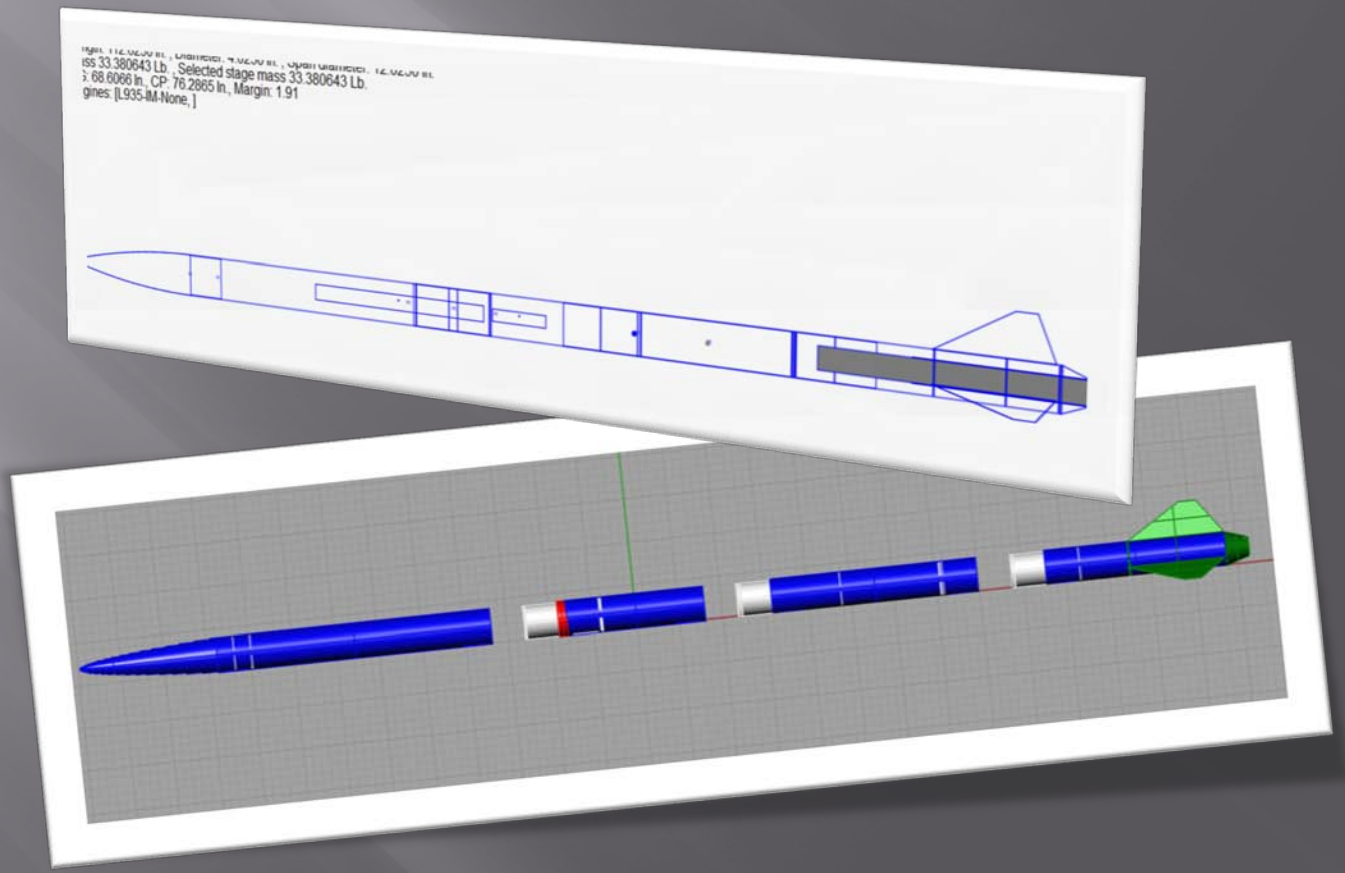
NORTHWEST INDIAN COLLEGE SPACE CENTER

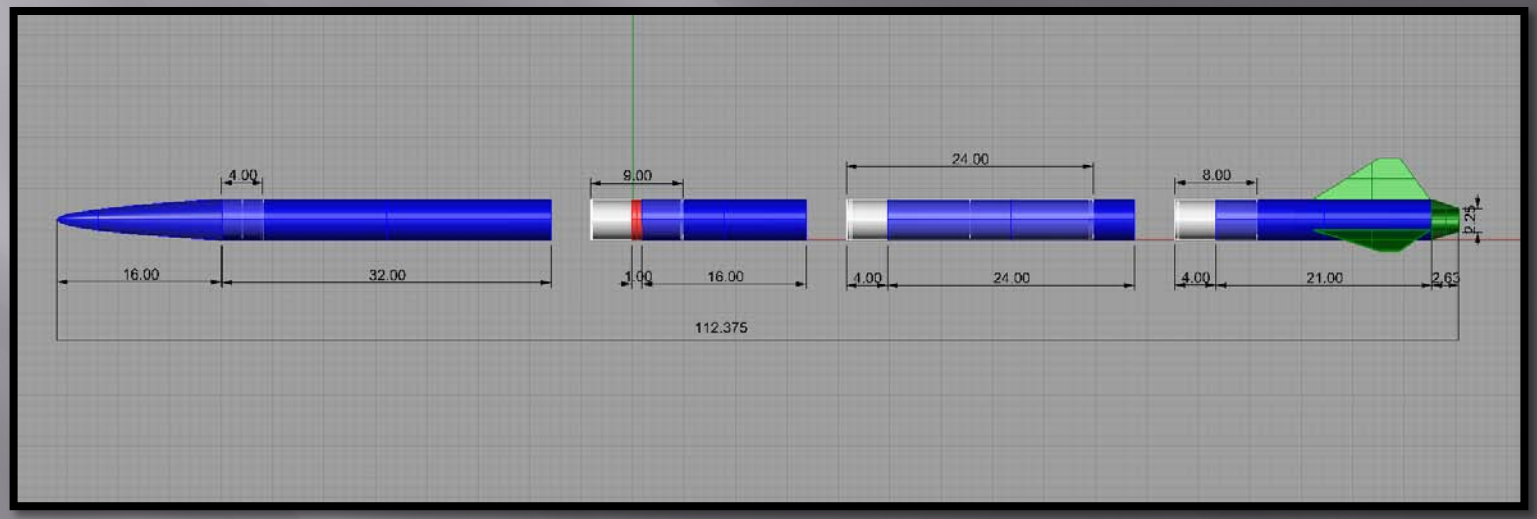
Team Skywalkers

Preliminary Design Review



Vehicle 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		



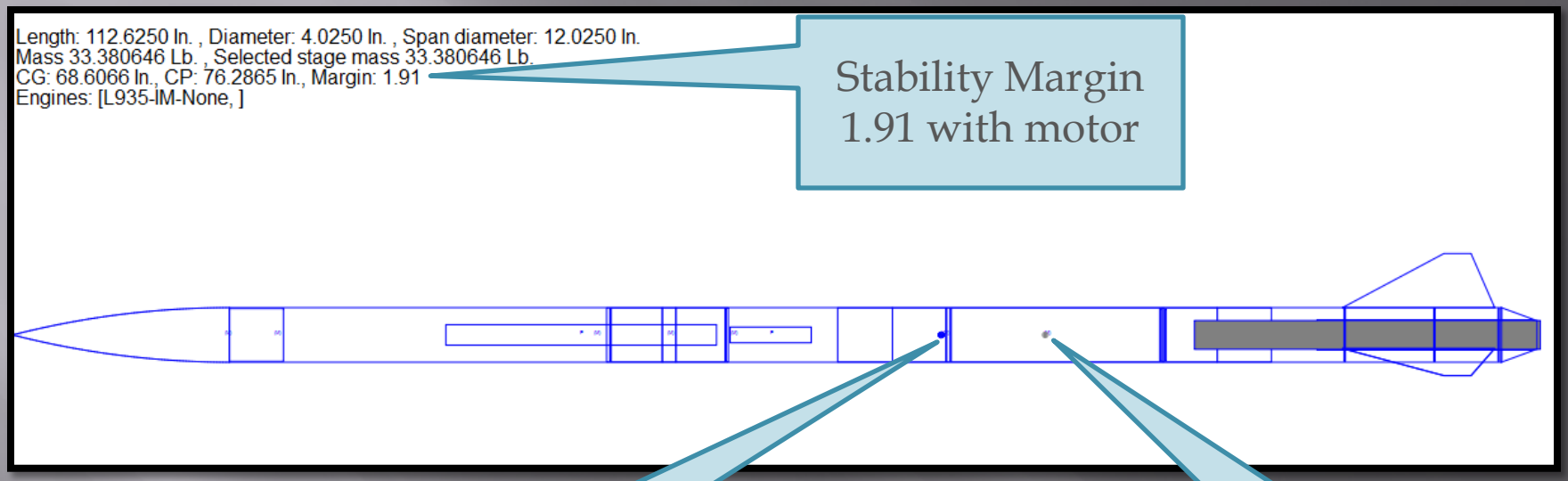
Materials

- The entire rocket is fiberglass, G10
- 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.

Design Justification

- We have to deal with a very wet recovery area.
- Dictated a water resistant rocket.
- Examined fiberglass, blue tube, and carbon fiber.
- Fiberglass had the best qualities and was reasonably priced.

Static Stability Margin



Stability Margin
1.91 with motor

Center of Gravity
68.61

Center of Pressure
76.23

Stability Margin = (CP-CG)/Diameter

Vehicle Safety Verification & Testing Plan

Safety Officer – Justin is responsible for ensuring that all safety procedures, regulations, and risk assessments are followed.

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.

Safety Rules and Regulations
Potential Failure Modes and Mitigation

Motor Selection & Justification

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
Competition	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
Low Level Test	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
SubScale	AT G80	137	30.799	78.0	17.535	108.00	24.279	2.75	11.200	6.376	8.829	1928	Single	67.27

- Motor has enough thrust to get the rocket safely off the launch rail.
- Motor has enough thrust to achieve the predicted altitude.

Thrust-to-Weight Ratio

Thrust to Weight Ratio = Pounds of Thrust/Weight of Skybolt

Motor	Total Impulse		Average Thrust		Maximum Thrust		Loaded Weight (lbs)	Ratio			RocSim Altitude	Lift Off (fps)
	N	lbs	N	lbs	N	lbs		Total Impulse	Avg. Thrust	Max Thrust		
CTI L935	3147	707.474	933.8	209.927	1585.60	356.457	33.38	21.195	6.289	10.679	5554	55.11

Rail Exit Velocity
55.11 fps

Launch Vehicle Verification

- Ground Tests
- Simulation Examinations
- Visual Inspections
- NAR Mentor Inspections
- Test Flights
- Data Analysis

Test Plan Overview

- Black Powder Ground Tests
- Avionics Inspection and Tests
- Visual Inspections
- NAR Mentor Inspections
- Scheduled Test Flights
- Data Analysis

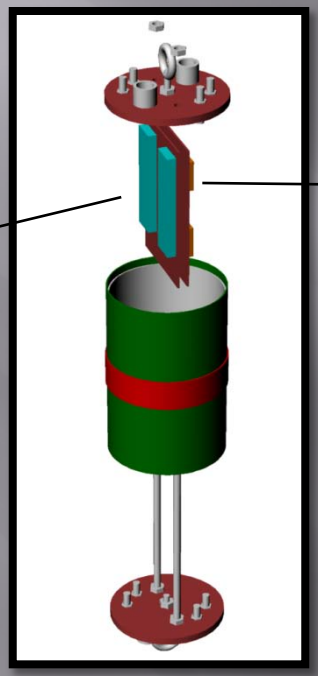
Component Discussion

- Airframe
- Ebay
- Power Management System
- Fin Can
- Recovery System

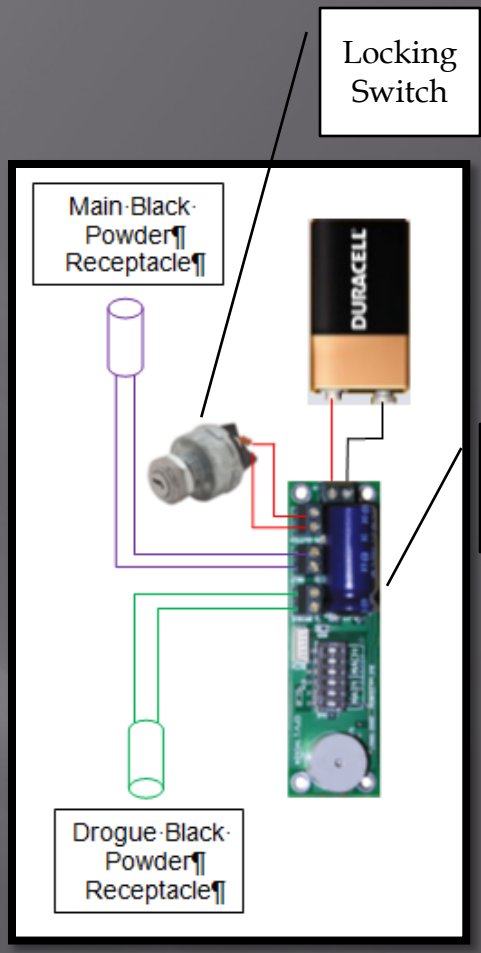
Airframe

- Constructed of G10 Fiberglass
- Permanent Joints Connected with West Systems Epoxy
- Temporary Connections Fastened with 10-54 T-nuts and Screws
- Ebay Fastened with #2-56 Nylon Machine Screws

Ebay

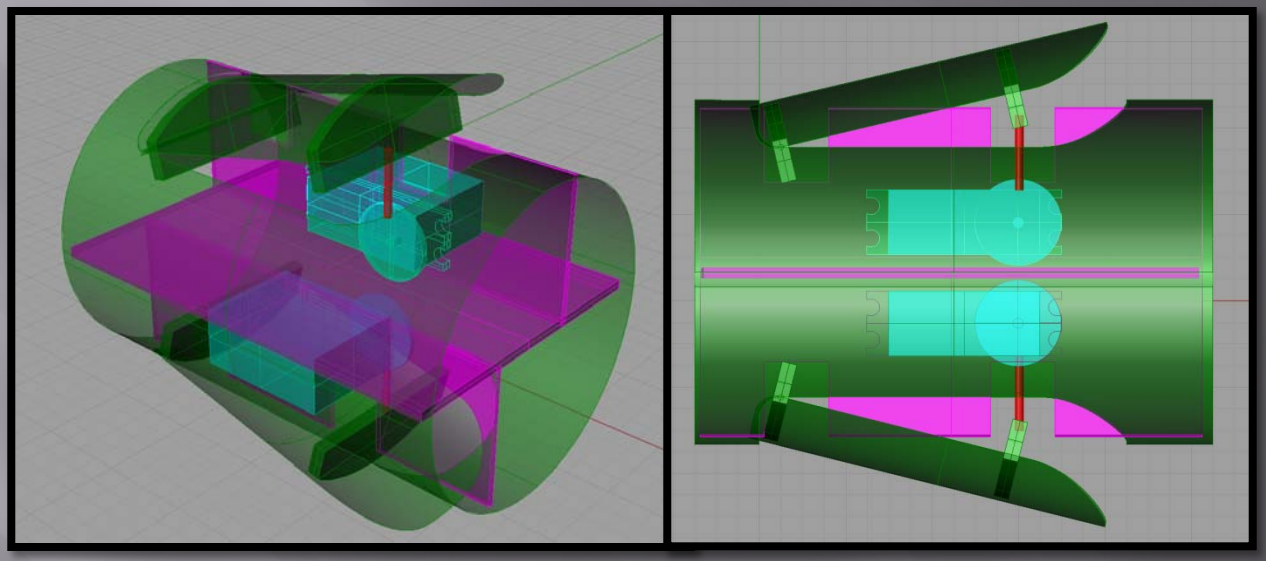


Ebay Concept



½ of the redundant dual deployment avionics system

Power Management System



Power Management System Concept with Arduino Controlled Hi Torque Servo Controlled Velocity Reduction System

Trajectory Numerical Simulation Program

Rocket	USLI		Chute diam	Dc	2					
Rckt Mass (empty)	Mr	10.99	Time Incr	dt	0.1					
Eng. Case mass	Me	0.772	Mass Decr (propellant burned)	dm	0.31897019	Avg. Thrust				
Propellant mass	Mp	1.177	Grav. Const	gc	9.8	650.59				
Diameter, rocket	Dr	0.10244	Area, (widest part)	A	0.008241932					
Impulse, motor(N-sec)	Im	2437	Chute area	A_2	3.141592654	True Impulse				
Thrust (Newtons)	Ta	659	Burn Time	tb	3.69	2400.66				
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	

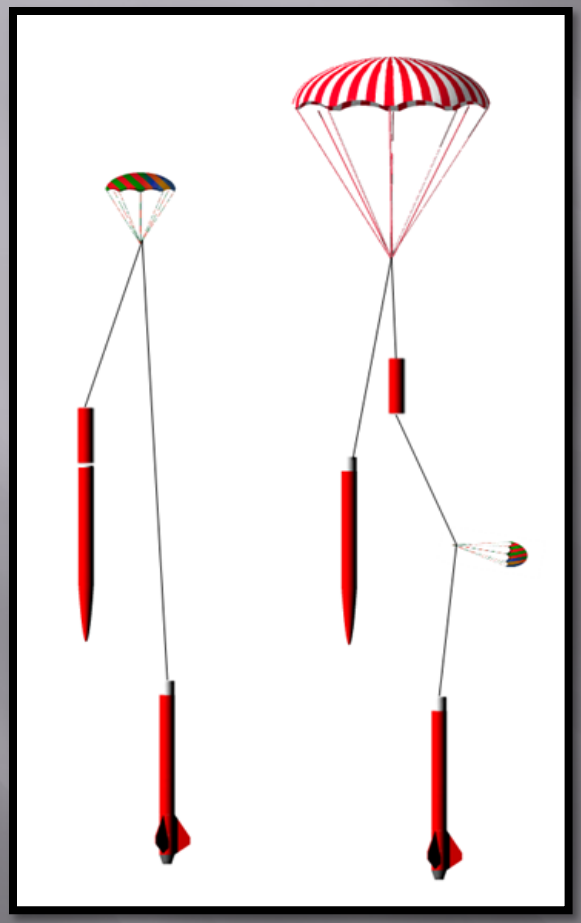
Flight Time	Drag Force	Thrust	Net Force	Mass	Acceleration	Velocity (m/s)	Altitude (m)	Rocket Area		Air Density
t	Fd	Ft	F	M	Acc	V	Y	Area	mph	rho
0.0	0.00	0.00	-126.80	12.94	0.00	0.00	0.00	0.01	0.00	1.22
0.1	0.00	1065.32	938.83	12.91	72.74	7.27	1.09	0.01	16.27	1.22
0.2	0.19	1020.05	893.69	12.88	69.41	14.21	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

Sample data with CTI K660 motor

Fin-to-Fin Can Construction

- Through-the-Wall Construction
- Fiberglass reinforcement
- Aero Pack Tail Cone and Motor Retainer

Recovery System



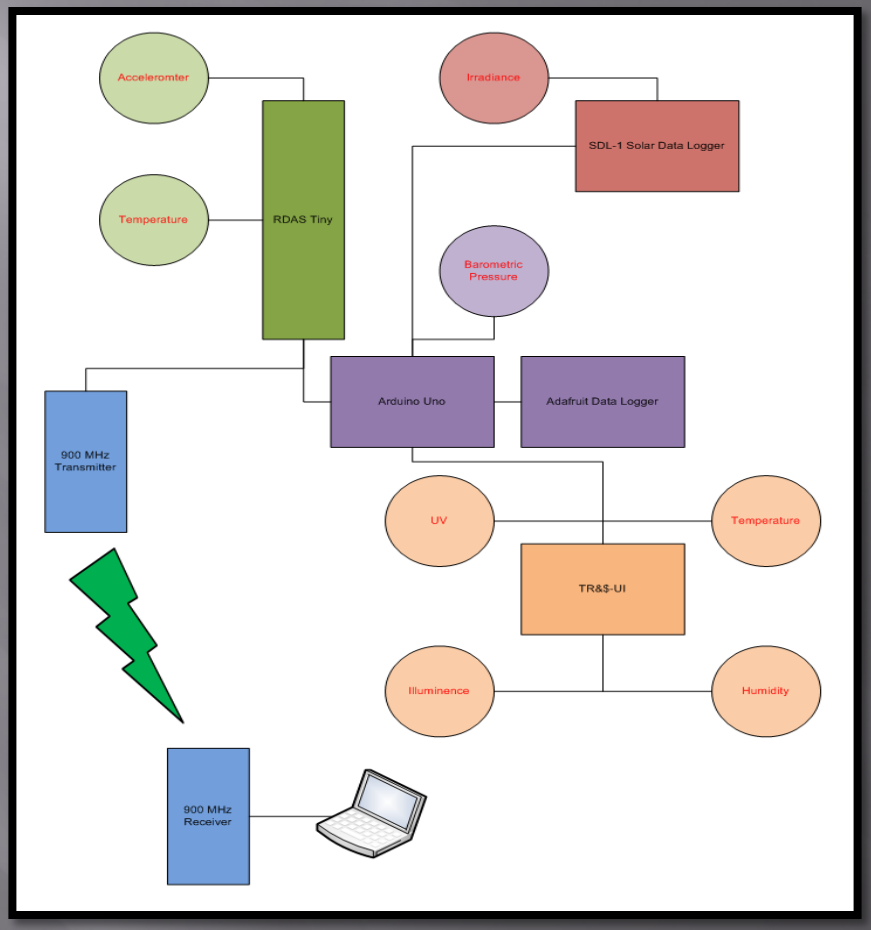
- Recovery harnesses - 9/16’ tubular nylon.
- Drogue harness - 30 feet long.
- Main harness - 20 feet long.
- Each harness end is connected to a 3/8” closed eyebolt with quicklinks.

Recovery System Properties

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	

Science Payload



Preliminary Instrumentation Block Diagram

Payload Subsystems

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	

Payload Verification

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

Payload Test Plan

- Test each component as it's built
- Gather baseline data for each component
- Integrate one component at a time and verify it's functioning satisfactorily
- Ground test entire system
- Flight test payload