NASA Student Launch Initiative 2007-2008

Washington County (Wisconsin) 4-H Rocketry

Student Launch Initiative

Preliminary Design Review

November 28, 2007

Electrical Power Generation
from a Rocket Powered Wind Turbine
and Permanent Magnet Generator

Washington County 4-H Rocket Club
814 Century Ct.
Slinger, WI 53086

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1 Summary of PDR Report

1.1 Team Summary

Name:	Washington County 4-H Rocketry Club
Location:	Slinger, Wisconsin
Members:	Cameron Schulz, Katlin Wagner, Ben Pedrick, Brady Troeller
Mentors:	Doug Pedrick, Pat Wagner, Jim Decker, Ed Kreul

1.2 Launch Vehicle Summary

The launch vehicle specifications are as follows:

Airframe:	Fiberglass
Diameter:	4.0 inches
Length:	82 inches
Weight:	18.5 lbs
Motor Choice:	Animal Motor Works – 54mm, K650RR
Recovery System:	Redundant dual event altimeters that will deploy an 18” drogue at apogee and 60” main parachute at 500 feet

The team’s goal is to design and construct a reusable rocket that will travel to a distance of one mile in altitude. The rocket will be stable enough to safely carry a four-pound payload in the nosecone.

1.3 Payload Summary

The payload will generate electrical power by harnessing the wind energy created by the mass of oncoming air pushing against the airframe during ascent.

2 Changes Made Since Proposal

2.1 Vehicle

The original proposal included a vehicle design similar to the current design. It remains approximately 8 feet long and 4 inches in diameter. However, instead of a scratch-build rocket, the team has decided to use a proven rocket design - the Mad Dog rocket kit from Performance Rocketry – as the core rocket. The motor manufacturer and size has also changed from a J210 Cesaroni to a K650RR from Animal Motor Works.

To accommodate the payload being moved to the front of the rocket (see section 2.2), the nosecone is cut off at the three-inch diameter mark. Several of the electronics components are still being reconsidered. An Olsen Electronics altimeter is no longer available for purchase and thus an Ozark Aerospace ARTS2 altimeter will be used in its place.

2.2 Payload

The original payload design had the turbines coming out of the side of the airframe just above the motor mount. The generator shaft was perpendicular to the airframe, requiring a vertical fan blade assembly. Vertical fan blade assemblies are not as efficient as horizontal ones since for half of their rotation they have to fight against the direction of the airflow. In order to try to balance the drag, two turbine blade assemblies and two generators were required.

Now the payload is inside a cut off nose cone and the shaft is mounted parallel with the airframe, with the turbine fan mounted horizontally. This change was done for several reasons: a) only one generator/turbine assembly is needed, reducing the payload weight considerably, b) the additional drag caused by the turbine fans is evenly distributed on the airframe, rather than offset, c) a horizontal wind turbine orientation is more efficient.

A commercial generator will most likely be used, where as a custom generator was being considered previously. These changes have also forced a modification to the vehicle. Now the air exiting the turbine will have to either be externally ducted out of the nose cone or lower down on the airframe.

2.3 Activity/Outreach

Initially, our outreach plan included rocket education through both a 4-H Cloverbud meeting of 1st – 3rd grade students, as well as a workshop at Peace Lutheran Elementary School for 4th graders.

The 4-H Cloverbud meeting is scheduled for Saturday, December 15, 2007 with approximately 40 – 50 kids tentatively in attendance. In addition, we are partnering with 2 other University of Wisconsin – County Extensions to conduct a Tri-County 4-H Science, Engineering and Technology (SET) workshop on Saturday January 26th in

Sheboygan, Wisconsin for about 20 youth leaders. The team is no longer planning to do a workshop at Peace Lutheran Elementary School.

2.4 Other

The team successfully found a high-power rocketry mentor, Ed Kreul. Ed is Tripoli and NAR Level 3 Certified and brings a great deal of experience and enthusiasm to the team.

3 Vehicle Criteria

3.1 Selection, Design, and Verification of Launch Vehicle

3.1.1 Mission Statement

The Washington Co. Wisconsin 4-H SLI Team will design, build, and launch a rocket that generates electrical power by harnessing the wind moving against the accelerating airframe.

3.1.2 Vehicle Requirements and Mission Success Criteria

- The vehicle shall fly to 5,280 feet in altitude.
- The vehicle shall be in a reusable state when it returns.
- The vehicle shall produce a recognizable amount of electricity.
- The vehicle shall be able to handle the forces put upon it not only from acceleration and other aerodynamic forces, but also from the stress put on the vehicle from the payload.

3.1.3 Milestone Schedule

4-H SLI Project
Project Start Date: Wed 8/15/07
Project Finish Date: Fri 5/23/08

Project Milestones

Name	Finish Date
Washington County 4H SLI Project	Fri 5/23/08
RFP (Request for Proposal)	Fri 9/28/07
Submit RFP to NASA	Fri 9/28/07
PDR (Preliminary Design Review)	Wed 11/28/07
Vehicle design	Sat 11/24/07
Review design with team	Sat 11/24/07
PDR due to NASA	Wed 11/28/07
Half Scale Rocket	Sun 1/20/08
Launch half-scale	Sat 1/12/08
Backup launch date	Sat 1/19/08
Full Scale Rocket	Sun 2/24/08
Ground Testing	Sat 2/23/08

Vehicle / Payload integration	Sat 2/23/08
Launch full-scale	Sat 2/23/08
CDR (Critical Design Review)	Mon 1/28/08
CDR due to NASA	Tue 1/22/08
CDR presentation to NASA	Mon 1/28/08
FRR (Flight Readiness Review)	Mon 3/31/08
FRR Due to NASA	Mon 3/24/08
FRR Teleconference w/ NASA	Mon 3/31/08
PLAR (Post launch analysis review)	Fri 5/23/08
PLAR Due to NASA	Fri 5/23/08

3.1.4 Vehicle Design

The vehicle design has gone through much iteration. The first design was to construct a rocket with a four-inch diameter tube that would have two turbines mounted to the exterior of the rocket. The team decided against this because with such a narrow tube the commercially available generators being considered would not fit side-by-side inside the payload section. The next design moved to a six-inch diameter tube so two generators could be mounted on the inside of the rocket. Each generator was over 3 pounds. This design was scratched because it would be very difficult to get a rocket of that diameter and mass to the 1 mile target altitude using only a K motor.

The current vehicle design is to modify a proven rocket from Performance Rocketry – the Mad Dog Dual Deployment. The Mad Dog was chosen for several reasons: It is an established airframe with proven launch stability. Performance Rocketry also makes a smaller cousin – the Little Dog that has similar characteristics that will be used for the half-scale simulation. Because of the current payload design, the nosecone will be cut off at a diameter of three-inches so that a turbine can be mounted inside of the nosecone (section 4.1).

The Mad Dog has a four-inch diameter tube that is constructed of fiberglass tubing. Fiberglass was chosen because it can withstand the flight stress the rocket will under go. One drawback is the weight of fiberglass; it is very heavy. A 4-inch fiberglass tube weighs nearly a pound per linear foot. The rocket is currently designed to have three sections. The top section, the nosecone, is where the payload will be located. The sustainer section is where the main parachute will be housed. The booster section is where the drogue and the motor will be. The current estimated weight for the vehicle and payload is about 18 pounds. Figure 1 depicts the Rocksim view of the rocket as currently designed.

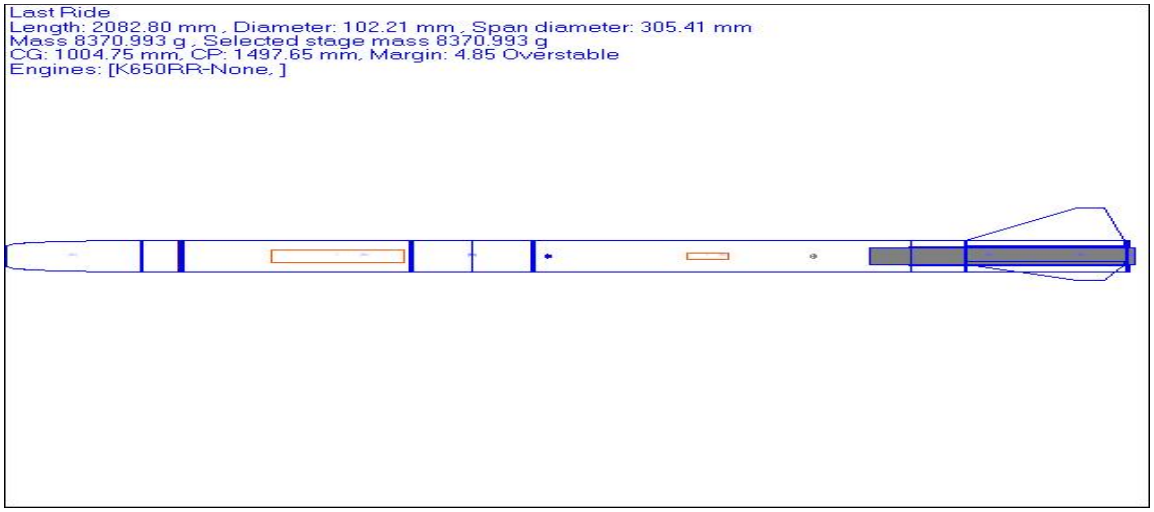


Figure 1

Figure 2 is a frontal view of the rocket showing the turbine.

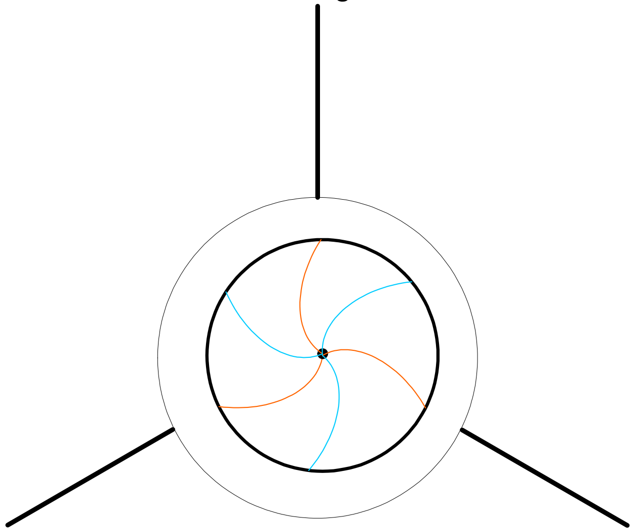


Figure 2

The altimeters are a RRC2 Mini from Missile Works and an ARTS2 from Ozark Aerospace. The ARTS2 was chosen because it measures instantaneous velocity at a rate up to 200Hz. Velocity data must be collected in order to calculate the actual power efficiency of the generator system versus predicted efficiency. Location tracking will be done with a transmitter and receiver from Adept Rocketry.

Current simulations indicate that a K650RR motor from Animal Motor Works will achieve the target altitude. The coefficient of drag predicted by RockSim will most likely be different than the actual drag due to the difficulty in modeling the turbine. This could negatively impact our altitude. Half-scale and full-scale test flights will help us better determine the best motor size. The best kind of testing we can do is actual flight-testing rather than depending upon RockSim simulations.

3.1.5 Vehicle Subsystems

Propulsion

The engine is a re-loadable K650RR from Animal Motor Works. This is a 54mm motor with a total impulse of 1840 N and a burn time of 2.7 seconds.

Recovery

Top Flight Recovery has donated the recovery system. We currently plan on using an 18-inch drogue made of rip-stop nylon. The main parachute is 60 inches and is made of rip-stop nylon. The parachutes will be harnessed into the airframe of the rocket. We will no longer be using pistons but instead we will use a Kevlar shield.

The rocket will have dual altimeters on board for redundancy. As mentioned, these will be an ARTS2 manufactured by Ozark Aerospace and an RRC2 mini manufactured by Missile Works.

Tracking

The tracking device used is the T400AM from Adept Rocketry.

3.1.6 Verification plan

To test the design of the rocket we will be conducting a half-scale launch. This will help validate rocket design and stability. A wind tunnel test will be conducted to test and validate the payload design. To test the recovery system an ejection charge test will be conducted with our level 3 certified mentor to ensure the proper amount of black powder is used to eject the parachutes safely.

3.1.7 Project Risks

Item / Function	Potential Risk(s)	Severity	Potential Cause(s)/ Mechanism(s) of Risk	Probability	Risk Priority	Recommended Action(s)
Half-scale rocket	½ scale not built on time	10	Unavailability of parts	1	**10**	Order early; Make our own
			Personal schedules don't allow time to complete			Start early; plan ahead; limit outside activities; recruit more people to the team
		3	Wind tunnel not available for testing	3	**9**	Make our own wind tunnel with leaf blower

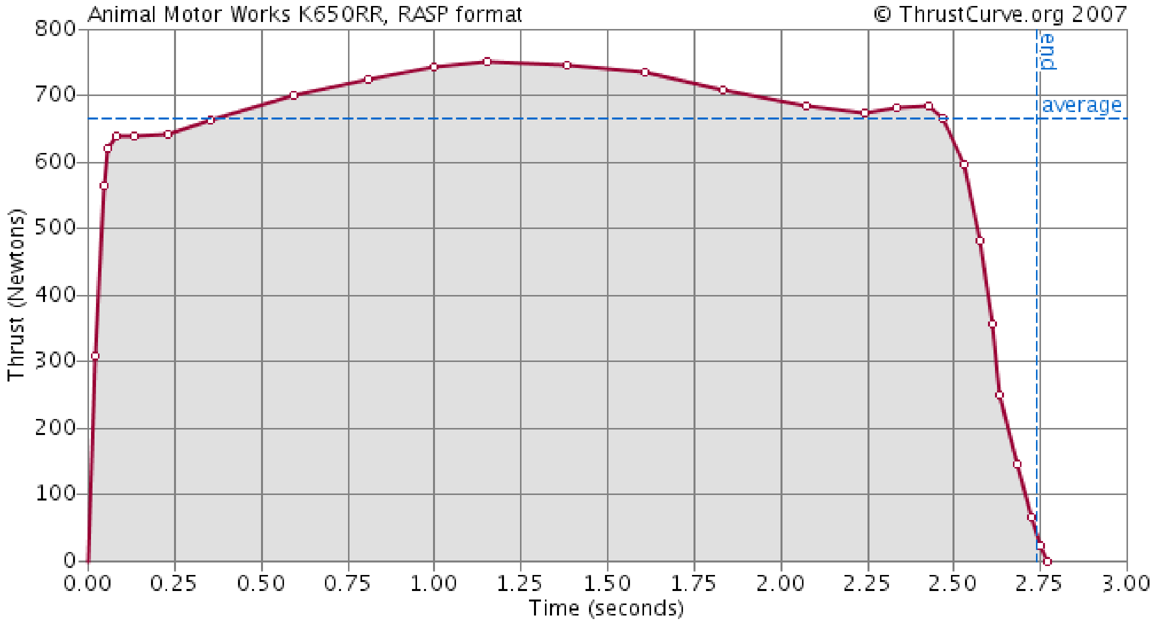
		7	High-powered site not available on/near dates needed	4	**28**	Multiple launch sites identified.
		7	Weather prohibits flight-testing.	5	**35**	Identify multiple launch dates; complete half-scale early
Full-scale rocket	Full scale not built on time	10	Unavailability of parts	1	**10**	Order early; Make our own
			Personal schedules don't allow time to complete			Start early; plan ahead; limit outside activities; recruit more people to the team
		3	Wind tunnel not available for testing	3	**9**	Make our own wind tunnel with leaf blower
		7	High-powered site not available on/near dates needed	4	**28**	Multiple launch sites identified. Bong, WI, Princeton, IL, Walcott, IA, Metamora, IL
		7	Weather prohibits flight-testing.	5	**35**	Identify multiple launch dates; complete half-scale early
Science Experiment		7	Inability to determine expected generator RPM for any given airspeed.	8	**56**	Measure wind-speed to RPM in wind tunnel.
		7	Number, size, and shape of turbine blades cannot be determined easily.	8	**56**	Prototype multiple types and numbers of blades; test in wind-tunnel
		9	Inability to create an adequate circuit design.	6	**54**	Start early; test; engineer for worst-case power generation
		10	Unavailability of parts	1	**10**	Make our own; reconsider design
		10	Cannot buy commercial available turbine blades, or they are cost prohibitive.	2	**20**	Redesign with consideration of blade procurement
		7	Circuit design does not measure power generated	4	**28**	Build and test circuit prior to launch. Simulate by turning generator with drill or via compressed air or leaf blower

3.1.8 Construction Plan

According to our current project plan, construction on the half scale of the rocket will begin on December 18, 2007. The half scale will be a modified Little Dog from Performance Rocketry. The full-scale rocket construction will begin on January 21, 2008. The construction will be done in Brady Troeller's father's garage and Doug Pedrick's basement. We will use the expertise of our level 3 mentor Ed Kreul for assistance in the building process of the high-powered rocket and all of its subsystems.

3.1.9 Mission Performance

The current motor is the K650RR from Animal Motor Works. The thrust curve for this motor is shown in Figure 3. The velocity of this motor will greatly affect the payload as velocity helps determine how fast the turbine is rotating. The power generated by a wind turbine is proportional to the cube of the velocity of the air.



3.2 Payload Integration

The generator will fit vertically into the nosecone, sliding in from the back. Due to the nature of the payload experiment, the rocket will need to be able to support the torque created by the rapidly spinning turbine blades and the extra weight of the induction generator. The turbine blades will need to be placed in the cut-off diameter of the nosecone. The vehicle must also allow for the ducting of the airflow once it exits the turbine blade assembly.

3.3 Launch Operation Procedures

3.3.1 Launch system and platform

- Launch system is an electrically controlled and safed system and is supplied by the hosting club or organization.
- The launch pads are heavy duty pads designed for the weight of the rocket and will have a standard rail (10/10 rail size) utilizing stand rail buttons (.25 inch diameter) on the rocket.

3.4 Safety and Environment

3.4.1 Safety Officer

Our team safety officer is Katlin Wagner.

3.4.2 Failure Mode and Effects Analysis (FMEA) of Vehicle

Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	Severity	Potential Cause(s)/ Mechanism(s) of Failure	Probability	Risk Priority	Recommended Action(s)
Recovery		Rocket destroyed on impact.	10	Ejection blow by	1	**10**	Use the right size Kevlar shroud; pack parachute correctly.
		Rocket destroyed on impact.	10	Ematch doesn't lite	3	**30**	Use redundant e-match.
		Rocket destroyed on impact.	10	Not enough black powder	3	**30**	Static ground test amount.
	Parachute or shock cords tear.	High-speed descent.	10	Too much black powder	3	**30**	Static ground test amount.
	Parachute does not fully deploy.	High-speed descent.	10	Shroud lines tangle	2	**20**	Pack parachute correctly.
		Uncontrolled descent.	10	Shock cord snaps	2	**20**	Use proper size cord. Ensure deployment at a lower velocity.
	Drogue, but not main deploys	High-speed descent.	8	Main ejection powder does not light.	2	**16**	Use redundant e-match and redundant event altimeters.
	Main, but not drogue deploys	Main deploys at high speed, potentially overstressing shock cord.	7	Drogue ejection powder does not light.	2	**14**	Use redundant e-match and redundant event altimeters.
	Parachute rips	High-speed descent.	8	Shroud lines not attached well.	2	**16**	Use high-quality, commercial parachute.
		Payload data is non-recoverable	10	Impact with ground dislodges electrical components, losing data.	3	**30**	Use non-volatile memory.
	Altimeter prematurely fires ejection charge.	Experiment is unsuccessful	10	Turbulent air from experiment turbine outflow over static ports causes mis-calculation of altitude by altimeter	5	**50**	Use event timer instead of barometric pressure based altimeter.
Propulsion	CATO	Rocket does not reach desired altitude.	10	Faulty motor.	1	**10**	

	Reloadable motor failure.	Rocket does not reach desired altitude.	10	Motor assembled/loaded incorrectly.	2	**20**	Follow instructions; have more than one person overseeing loading; use single-use motor.
Vehicle	Zippering	Uncontrolled descent.	7	Weak airframe	2	**14**	Use fiberglass airframe.
	Fins break on launch	Unstable flight.	10	Fins too weak; incorrectly installed	2	**20**	Use fiberglass fins; use through-the-wall mount; use strong epoxy
	Weathercocking	Lower than expected altitude, resulting in not as much electricity being generated.	6	Overstability	4	**24**	Design to bring stability margin down to below 2. Use a higher initial thrust motor.
	Motor mount failure	Motor travels up through airframe	10	Improper construction and/or materials.	3	**30**	Use experience from mentor; use strong epoxy; use heavy-duty centering rings

3.5 Listing of personnel hazards

Personnel hazards are possible during both construction and flight.

During construction, some materials being used may pose a safety risk to team members during their use. These materials may include: epoxy, fiberglass dust, black powder, and handling of the rocket engines. Extreme caution must be used in tandem with these hazardous materials because of the effects they may have on the team members. Power tools will also be used to manufacture / modify the parts needed to integrate the payload and vehicle assemblies. Proper safety briefings, usage instructions, use of proper safety equipment and mentor supervision will be executed during all team involvement of the construction.

Flight hazards are also large consideration with a project of this size. Engine failure, recovery device failure, and rocket flight are of the biggest concern. Following proper high-powered safety distances will help prevent injury in the event of a motor catastrophe, calculating proper ejection charges pre-flight recovery tests, using redundant altimeters and following specific pre-flight assembly tasks will reduce the risk of flight failure. Proper design simulations under various flight conditions will help ensure the team has the most sound rocket design being placed on the pad at launch time.

3.6 Environmental Concerns

The team has the potential of using a several different launch sites in the southeast Wisconsin / Northern Illinois area. These launch sites are multi-use recreational sites used by different groups and organizations. We will be following all site restrictions posted as well as making sure there is proper safety equipment available.

The payload poses little risk to the environment. There is a potential that on board batteries and equipment may fail and expose toxic material to the environment. The team will properly dispose of and clean up any material that may come in contact with the environment.

In additional, the team will consult with sponsoring clubs to ensure fire hazards risks are minimized and proper fire equipment is on hand at all launches.

3.7 Launch Operations

These operations are a work in progress. Additional work is required here.

1. Determine flight conditions (temperature, wind, barometric pressure, etc.)
2. Prepare the rocket for flight
    a. Recovery System (parachutes, altimeters, black powder charges, ematches)
    b. Motor (load engine, igniter), validate engine is secured
    c. Payload (load payload, secure payload, validate electronics are working)
3. Set rocket on launch pad
4. Clear the launch area in case of pre-mature ignition of ematches
5. Arm the electronics
6. Arm the igniter
7. Second call to clear the launch area
8. Countdown to launch
9. Launch Rocket
10. Locate rocket with tracking device
11. Safely retrieve rocket
12. Make sure rocket is safe before retrieving altimeter telemetry and payload telemetry
13. Perform download of telemetry data for study and validation.

4 Payload Criteria

4.1 Selection, Design, and Verification of Payload Experiment

4.1.1 Payload System

In our circuit we need to have a device that can measure and store a time series record of the shaft RPMs, volts, amps, and watts output from the generator. We have looked into three data recorders that can possibly meet our requirements. After PDR we will further investigate and decide by CDR which device we will have in our payload. It is also possible that flight data recorders will be put into the half-scale test launches as well.

Flight Computers/ Data Recorders	*Pros*	*Cons*
R-DAS	▪ Available Memory ▪ Analog inputs for input of experiment data ▪ Dual Deployment	▪ Does not inherently measure amps, volts, or watts ▪ Expensive
Watt's Up Meter	▪ Small form factor ▪ 0.01v, 0.01a, 0.1W resolution ▪ Has auxiliary power source	▪ Memory is volatile
Eagle Tree Systems eLogger V3	▪ LCD output ▪ USB interface ▪ Measures amps, volts, and watts. ▪ Optional GPS, flight speed, altitude, and RPM measurement ▪ Doesn't lose memory if the power is lost ▪ Lightweight (20g)	▪ Doesn't have deployment capabilities ▪ 10Hz sampling ▪ Unknown power consumption ▪ Unknown resolution and accuracy ▪ Not yet shipping

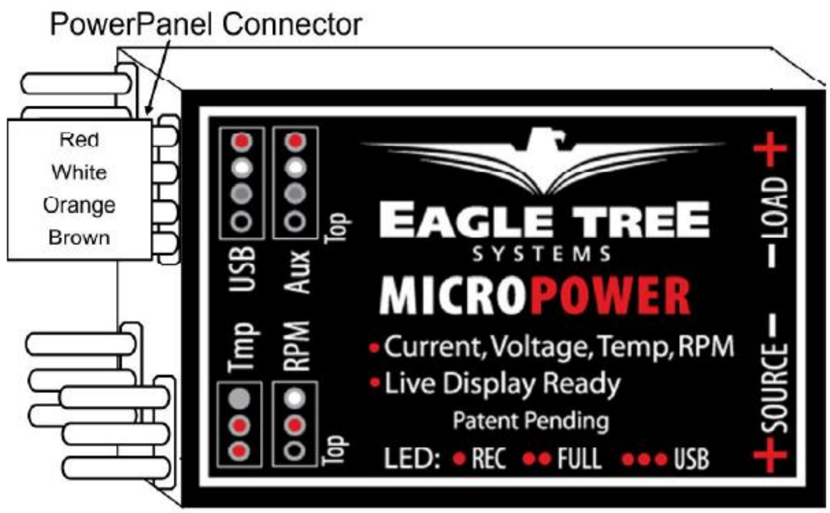


Figure 3. Eagle Tree eLogger V3

We are still deciding on whether to use a permanent magnet DC generator or use a motor used in RC airplanes as our DC generator.

4.1.2 Subsystem Details

Fan Blades

The blades will be placed in the tip of the nose cone to scoop the moving air. The energy from the air is used to spin the shaft that drives the generator. Currently we are looking at using a ducted fan assembly from an electric R/C airplane. R/C fan blades are rated for number of RPMs. We are figuring out how many RPMs our generator can handle so we can match the right turbine blades with it.

Assuming that the rocket reaches a maximum velocity of 800 fps, 2500 cfm (3 in. diameter blade) of air will go through the assembly. The fan will need to be able to handle the angular velocity and the friction created by moving air.

Generator

The generator will be placed strategically below the fan blades within the nosecone. It will be directly connected to the rotating shaft. The generator we plan on using will be commercially made, as they are of the best efficiency and are already proven to work.

The generator will only be able to handle a maximum number of rpm so we will make sure that the speed that the fan spins at is below the maximum rated speed of the generator.

Circuit Components

In the circuit we will include multiple electronics to record and store the electricity the generator produces. In the bay we will have a dead battery that will act as a load on the circuit and store the generated electricity. The other main component is the electric data collector. We are considering using an eLogger V3 to obtain data. It can record up to +/- 100 amps, 4.5 – 100 volts, shaft RPM and has GPS capabilities.

A design concern is limiting – or measuring – the amount of generated current used by the data logger to carry out its operations. Unfortunately, the eLogger V3 does not have an auxiliary power source. The circuit will also need to be able to handle more than the maximum power output of the generator so that it does not burn-up in mid-flight.

Nosecone

The nose cone will house the majority if not the entire payload. It is going to be made of fiberglass for the best structurally sound design.

The tip of the nose cone will be cut off so we can fit the fan blades inside it.

Ducting

The ducts will direct the air to the outside of the rocket so we don't have air pooling in from the fan. It will let more air move through the fan. If there are no vents then the air cannon properly go through the fan and it will create unwanted drag, not to mention make the generator less efficient.

The ducts will come out beneath the nosecone. They will probably be made of plastic tubing or smaller body tubes.

4.1.3 Verification plan and status

We will test the payload as a whole entity. Based on our resources, we can test the system by using one or more of the following: We could use a wind tunnel on our full-scale rocket at Marquette University or UW-Madison. Another option is to use a leaf blower right in front of the nosecone so all the air moves into the fan. Our last option is to just launch the full-scale and half-scale and observe how well they work.

4.1.4 Preliminary integration plan

We will have screw mounts in the nose cone to attach the turbine blade assembly. The turbine blade screws will be accessed from the front of the nose cone. The entire payload (turbine blades, generator and circuit board assembly) will slide into the nose cone and attach to the previously mentioned mounts and to the nose cone shoulder. Right now we are unsure how we are going to vent the airflow after it passed through the turbine blades. One option is tubing carried down through a portion of the airframe. Another option is to drill duct holes in the nose cone. We will have to be careful that we don't produce any turbulent airflow over the altimeters.

4.1.5 Precision of measurement and recovery

We will measure power output by tenth of a watt precision. Post launch we will measure the amount of stored energy and compare it to the amount of energy stored before the launch.

4.2 Payload Concept Features and Definition

4.2.1 Creativity and originality

Our experiment is unique because, to our knowledge, no one has ever attempted to put this type of payload in a high-powered rocket before.

4.2.2 Uniqueness and significance

The team decided to plan a science experiment based around electricity generation. The Milwaukee Journal Sentinel recently reported that Wisconsin emits greenhouse gases at a rate that is about one-third higher than the national average. Wisconsin utilities rely heavily on coal-burning power plants, with several more currently under construction. We need to start looking seriously at renewable and alternative energy sources instead of relying primarily on fossil fuels. Renewable energy is most attractive since it is extracted from natural resources that are continuously replenished. These include wind, sunlight, tides, and geothermal heat. All of these naturally occurring types of energy can be harnessed to generate electricity. We are interested in exploring renewable energy because it will play a major role in the future of this country.

4.2.3 Suitable level of challenge

There are many unknowns in this experiment: size of turbines, how fast the turbines are going to spin, how big of a generator to use, how different thrust curves affect payload performance. It may not even be possible to generate electricity of any consequence.

4.3 Science Value

4.3.1 Science payload objectives

There are several objectives of the payload:

- Demonstrate that it is possible to generate measurable electrical power
- Compare the predicted and actual power generated
- Compute the efficiency of our wind turbine system using the equation found in section 4.3.4. This will give the percentage of the total energy in the wind that was harnessed by our payload.

4.3.2 Payload success criteria

The payload will be considered a success if it generates enough electricity to be measurable, and if it comes close to generating the amount of energy we predict it will.

4.3.3 Experimental logic, approach and method

Our experiment depends on many different variables that will effect how efficient, or how much electricity the generator will produce. Outlined below are some of the major variable that affect the payload.

Independent variables	*Dependent variables*
Motor size and thrust characteristics (in turn affects velocity of the airflow into the turbine)	**RPM of fan blades (dependent upon rocket velocity)**
Coefficient of Drag of the vehicle	**Air density**
	Power generated
	Power efficiency of the generator

4.3.4 Measurement

The on-board altimeters will measure velocity of the rocket, from which the airflow velocity can be inferred. They will also sample the density of the air at various altitudes. Our custom circuitry will measure the instantaneous power output of the generator. Using equation 1, we will be able to compute the power efficiency of our system.

Effective Power = Cp * 0.5 * Swept Area * Air Density * Velocity^3 (Eq. 1)

Where Cp is the power efficiency. See our proposal for full explanation and derivation of this equation.

4.4 Safety and Environment

4.4.1 Safety Officer

Our team safety officer is Katlin Wagner.

4.4.2 Failure Mode and Effects Analysis (FMEA) of Payload

Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	Severity	Potential Cause(s)/ Mechanism(s) of Failure	Probability	Risk Priority	Recommended Action(s)
Science Experiment	Electrical failure of the Payload	Experiment is unsuccessful	7	Faulty circuitry and/or electronics	3	**21**	Test circuit;
		Experiment is unsuccessful	7	Water incursion from humidity/rain	3	**21**	Static test with pressurized water.
		Experiment is unsuccessful	7	Dead Battery	1	**7**	Use new battery on every launch.

		Experiment is unsuccessful	7	Stress and Vibration of launch	5	**35**	Ensure all components are rigidly attached; ground shake test
	Mechanical failure of the Payload	Experiment is unsuccessful	7	Turbine shaft breaks	2	**14**	Wind tunnel tests; ensure generator is rated for a higher RPM than expected.
		Experiment is unsuccessful	7	Fan blades break	3	**21**	Ensure blade assembly is rated for a higher RPM than predicted.
		Experiment is unsuccessful	7	Over-rev generator.	5	**35**	Ensure generator is rated for a higher RPM than predicted. Choose a motor that has a longer, flatter thrust curve.
		Experiment is unsuccessful	7	Blades/generator torque breaks attachment to airframe.	4	**28**	Use fiberglass nosecone and airframe tube.
		Experiment is unsuccessful	7	Bird strike on ascent.	1	**7**	Bring retriever dog to fetch bird.

4.4.3 Personnel hazards

An electrical shock hazard is present when handling the payload. Handling the on-board battery should pose no more risk than of handling any household battery. Our electrical engineer advisor, Mr. Decker, will also train us on any additional risks in the circuitry.

A wire mesh will be in front of the turbine, mitigating the hazard of a rapidly spinning blade assembly. This is especially important during static ground testing.

4.4.4 Environmental concerns

Beyond having NiMH batteries on-board, there are no other environmental concerns with our payload.

5 Project Management

5.1 Budget plan

Qty	Item Description	Manufacturer	Cost
Full Scale Rocket			
1	Full Scale Rocket	Performance Rocketry	$169
1	Centering Ring	Public Missiles	$5
1	Main Chute-60”	Top Flight Recovery	Donated
1	Drogue-16”	Top Flight Recovery	Donated
1	Coupler	Loc Precision	$4
1	Motor Retainer	Aeropack	$34
1	54mm Motor Mount	Public Missiles Ltd.	$50
2	Recovery Harness	Top Flight Recovery	Donated
Electronics			
1	RRC2 Mini Altimeter	Missile Works	$80
1	Arts2 Altimeter	Ozark Aerospace	$185
	Electric Matches, Light Bulbs, Wiring, Safety Switches	Various Sources	$50
	Black Powder / Pyrodex	TBD	$15
1	T400AM Transmitter	Adept Rocketry	$60
1	Three Element Directional Receiving Antenna	Adept Rocketry	$30
Half Scale Rocket			
1	Half Scale Rocket	Performance Rocketry	$79
1	Centering Ring	Public Missiles	$5
1	Main Chute-30”	Top Flight Recovery	Donated
1	Drogue-9”	Top Flight Recovery	Donated
1	Motor Retainer	Aeropack	$29

2	Recovery Harness	Top Flight Recovery	Donated
Propulsion			
2	Half Scale Motor	Animal Motor Works	$50
2	K650RR	Animal Motor Works	$100
Payload			
1	3" RC Ducted Fan Assembly	TBD	$65
1	1.5" RC Ducted Fan Assembly	TBD	$50
1	Circuit Components	Various	$25
	eLogger V3	Eagle Tree Systems	$110
1	DC Induction Generator (Motor)	Hobby Lobby	$120
Outreach			
50	Watchamacallit	Fliskits Inc.	$125
Miscellaneous Items			
	Website URL License		$120
	Miscellaneous Supplies		$50
High-Level Cost Estimate:			$1800

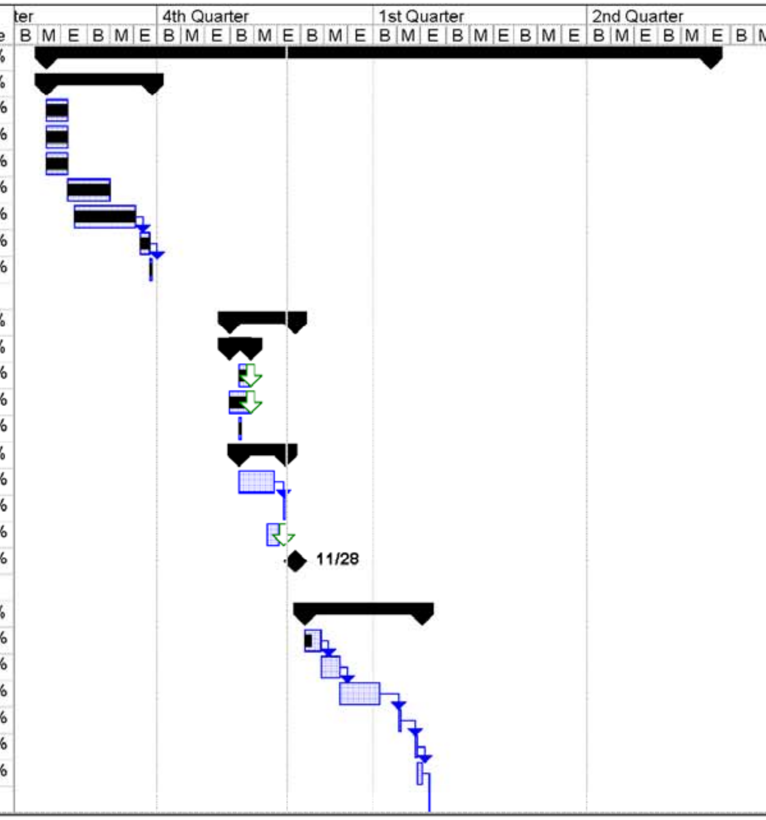
5.2 SLI Project Plan

The detailed schedule follows:

Washington County 4H
SLI Project

2007-2008

ID		Task Name	Duration	Start	Finish	% Complete
1		**Washington County 4H SLI Project**	**275 days?**	**Wed 8/15/07**	**Fri 5/23/08**	**44%**
2	✓	**RFP (Request for Proposal)**	**45 days?**	**Wed 8/15/07**	**Fri 9/28/07**	**100%**
3	✓	Initial brainstorming	9 days	Wed 8/15/07	Thu 8/23/07	100%
4	✓	Assign tasks and responsibilities	9 days	Wed 8/15/07	Thu 8/23/07	100%
5	✓	Initial payload design	9 days	Wed 8/15/07	Thu 8/23/07	100%
6	✓	Initial rocket design	18 days	Fri 8/24/07	Mon 9/10/07	100%
7	✓	Create RFP	26 days	Mon 8/27/07	Fri 9/21/07	100%
8	✓	Review RFP	4 days?	Mon 9/24/07	Thu 9/27/07	100%
9	✓	Submit RFP to NASA	1 day?	Fri 9/28/07	Fri 9/28/07	100%
10						
11		**PDR (Preliminary Design Review)**	**27 days?**	**Thu 11/1/07**	**Wed 11/28/07**	**42%**
12	✓	**Payload Design**	**9 days?**	**Thu 11/1/07**	**Fri 11/9/07**	**100%**
13	✓	Prototype generator	5 days?	Mon 11/5/07	Fri 11/9/07	100%
14	✓	Paper design of payload circuit	9 days?	Thu 11/1/07	Fri 11/9/07	100%
15	✓	Investigate off-the shelf components	1 day?	Mon 11/5/07	Mon 11/5/07	100%
16		**Vehicle design**	**19 days?**	**Mon 11/5/07**	**Sat 11/24/07**	**0%**
17		Re-work initial design	15 days	Mon 11/5/07	Mon 11/19/07	0%
18		Review design with team	1 day?	Sat 11/24/07	Sat 11/24/07	0%
19		Payload - vehicle integration	5 days?	Sat 11/17/07	Wed 11/21/07	0%
20		PDR due to NASA	0 days	Wed 11/28/07	Wed 11/28/07	0%
21						
22		**Half Scale Rocket**	**49 days?**	**Mon 12/3/07**	**Mon 1/21/08**	**8%**
23		Finalize design	7 days	Mon 12/3/07	Sun 12/9/07	40%
24		Order parts	8 days	Mon 12/10/07	Mon 12/17/07	0%
25		Construction	16 days	Tue 12/18/07	Thu 1/3/08	0%
26		Launch half-scale	1 day?	Sat 1/12/08	Sat 1/12/08	0%
27		Backup launch date	1 day?	Sat 1/19/08	Sat 1/19/08	0%
28		Validate Results	2 days	Sun 1/20/08	Mon 1/21/08	0%
29						



Project: 4-H SLI Project 1
Date: Sun 11/25/07

Task		Milestone	◆	External Tasks	
Split		Summary		External Milestone ◆	
Progress		Project Summary		Deadline ⇩	

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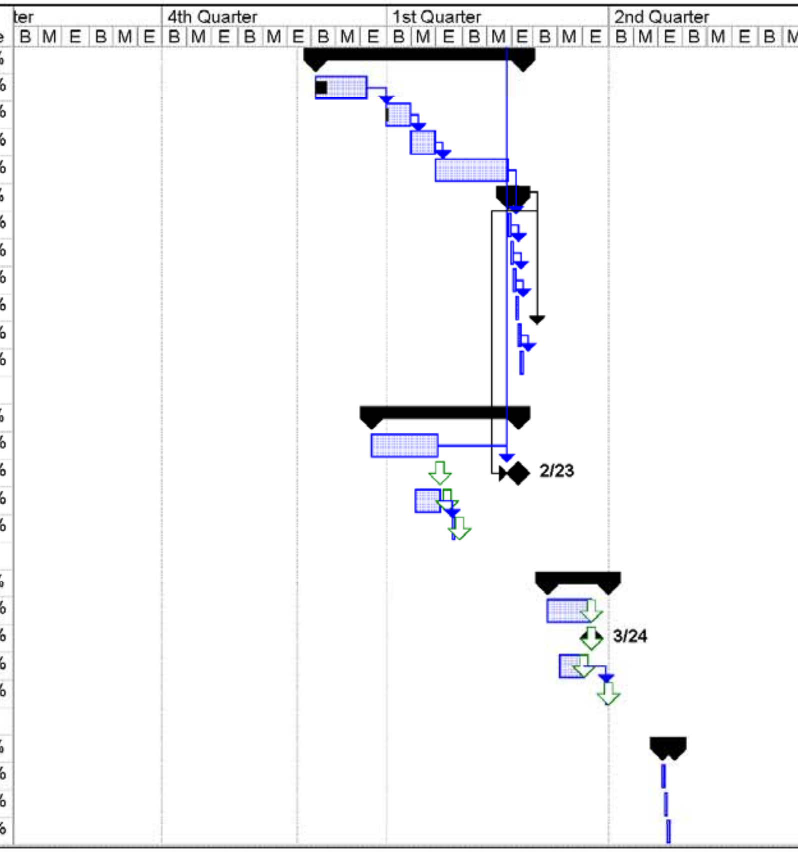
Washington County 4H
SLI Project

2007-2008

ID		Task Name	Duration	Start	Finish	% Complete
30		**Full Scale Rocket**	**84 days?**	**Mon 12/3/07**	**Mon 2/25/08**	**6%**
31		Finalize payload design	21 days?	Mon 12/3/07	Sun 12/23/07	20%
32		Finalize rocket design	10 days	Tue 1/1/08	Thu 1/10/08	3%
33		Order parts	10 days	Fri 1/11/08	Sun 1/20/08	0%
34		Construction	30 days	Mon 1/21/08	Tue 2/19/08	0%
35		**Ground Testing**	**4 days?**	**Wed 2/20/08**	**Sat 2/23/08**	**0%**
36		Payload testing (electronics)	1 day?	Wed 2/20/08	Wed 2/20/08	0%
37		Wind tunnel testing	1 day?	Thu 2/21/08	Thu 2/21/08	0%
38		Analyze results	1 day?	Fri 2/22/08	Fri 2/22/08	0%
39		Recovery subsystem testing	1 day?	Sat 2/23/08	Sat 2/23/08	0%
40		Launch full-scale	1 day?	Sun 2/24/08	Sun 2/24/08	0%
41		Analyze Results	1 day?	Mon 2/25/08	Mon 2/25/08	0%
42						
43		**CDR (Critical Design Review)**	**60 days?**	**Wed 12/26/07**	**Sat 2/23/08**	**0%**
44		Create CDR document	27 days	Wed 12/26/07	Mon 1/21/08	0%
45		CDR due to NASA	0 days	Sat 2/23/08	Sat 2/23/08	0%
46		Create CDR presentation	10 days	Sun 1/13/08	Tue 1/22/08	0%
47		CDR presentation to NASA	1 day?	Mon 1/28/08	Mon 1/28/08	0%
48						
49		**FRR (Flight Readiness Review)**	**25 days?**	**Fri 3/7/08**	**Mon 3/31/08**	**0%**
50		Create FRR document	18 days	Fri 3/7/08	Mon 3/24/08	0%
51		FRR Due to NASA	0 days	Mon 3/24/08	Mon 3/24/08	0%
52		Create FRR presentation	10 days	Wed 3/12/08	Fri 3/21/08	0%
53		FRR Teleconference w/ NASA	1 day?	Mon 3/31/08	Mon 3/31/08	0%
54						
55		**SLI in Huntsville**	**5 days?**	**Wed 4/23/08**	**Sun 4/27/08**	**0%**
56		Travel	1 day?	Wed 4/23/08	Wed 4/23/08	0%
57		Rocket fair	1 day?	Thu 4/24/08	Thu 4/24/08	0%
58		Hardware Check	1 day?	Fri 4/25/08	Fri 4/25/08	0%



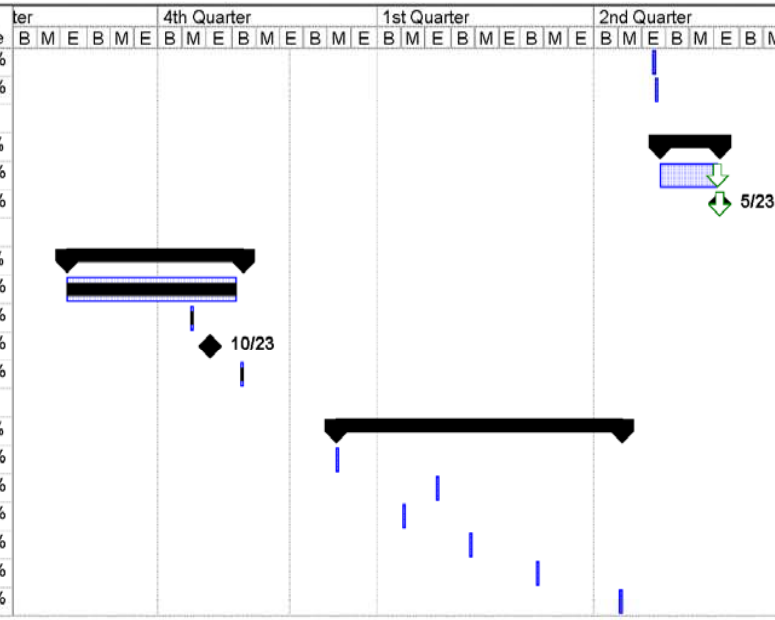
Project: 4-H SLI Project
Date: Sun 11/25/07

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

Washington County 4H
SLI Project

2007-2008

ID		Task Name	Duration	Start	Finish	% Complete
59		Launch day	1 day?	Sat 4/26/08	Sat 4/26/08	0%
60		Return home	1 day?	Sun 4/27/08	Sun 4/27/08	0%
61						
62		**PLAR (Post launch analysis review)**	**19 days**	**Tue 4/29/08**	**Fri 5/23/08**	**0%**
63		Create PLA document	18 days	Tue 4/29/08	Thu 5/22/08	0%
64		PLAR Due to NASA	0 days	Fri 5/23/08	Fri 5/23/08	0%
65						
66	✓	**Miscellaneous**	**74 days?**	**Fri 8/24/07**	**Mon 11/5/07**	**100%**
67	✓	Identify Level 2 mentor	71 days?	Fri 8/24/07	Fri 11/2/07	100%
68	✓	SLI Teams Announced	1 day?	Mon 10/15/07	Mon 10/15/07	100%
69	✓	SLI teleconference	0 days	Tue 10/23/07	Tue 10/23/07	100%
70	✓	Team website live	1 day?	Mon 11/5/07	Mon 11/5/07	100%
71						
72		**Community Outreach**	**119 days?**	**Sat 12/15/07**	**Sat 4/12/08**	**0%**
73		Cloverbuds rocket workshop	1 day?	Sat 12/15/07	Sat 12/15/07	0%
74		Tri-County SET workshop	1 day?	Sat 1/26/08	Sat 1/26/08	0%
75		January county-wide meeting	1 day?	Sat 1/12/08	Sat 1/12/08	0%
76		February county-wide meeting	1 day?	Sat 2/9/08	Sat 2/9/08	0%
77		March county-wide meeting	1 day?	Sat 3/8/08	Sat 3/8/08	0%
78		April county-wide meeting	1 day?	Sat 4/12/08	Sat 4/12/08	0%



Project: 4-H SLI Project
Date: Sun 11/25/07

Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

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5.3 Outreach

Community outreach currently includes two activities. We will be conducting a workshop for the Washington County 4-H Cloverbuds on Saturday, December 15th, 2007. Cloverbuds is designed for 4-H youth in 1st through 3rd grade. It is anticipated that 40 to 50 young children will be attending the workshop where they will build Watchamcallits from Fliskits. In addition to learning basic construction techniques and rocket safety, they will be launching their newly made rockets with Estes 1/2 A3 engines.

As part of the 4-H Space, Engineering and Technology (SET) program, the SLI team will be partnering with our mentors who are also the Washington County 4-H countywide aerospace leaders to conduct a workshop on January 26, 2008. The workshop will be geared towards 4th grade students to expose them to rocketry at the Tri-County workshop in Sheboygan, Wisconsin. This workshop will teach youth and parents how to construct and fly a model rocket and the safety rules needed to participate in rocketry in a safe manner.

In addition to these two outreach events, team members will be helping lead and mentor the Washington County 4-H rocketry project. These meetings will be more in depth meetings discussing higher levels of rocket building. The primary focus of these meetings will to help youth of all ages construct their county fair rocket.

6 Conclusion

Refinement and changes will evolve as progress continues on the Washington County 4-H team project – to design, build, and launch a rocket that generates electrical power by harnessing the wind moving against the accelerating airframe. The team is confident that a rocket can be designed that will be able to accommodate the final payload design. Significant changes to the vehicle include changes at the nose of the rocket to accommodate the move of the payload and wind turbine to the front of the rocket, as well as refining our parts list including electronics and motor to meet our flight requirements.

The team continues to evaluate risk and look for ways to reduce project risk. Since our proposal, the following risk mitigation strategies have been put in place:

- The team found a well-qualified level 3 certified rocket expert in Ed Kreul
- The current design uses as many commercially available products as possible. Including purchased rocket kits, generators and turbine blades for the project. While modifications for the payload will need to be made, having a proven design for both the half scale

and full-scale rockets that complement each other is a significant development that enhances the project success.
- The team continues to develop a project plan to keep progress on track
- The team has created 2 sub-teams focusing on the vehicle and payload respectively
- The team has identified sub-assembly pre-flight testing for critical components including wind payload electronics testing, tunnel testing and recovery testing of the ejection charge prior to any full scale launch
- The team has evaluated risk and put a significant amount of time understanding how to reduce that risk through the Failure Mode and Effects Analysis

The project's greatest risk currently is the payload design and circuitry. With the planning identified above, continued dedication to the project, and leadership from the mentors, the team is confident that they are managing this risk appropriately.

This project is stretching everyone on the team as progress continues. It is providing learning opportunities for everyone involved, pushing us to be more creative and think far outside of what we thought we were capable of. The team is making the most of this SLI experience.