shall 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.	Arduino microcontroller-based sensors	Test	Work in Progress
The payload shall take at least 2 pictures during descent and 3 after landing.	Multiple Cameras oriented appropriately	Test	Cameras purchased
The payload shall 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.			Work in Progress
The data from the payload shall be stored onboard and transmitted wirelessly to the team's ground station at the time of completion of all surface operations.	900 MHz transmitter & receiver	Test	Work in Progress

#### **IV.1.5 Preliminary Integration Plan**

The Arduino UNO will be the primary data collection center .It will collect data from the SDL-1 Solar Data Logger, the TR-74UI unit, and the BMP085 barometric pressure sensor. The UNO will transfer its data to the 900 MHz transmitter which is powered by the RDAS Tiny altimeter. Data will be transmitted to a receiver that is connected to a laptop computer. Data is also stored on board the computer via the Adafruit Data Logger.

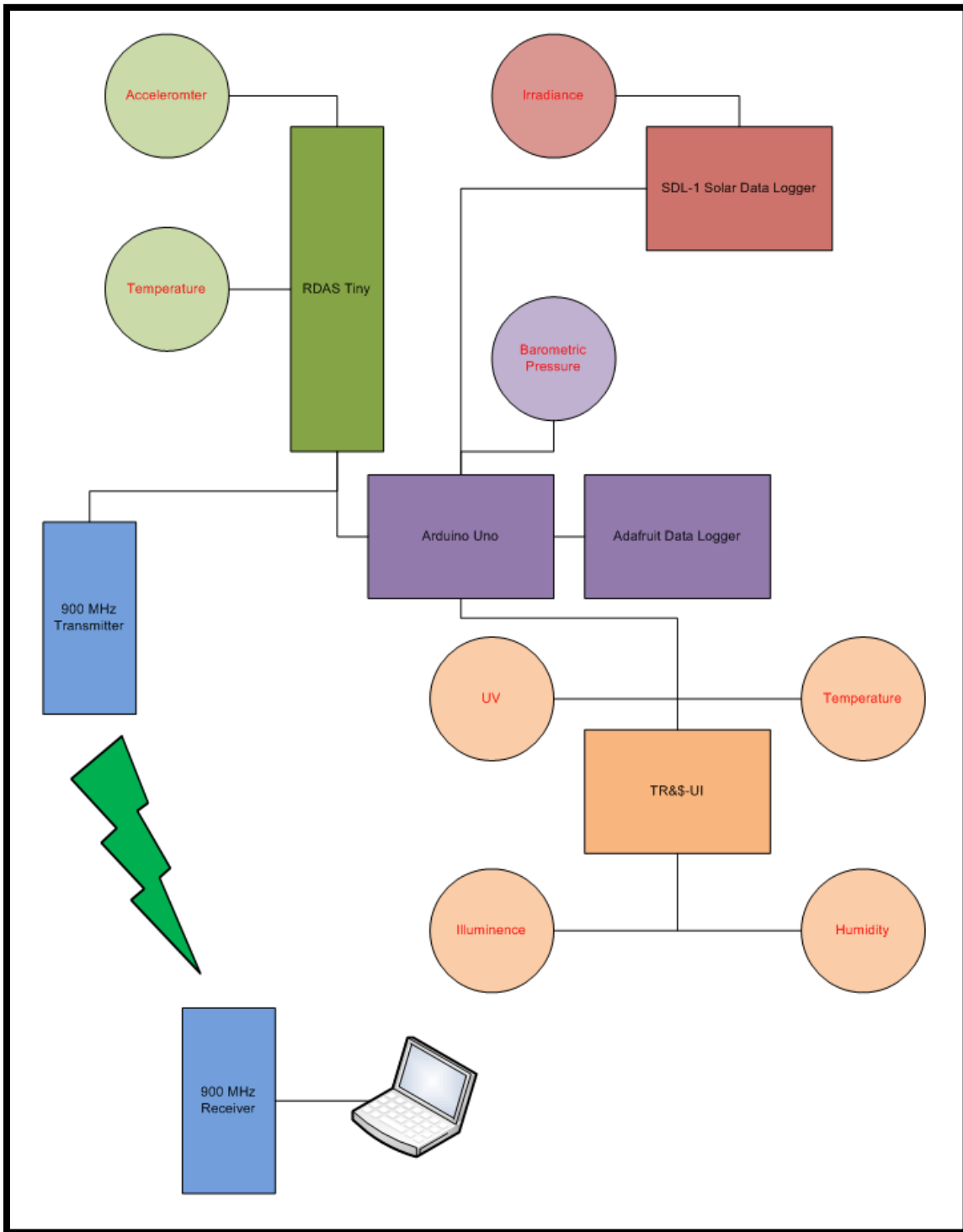
#### **IV.1.6 Instrumentation Precision, Repeatability and Data Recovery**

<b>Instrument</b>	<b>Sensor</b>	<b>Capability</b>
AED Electronics	Temp	Temperature measurement: -40 to 85 degC, resolution 0.22 degC (-40 to +185 degF, resolution 0.39 degF)
	2-Axis Accelerometer	Configurable range: +/- 50g, +/- 25g, +/- 10g and +/-5g (each axis can have a different scale)
TR-74UI	Temp	0-55 C
	Humidity	10-95% RH
	Illuminance	0-130,000 lx
	UV Intensity	0-30 mW/cm <sup>2</sup>
SDL-1 Solar Data Logger	Irradiance	Range 1520 W/m <sup>2</sup>
Barometric Pressure Sensor - BMP085 Breakout	Barometric pressure	300-1100hPa (+9000m to -500m)

*Table 7, Instrument Precision*

Precision will be determined by extensive testing and comparing the results to standard laboratory instruments. Assuming that our construction and testing are robust, we should be able to repeat our results throughout the duration of this project and beyond.

### IV.1.7 Science Payload Schematics



*Figure 22, Preliminary Instrumentation Block Diagram*

#### ***IV.1.8 Payload Key Components Interaction to Achieve Desired Results***

The sensors will collect information based upon the programming of the Arduino Uno. The data will be stored in the data logger as well as passed onto the 900 MHz transmitter. The transmitter will transmit the data to the receiver that is connected to a laptop.

### **IV.2 Payload Concept Features and Definition**

#### ***IV.2.1 Creativity and Originality***

Only two team members have 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.

#### ***IV.2.2 Uniqueness or Significance***

Our payload will essentially create a vertical profile of the atmosphere from ground level to 1 mile AGL. This data will be analyzed by the rocket team and students from the NWIC Native Environmental Science program. This payload is significant because it will capture data about the atmosphere, and this data can be analyzed and perhaps used by students in the Native Environmental program of study when we do our own launches on the Lummi Nation Reservation.

#### ***IV.2.3 Suitable Level of Challenge***

This is a totally new process for most of the students. 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 except for last year's USLI project. We've had little to no experience working on a project of this magnitude. That being said, Sky Walkers are confident that we can complete this project successfully. 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.

### **IV.3 Science Value**

The objective of the science payload is to collect data and learn to analyze that data and report it in a meaningful way. We will be working with the Native Environmental Science students and the math instructor to analyze this data.

#### ***IV.3.1 Payload Objectives***

Team Skywalker's intention is two faceted: 1) gather atmospheric data and present it in a meaningful format; and, 2) see if we can develop a power management system so that we can achieve a predicted altitude.

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.

The second objective will develop our analytical, programming, engineering, and construction skills.

Our major reasons for doing this are to not only satisfy the SMD goals, but to enhance the learning and knowledge of our team members. All of the team members want to be challenged and to build upon last year's team success. *(Advisor's note: several administrators and faculty members have likened the Space Center's activities to a major university's successful athletic team. This project has brought pride to both the college and the Space Center's team members.)*

#### **IV.3.2 Payload Success Criteria**

1. Sensors need to make successful readings during the entire descent of the rocket and while on the ground.
2. Cameras need to successfully record during the descent of the rocket and while on the ground.
3. Microcontroller needs to store all of the data it collects in an SD card without any loss or corruption of data
4. Data needs to be successfully transmitted to the laptop
5. Data needs to be transferred to a laptop without any loss or corruption

#### **Power Management Success Criteria**

1. Velocity Reduction System Deploys at the appropriate time and speed
2. Microcontroller performs as programmed
3. Mechanical system works as designed
4. Target altitude reached

#### **IV.3.3 Experimental Logic, Approach, and Investigation Method**

Sky Walkers' 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.

#### **IV.3.4 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. Prior to the competition flight, we will have a baseline for each of the sensors that we have developed from a controlled environment.

#### **IV.3.5 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 be 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.

### ***IV.3.6 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.

A typical test session follows this order:

1. Test battery voltages
2. Power up the system
3. Gather data for a set amount of time
4. Power down the system
5. Analyze the data
6. Trouble shoot mechanical, electrical and/or programming issues.

## **IV.4 Payload Safety and Environment**

### ***IV.4.1 Safety Officer***

Justin is the safety officer.

### ***IV.4.2 Failure Modes***

Payload failure modes can be hazardous or nonhazardous. Hazardous failures may result injury to personnel or damage to property. Non-hazardous failures are failures affecting the success of the mission, but not resulting in injury to personnel or damage to property (other than that of the team). See page 20 for more details.

### ***IV.4.3 Personnel Hazards***

Personnel hazards have discussed elsewhere. Please see page 20 for more details.

### ***IV.4.4 Payload Environmental Concerns***

Nothing in the payload constitutes an environmental hazard.

## **V) Activity Plan**

### **V.1 Budget Plan**

Qty	Description	Total Price
	Scale Model Rocket	

1	LOC Precision Vulcanite Kit	\$69.95	\$69.95
1	48" 54mm Airframe	\$7.30	\$7.30
3	Tube Couplers - 54mm	\$2.05	\$6.15
1	1/4" Plywood	\$6.99	\$6.99
2	Aerotech G80	\$26.99	\$53.98
			\$144.37
<b>Full Scale Rocket</b>			
1	Performance Rocketry MadDog DD	\$179.55	\$179.55
1	4" G10 Airframe - 48"	\$83.60	\$83.60
1	4" Tail Cone	\$28.50	\$28.50
2	G10 Sheet, 3/32 x 12 x12	\$13.30	\$26.60
2	4" Coupler	\$20.90	\$41.80
1	1/4" Plywood	\$6.99	\$6.99
1	Aero Pack tail cone	\$54.99	\$54.99
1	G10 Sheet, 1/8 x 12 x12	\$17.10	\$17.10
			\$439.13
<b>Motors for Full Scale Rocket</b>			
2	CTI 54mm 6 grain reload	\$182.95	\$365.90
1	CTI 54 mm 6XL grain motor casing	\$106.95	\$106.95
2	Aerotech 54mm 5 grain reload	\$119.66	\$239.32
1	RMS-54/2560 MOTOR	\$199.80	\$199.80
			\$911.97
<b>Miscellaneous Parts</b>			
1	Misc Construction Supplies - paint, glue	\$100.00	\$100.00
1	Misc hardware - bolts, nuts, links	\$100.00	\$100.00
			\$200.00
<b>Recovery System</b>			
1	Recovery materials, nomex, nylon, kevlar	\$60.00	\$60.00
1	Black Powder	\$40.00	\$40.00
1	78" Parachute	\$79.95	\$79.95
1	28" Parachute	\$16.75	\$16.75
1	RDAS-Tiny altimeter	\$300.00	\$300.00
2	MAWD Altimeter	\$99.95	\$199.90
			\$696.60
<b>Payload and Tracking System</b>			
1	GPS Unit	\$295.00	\$295.00
1	Payload camera	\$9.95	\$9.95
1	Science Payload	\$2,100.00	\$2,100.00
1	Arduino Uno	\$19.95	
1	Arduino Pro Mini	\$29.95	
1	Adafruit Data Logger	\$29.95	
1	Power Management System	\$200.00	\$200.00

3	HiTec HS 645MG Ultra Torque Servo	\$31.99	
1	Arduino Uno	\$19.95	
			\$2,604.95
		<b>Total</b>	<b>\$4,997.02</b>
<b>Travel</b>			
12	Huntsville Travel	\$575.00	\$6,900.00
4	Huntsville Lodging	\$200.00	\$800.00
			\$7,700.00
<b>Project Income</b>			
	NASA SMD		\$3,000.00
	Outreach		\$3,000.00
	Washington State Space Grant		\$2,000.00
	Tribal Support		\$5,000.00
			\$13,000.00
<b>Budget Summary</b>			
	Scale Rocket	\$144.37	
	Competition Rocket	\$439.13	
	Propulsion	\$911.97	
	Construction Supplies	\$200.00	
	Recovery	\$696.60	
	Electronics & Payload	\$2,604.95	
		\$4,997.02	
	Travel & Lodging	\$7,700.00	
<b>Project Income</b>			
			\$13,000.00

## V.2 Timeline

Please see Appendix B

## V.3 Educational Engagement

As of the report submittal, Team Skywalkers have participated in the following educational engagement activities:

- AISES National Conference
- Windward Discovery Academy (Special Education Students)
- AISES Presentation at Northwest Indian College

Additionally, we are published monthly in the Lummi Nation paper, Squol Quol. See Appendix N

We've also been recognized by the Tribal College Journal

<http://www.tribalcollegejournal.org/archives/7918>

and we have a NASA webpage devoted to us.

<http://www.nasa.gov/audience/foreducators/postsecondary/features/inexperience-stop-flying.html>

We are in communication with the school districts in Whatcom County, Washington. We are working with the middle schools to setup time lines to work with their science students.

Our outreach is focused on middle school aged students. However, we recognize the importance of a successful Native American science endeavor. We need to take this and reach as many people as possible. It is a vast contradiction to how many view Native Americans.

## **VI) Conclusion**

The Sky Walkers are confident in the design that we have created to meet the overall mission requirements in the USLI competition. The complete design be tested in the very near future. 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 Sky Walkers. 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 Sky Walkers is dependent upon dedication, hard work, and the excitement of doing something that few of us have previously done.

# Appendix A – Launch Vehicle Fly Sheet

## Milestone Review Flysheet

PDR, CDR, FRR

<b>Institution Name</b>	Northwest Indian College
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<b>Milestone</b>	PDR
------------------	-----

Vehicle Properties	
Diameter (in)	4
Length (in)	112.625
Gross Liftoff Weight (lb)	33.38
Launch Lug/button Size	0.5
Motor Retention	Aero Pack Tail Cone/Retention

Motor Properties	
Motor Manufacturer	CTI
Motor Designation	L395-IM
Max/Average Thrust (N/lb)	1585.6N/933.8N
Total Impulse (N-sec/lb-sec)	3147 Ns
Mass pre/post Burn (lb)	5.6 lb/2.15 lb

Stability Analysis	
Center of Pressure (in from nose)	76.29
Center of Gravity (in from nose)	68.61 (w/motor)
Static Stability Margin	1.91
Thrust-to-Weight Ratio	6.289 avg/10.679 max
Rail Size (in) / Length (in)	1 in/72 in

Ascent Analysis	
Rail Exit Velocity (ft/s)	55.12
Max Velocity (ft/s)	582.36
Max Mach Number	0.52
Max Acceleration (ft/s <sup>2</sup> )	251.14
Peak Altitude (ft)	5,280

Recovery System Properties				
Drogue Parachute				
Manufacturer/Model		Sky Angle Cert3		
Size		24"		
Altitude at Deployment (ft)		5,280		
Velocity at Deployment (ft/s)		34.5		
Terminal Velocity (ft/s)		72.42		
Recovery Harness Material		Kevlar		
Harness Size/Thickness (in)		9/16"		
Recovery Harness Length (ft)		30		
Harness/Airframe Interfaces		3/8" closed steel eyebolt		
Kinetic Energy During Descent (ft-lb)	Section 1	Section 2	Section 3	Section 4
	162.88	977.23	1140.14	

Recovery System Properties				
Main Parachute				
Manufacturer/Model		Sky Angle Cert3 Xlarge		
Size		89 sq ft		
Altitude at Deployment (ft)		700		
Velocity at Deployment (ft/s)		72.42		
Landing Velocity (ft/s)		12.11		
Recovery Harness Material		Kevlar		
Harness Size/Thickness (in)		9/16"		
Recovery Harness Length (ft)		20		
Harness/Airframe Interfaces		3/8" closed steel eyebolt		
Kinetic Energy Upon Landing (ft-lb)	Section 1	Section 2	Section 3	Section 4
	6.31	37.84	44.14	

Recovery System Properties				
Electronics/Ejection				
Altimeter(s) Make/Model		PerfectFlite MAWD		

Recovery System Properties				
Electronics/Ejection				
Rocket Locators (Make, Model)	Garmin Astro 200, DC 20			

Redundancy Plan	2nd PerfectFlite MAWD
Pad Stay Time (Launch Configuration)	2 hours

Transmitting Frequencies	<b>***Required by CDR***</b>
Black Powder Mass Drogue Parachute (gram)	1.56
Black Powder Mass Main Parachute (gram)	3.1

<h1>Milestone Review Flysheet</h1>
<b>PDR, CDR, FRR</b>

<b>Institution Name</b>	Northwest Indian College
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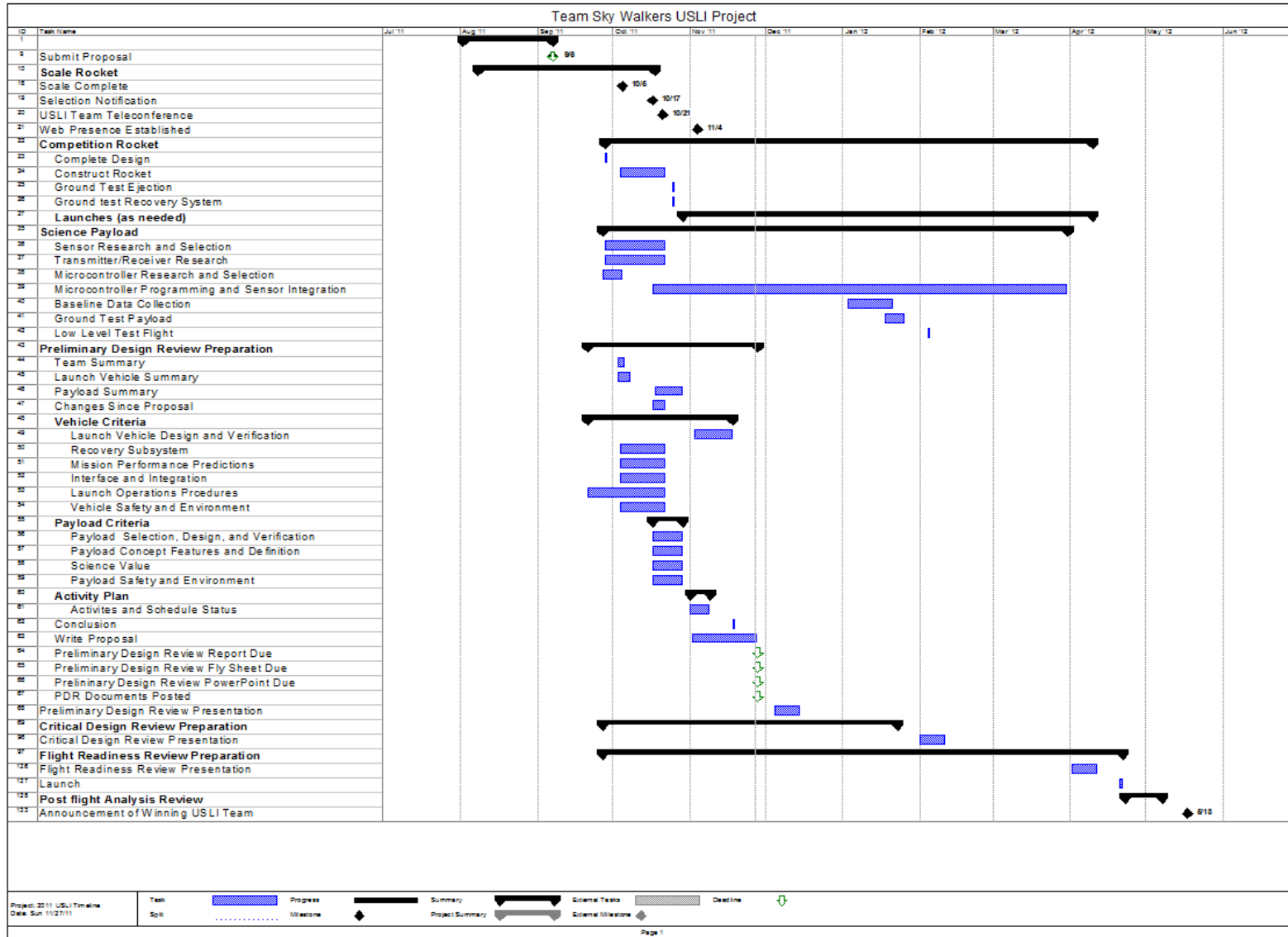
<b>Milestone</b>	PDR
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<b>Payload/Science</b>	
Succinct Overview of Payload/Science Experiment	SMD atmospheric measuring and photography Power Management system
Identify Major Components	Nose cone, main parachute bay, ebay, drogue parachute bay, science/power management bay, fin can, propulsion system, recovery system
Mass of Payload/Science	6.4 pounds

<b>Test Plan Schedule/Status</b>	
Ejection Charge Test(s)	Tested for subscale - complete Scheduled for competition rocket -
Sub-scale Test Flights	Complete 11/12/11
Full-scale Test Flights	Scheduled: 12/17, 1/14/12, 2/18/12, 3/12/12, 4/9/12

<b>Additional Comments</b>	

# Appendix B – Time Line



## Appendix C – Competition Rocket Verification Plan

Requirement	Design Feature	Verification	Status
1. Option 2: The Science Mission Directorate (SMD) at NASA HQ will provide a \$3,000 sponsorship to any team that chooses to build and fly a deployable science payload meeting the following criteria:	SMD Payload	Inspection	Work in Progress
The payload shall gather data for studying the atmosphere during descent and after landing. Measurements shall include pressure, temperature, relative humidity, solar irradiance and ultraviolet radiation. Measurements shall 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.	Arduino microcontroller-based sensors	Test	Work in Progress
The payload shall take at least 2 pictures during descent and 3 after landing.	Multiple Cameras oriented appropriately	Test	Cameras purchased
The payload shall 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.			Work in Progress
The data from the payload shall be stored onboard and transmitted wirelessly to the team's ground station at the time of completion of all surface operations.	RDAS-Tiny transmitter & receiver	Test	Work in Progress
Separation of payload components at apogee will be allowed, but not advised. Separating at apogee increases the risk of drifting outside of the recovery area. The payload shall carry a GPS tracking unit. Minimum separation altitude shall be 2,500 ft.	Not Applicable	Not Applicable	Not Applicable
2. The launch vehicle shall deliver the science or engineering payload to, but not exceeding, an altitude of 5,280 feet above ground level (AGL). One point will be deducted for each foot achieved below the target altitude. Two points will be deducted for each foot achieved above the target altitude. Any team whose vehicle travels over 5,600 ft. according to their competition altimeter will be disqualified from being able to receive the overall competition award and will receive a score of zero for the altitude portion of their total score.	Design through Rocksim 9, Power Management System	Test	Work in Progress
3. The vehicle shall carry one Perfect Flight MAWD or ALT15 altimeter for recording of the official altitude used in the competition scoring. Teams may have additional altimeters to control vehicle electronics and payload experiments. At the flight hardware and safety check, a NASA official will mark the altimeter which will be used for the official scoring. At the launch field, a NASA official will also obtain the altitude by listening to the audible beeps reported by the altimeter. The following circumstances will warrant a score of zero for the altitude portion of the competition:	Two PerfectFlite MAWD altimeters	Inspection	Complete
a. The official, marked altimeter is damaged and/or does not report an altitude after the team's competition flight.	Safe Recovery will preclude this	Inspection	Work in Progress
b. The team does not report to the NASA official designated to record the altitude with their official marked altimeter by 5:00 pm on the day of the launch.	Check list will preclude this	Inspection	Work in Progress
4. The recovery system electronics shall have the			

following characteristics:			
a. The recovery system shall be designed to be armed on the pad.	Locking key switches installed	Inspection	Work in Progress
b. The recovery system electronics shall be completely independent of the payload electronics.	Payload electronics in separate science by		
c. The recovery system shall contain redundant altimeters. The term “altimeters” includes both simple altimeters and more sophisticated flight computers.	Designed with two independent systems		
d. Each altimeter shall be armed by a dedicated arming switch.	Locking Key Switches		
e. Each altimeter shall have a dedicated battery.	Designed with two independent systems including batteries		
f. Each arming switch shall be accessible from the exterior of the rocket airframe.	Locking switches located on ebay ring		
g. Each arming switch shall be capable of being locked in the ON position for launch.	Switches that lock with a key are installed		
h. Each arming switch shall be a maximum of six (6) feet above the base of the launch vehicle.	Switches located 64 inches from base of rocket		
5. The recovery system electronics shall be shielded from all onboard transmitting devices, to avoid inadvertent excitation of the recovery system by the transmitting device(s).	Ebay lined with aluminum foil	Inspection	Work in Progress
6. The launch vehicle and science or engineering payload shall remain subsonic from launch until landing.	Designed with Rocksim 9 to stay subsonic	Simulation	Work in Progress
7. The launch vehicle and science or engineering payload shall be designed to be recoverable and reusable. Reusable is defined as being able to be launched again on the same day without repairs or modifications.	Designed with Rocksim 9	Simulation	Work in Progress
8. The launch vehicle shall stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee and a main parachute is deployed at a much lower altitude. Tumble recovery from apogee to main parachute deployment is permissible, provided that the kinetic energy is reasonable.	Designed with Rocksim 9, using drogue at apogee and main at 700 feet	Simulation	Work in Progress
9. Removable shear pins shall be used for both the main parachute compartment and the drogue parachute compartment.	2 - #2-56 nylon screws will be shear pins	Ground Testing	Work in Progress
10. The launch vehicle shall have a maximum of four (4) independent or tethered sections.	Designed with three	Inspection	Work in Progress
a. At landing, each independent or tethered sections of the launch vehicle shall have a maximum kinetic energy of 75 ft-lbf.	Designed via calculations	Simulation	Complete
b. All independent or tethered sections of the launch vehicle shall be designed to recover with 2,500 feet of the launch pad, assuming a 15 mph wind.	Designed with Rocksim 9	Simulation analysis	Complete
11. The launch vehicle shall be capable of being prepared for flight at the launch site within 2 hours, from the time the waiver opens.	Designed as required	Check lists	Work in Progress

12. The launch vehicle shall be capable of remaining in launch-ready configuration at the pad for a minimum of 1 hour without losing the functionality of any onboard component.	Battery power calculated to last at least 2 hrs for each device using a battery	Simulation analysis	Work in Progress
13. The launch vehicle shall be launched from a standard firing system (provided by the Range) using a standard 10 - second countdown	Designed as required	Test	Work in Progress
14. The launch vehicle shall require no external circuitry or special ground support equipment to initiate the launch (other than what is provided by the Range).	None are necessary as designed	Inspection	Work in Progress
15. Data from the science or engineering payload shall be collected, analyzed, and reported by the team following the scientific method.	Data analysis will be examined post flight	Testing will follow payload completion prior to the competition flight	Work in Progress
16. An electronic tracking device shall be installed in each independent section of the launch vehicle and shall junction with an electronic, transmitting device, but shall not replace the transmitting tracking device.	Garmin GPS unit in nose cone	Ground tested complete. Flight test to follow	Work in Progress
17. The launch vehicle shall use a commercially available solid motor propulsion system using ammonium perchlorate composite propellant (APCP) which is approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA) and/or the Canadian Association of Rocketry (CAR).	Designed to use CTI/Aerotech reloadable motor	Inspection	Work in Progress
18. The total impulse provided by the launch vehicle shall not exceed 5,120 Newton-seconds (L-class). This total impulse constraint is applicable to any combination of one or more motors.	Designed as required, L motor largest permissible	Inspection	Work in Progress
19. All teams shall successfully launch and recover their full scale rocket prior to FRR in its final flight configuration.			
a. The purpose of the full scale demonstration flight is to demonstrate the launch vehicle's stability, structural integrity, recovery systems, and the team's ability to prepare the launch vehicle for flight.	Test flights scheduled prior to FRR	Test flight	Work in Progress
b. The vehicle and recovery system shall have functioned as designed.	Extensive ground testing where possible, test flights for the vehicle	Test flight	Work in Progress
c. The payload does not have to be flown during the full-scale test flight.			
▪ If the payload is not flown, mass simulators shall be used to simulate the payload mass.	Measured mass of actual payload will be either substituted or the payload will be flown	Test flight	Work in Progress
▪ If the payload changes the external surfaces of the launch vehicle (such as with camera housings and/or external probes), those devices must be flown during the full scale demonstration flight.	Test flight will be with rocket as its designed		Work in Progress
d. The full scale motor does not have to be flown during the full scale test flight. However, it is recommended that the full scale motor be used to demonstrate full flight readiness and altitude verification.	Both smaller and a full scale motor will be used in test flights	Test flight	Work in Progress

e. The success of the full scale demonstration flight shall be documented on the flight certification form, by a Level 2 NAR/TRA observer.	Our mentor and 3 other NAR L2 individuals are available		Work in Progress
f. After successfully completing the full-scale demonstration flight, the launch vehicle or any of its components shall not be modified without the concurrence of the NASA Range Safety Officer.	No changes will be made.		Work in Progress
20. The following items are prohibited from use in the launch vehicle:			
a. Flashbulbs. The recovery system must use commercially available low-current electric matches.	None of these have been included in the rocket design	Inspection	Complete
b. Forward canards.			
c. Forward firing motors.			
d. Rear ejection parachute designs.			
e. Motors which expel titanium sponges (Sparky, Skidmark, MetalStorm, etc.).			
f. Hybrid motors.			
21. Each team shall use a launch and safety checklist. The final checklist shall be included in the FRR report and used during the flight hardware and safety inspection and launch day.	Check lists are designed	Inspection and actual testing	Complete
22. Students on the team shall do 100% of the work on the project, including design, construction, written reports, presentations, and flight preparation with the exception of assembling the motors and handling black powder charges.	Implemented as required	Inspection	Work in Progress
23. The rocketry mentor supporting the team shall have been certified by NAR or TRA for the motor impulse of the launch vehicle, and the rocketeer shall have flown and successfully recovered (using electronic, staged recovery) a minimum of 15 flights in this or a higher impulse class, prior to PDR.	Implemented as required	Inspection	Complete
24. The maximum amount teams may spend on the rocket and payload is \$5000 total. The cost is for the competition rocket as it sits on the pad, including all purchased components and materials and the fair market value of all donated components and materials. The following items may be omitted from the total cost of the vehicle:			
a. Shipping costs.	Implemented as required	Inspection	Complete
b. Ground Support Equipment.			
c. Team labor.			

## **Appendix D - Northwest Indian College Space Center (NWIC-SC) Release Form for 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 E - GSE Check List***

- Fire Extinguisher
- 1st Aid Kit
- Launch Legs
- 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
- Fireproof Blanket
- Writing Pad
- Pencils/Pens
- Sandpaper
- Flight Card
- Liability Waiver
- Flight Data Sheets
- Portable Weather Station
- Mosquito Repellant (seasonal)
- FSR Radios w/fresh batteries
- Video/Still Camera
- Clipboard

## **Appendix F – Ebay and Recovery System Check List**

### Recovery System Preparation

#### **Recovery System, Drogue Chute:**

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

- Aft bay recovery harness to drogue
- Booster recovery harness to drogue
- Fold drogue chute per manufacturer's instructions.
- Insure shroud lines are free from tangles.
- Insure all quick links are secure.
- Insert ejection charge protection (dog barf).
- Insert folded and protected chute into drogue recovery compartment.

#### **Recovery System, Main Chute**

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

- Forward bay recovery harness to shock cord mount
- Forward bay recovery harness to main
- 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 folded and protected 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 container

- ❑ Pour measured amount of BP into BP container
- ❑ Fill remaining space with dog barf
- ❑ Tape over the BP container with tape to make certain that no BP escapes while filling the other cups.
- ❑ Repeat for the secondary BP container
- ❑ 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 container
- ❑ Pour measured amount of BP into BP container
- ❑ Fill remaining space with dog barf
- ❑ Tape over the BP container with tape to make certain that no BP escapes while filling the other containers.
- ❑ Repeat for the secondary BP container
- ❑ 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.**

## ***Appendix G - Motor and Launch Preparation Checklist***

### **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 from (CTI motor) forward end of reload
- Seal ejection charge hole with grease
- Insert reload into motor
- Fasten retaining tail cone
- Tape igniter to rocket airframe
- Discard trash properly

### **Launch team transports rocket to assigned launch pad**

## **Appendix H - Final Launch Preparation Checklist**

### **Tools to launch pad**

- Multi bit screwdriver
- Sandpaper
- Wire strippers
- Masking tape
- Small screwdriver
- Razor knife

### **Setup on launcher**

- Verify pad power is OFF
- Slide rocket on to rail guide
- Raise rail guide and position vertically as desired
- Remove both safety restraints from altimeter switches
- Altimeters – beeping
- Cameras on

### **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**

- 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 I - Post-Recovery Checklist***

### **Normal Post Flight Recovery**

- ❑ Take at least five photographs of the rocket and its components BEFORE touching it
- ❑ Check for non-discharged pyrotechnics.
- ❑ Safe all ejection circuits.
- ❑ Remove any non-discharged pyrotechnics.

### **Flight Failure Checklist**

- ❑ Take at least five photographs of the rocket and its components BEFORE touching it
- ❑ Disarm all non-fired pyrotechnic devices.
- ❑ Continue Normal Post Flight Recovery procedures.
- ❑ Carry the pieces back to the staging area with great solemnity and respect.

## **Appendix J - 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**

<b>Installed Total Impulse (Newton-Seconds)</b>	<b>Equivalent High Power Motor Type</b>	<b>Minimum Diameter of Cleared Area (ft.)</b>	<b>Minimum Personnel Distance (ft.)</b>	<b>Minimum Personnel Distance (Complex Rocket) (ft.)</b>
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 K - 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 L - Launch Wavier Activation**

<b>Date</b>	<b>Time</b>	<b>Initials</b>	<b>Agency</b>	<b>Phone</b>	<b>Timing</b>
			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
			<b>NOTAM</b>	<b>877-487-6867</b>	<b>Operations Concluded</b>
			<b>BLI ATC</b>	<b>360-734-2745</b>	
			<b>Vancouver ACC</b>	<b>604-586-4560</b>	

½ nm radius of the Whatcom VOR (HUH), 175 degree radial at 9 nm  
 Latitude 48°47'38.44"N. Longitude 122°38'26.09"W

# Appendix M - HPR Flight Card



## High Power Flight Card

### Northwest Indian College Space Center

RSO Initials: _____
Rod/Rail #: _____

Date: \_\_\_\_\_

Section Break (Continuous)

Rocketeer's Name: \_\_\_\_\_ Launching on: Rod  Rail

Tripoli / NAR#: \_\_\_\_\_ Current Cert Level: \_\_\_\_\_ Motor(s):  Single  Clustered  Staged  Air Starts

Rocket Manufacturer: \_\_\_\_\_ Main Motor: \_\_\_\_\_

Rocket Name: \_\_\_\_\_ More than one motor? If YES, see back: \_\_\_\_\_

Source:  Kit  Custom Color: \_\_\_\_\_ Recovery:  Motor Eject  Electronics  Dual Deploy

Length: \_\_\_\_\_ Diameter: \_\_\_\_\_ Recovery via:  Chute  Streamer  Other: \_\_\_\_\_

Weight: \_\_\_\_\_ First Flight of Rocket?: \_\_\_\_\_ Electronics: \_\_\_\_\_

Modifications: \_\_\_\_\_ 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: \_\_\_\_\_

Certification Flight → D L1 → D L2 → D L3 → Certifier: \_\_\_\_\_

Special Flight - Info: \_\_\_\_\_

Good Flight <input type="checkbox"/>
Failed Flight Reason
<input type="checkbox"/> Cata → <input type="checkbox"/> Hard Impact
<input type="checkbox"/> Shred → <input type="checkbox"/> Recovery Failed



## High Power Flight Card

### Northwest Indian College Space Center

RSO Initials: _____
Rod/Rail #: _____

Date: \_\_\_\_\_

Section Break (Continuous)

Rocketeer's Name: \_\_\_\_\_ Launching on: Rod  Rail

Tripoli / NAR#: \_\_\_\_\_ Current Cert Level: \_\_\_\_\_ Motor(s):  Single  Clustered  Staged  Air Starts

Rocket Manufacturer: \_\_\_\_\_ Main Motor: \_\_\_\_\_

Rocket Name: \_\_\_\_\_ More than one motor? If YES, see back: \_\_\_\_\_

Source:  Kit  Custom Color: \_\_\_\_\_ Recovery:  Motor Eject  Electronics  Dual Deploy

Length: \_\_\_\_\_ Diameter: \_\_\_\_\_ Recovery via:  Chute  Streamer  Other: \_\_\_\_\_

Weight: \_\_\_\_\_ First Flight of Rocket?: \_\_\_\_\_ Electronics: \_\_\_\_\_

Modifications: \_\_\_\_\_ 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: \_\_\_\_\_

Certification Flight → D L1 → D L2 → D L3 → Certifier: \_\_\_\_\_

Special Flight - Info: \_\_\_\_\_

Good Flight <input type="checkbox"/>
Failed Flight Reason
<input type="checkbox"/> Cata → <input type="checkbox"/> Hard Impact
<input type="checkbox"/> Shred → <input type="checkbox"/> Recovery Failed

# NWIC Space Center joins 2012 NASA competition

Northwest Indian College (NWIC) Space Center students will go toe to toe with students in colleges and universities across the nation in NASA's University Student Launch Initiative (USLI) competition.

On Oct. 17, Space Center advisor Gary Brandt was notified that NWIC's proposal was accepted and his students will again get to participate in NASA's student rocket building competition against top universities such as MIT, Vanderbilt University, Purdue University and the University of Washington.

NWIC was the second tribal college to join the national competition, and this year Haskell Indian Nations University will also participate.

Last year was NWIC's first as a USLI competitor — NWIC students came in 17th out of 33 teams. The students' experience in last year's competition will be hugely beneficial going into the competition this year, Brandt said.

"Experience is priceless," Brandt said. "We know what is supposed to happen and how to better

prepare ourselves."

That experience will be especially helpful this year — competition requirements this year are more challenging than last year.

The student teams will need to create a rocket that can fly to 5,280 feet into the air. For every foot short of that height, teams will lose one point, but they have to be careful not to go over too— for every foot exceeding 5,280 feet, teams will lose two points.

In addition to building and launching their rocket, NWIC's team, Team Sky

Walkers, will launch devices that collect atmospheric data, UV, solar irradiance, humidity, barometric pressure and temperature, and transmit that data to their ground station. Their rocket must also be equipped with a camera that can take properly oriented— sky on top, ground on the bottom— photos while in the air and on the ground.

The eight-month-long project includes delivering three presentations to NASA representatives, as well as writing and compiling four reports, which are

typically greater than 125 pages in length.

In addition to building a rocket for the NASA competition, the NWIC Space Center was also awarded a grant by NASA's Exploration Systems Mission Directorate for \$4,000 to build and fly a rocket with a system that can stop it at a predetermined altitude.

"We are off to a busy year," Brandt said.

You can follow the NWIC Space Team's progress at [blogs.nwic.edu/rocketteam](http://blogs.nwic.edu/rocketteam).



2011  
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