NASA Student Launch Initiative 2008-2009

Washington County (Wisconsin) 4-H Rocketry

Student Launch Initiative

Preliminary Design Review

December 4, 2008

Generate REnewable ENergy

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

Table of Contents

Summary of PDR Report

1.1 Team Summary

Name: Washington County 4-H Rocketry Club
Location: Slinger, Wisconsin
Members: Katlin, Ben, Isaac
Mentors: Doug Pedrick, Pat Wagner, Ed Kreul, Dave Duckert

1.2 Launch Vehicle Summary

The launch vehicle specifications are as follows:

Airframe:	Fiberglass
Diameter:	4.0 inches
Length:	97 inches
Weight:	28 lbs, with motor
Motor Choice:	Aerotech – 75mm, L850W
Recovery System:	Redundant dual event altimeters that will deploy a 24” drogue at apogee and 72” main parachute at 800 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 fly straight in wind up to 20MPH.

1.3 Payload Summary

The payload consists of three wind turbines attached inside fin tubes and a thermoelectric generator that will convert heat from the motor into electricity. The goal of the payload is to find the most efficient of the four generation techniques.

2 Changes Made Since Proposal

2.1 Vehicle

The original proposal included a vehicle design similar to the current design. The length and weight have changed slightly. From observations of recent test flights, the length of the six fin tubes has increased slightly.

2.2 Payload

Since the primary payload goal is to generate (and measure) power, the team wanted to do something interesting with the captured energy.

The original payload design was to use the generated electricity to power a real time video camera. Through a dialog with the camera manufacturer, BoosterVision, it was discovered that the BoosterVision camera takes about .75 seconds to power up and begin transmitting video. The team determined that the rocket would be about 100 feet off the ground before the turbines generated enough electricity to power the camera. The team decided not to use video that ran on the rocket's generated power because the best part of the launch is the blast off and the camera would not be powered up in time using the generated electricity. The team also decided that being this far off the ground, the smoke from the launch would be gone and the video would not be as interesting past that point.

The team decided to keep the BoosterVision camera on board but a regular 9v battery and not the self-generated electricity would power the camera.

Using the generated electricity is still a priority, so the team decided to use this generated electricity to charge a battery that will power a video camera mounted on top of a glider. The glider will be mounted inside one of the fin tubes. This glider will be released upon descent, broadcasting live video to a receiver on the ground.

Since the proposal the team has shifted the focus of the payload. It now will contain three wind turbines and a single thermoelectric generator. Each of the three wind turbines will have the same DC motor as a generator but have different styles of blades. The thermoelectric generator is a completely different technology the team wanted to compare to wind power. Each source will be measured with an Eagle Tree System's eLogger and the scientific method will be applied to determine which source produced power most efficiently. The team used an eLogger in the payload last year and the design of the circuitry necessary to operate it correctly for our purposes proved to be difficult and time consuming. The team will reuse the data collection circuit design from last year. This will greatly reduce the risk of experiment failure.

2.3 Activity/Outreach

The team has identified three outreach programs that have already been completed or have been planned for next year. These outreach programs will reach over 125 people in Washington County. See outreach section for further detail.

2.4 Other

The team has recruited Dave Duckert, an Electrical Engineer with GE Healthcare. Dave Duckert received a Bachelor of Science Degree in Electrical Engineering and a Masters Degree in Business Administration from the University of Wisconsin-Milwaukee and is a registered engineer (PE) in the state of Wisconsin. Dave has 12 years of experience designing water quality analytical equipment for the Hach Company and 12 years experience with General Electric doing project management work. In addition, Dave has done consulting work in the area of intrinsically safe circuit design.

Dave holds 4 US patents and has 9 US patent applications pending. In his spare time Dave enjoys competitive marksmanship.

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, and from heat created by the motor.

3.1.2 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 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

Timeline

Washington County 4-H 2008-2009 SLI Project Plan

Project Start Date: Mon 8/4/08
Project Finish Date: Fri 5/22/09

Project Milestones

Name	Finish Date
Request for Proposal (RFP)	Wed 10/1/08
RFP document delivered to NASA	Wed 10/1/08
Establish Team Website	Wed 11/5/08
Preliminary Design Review (PDR)	Fri 12/5/08
Vehicle concept testing	Sat 9/20/08
PDR document delivered to NASA	Fri 12/5/08
Critical Design Review (CDR)	Thu 1/22/09
Payload design - revision 2	Mon 12/15/08
Vehicle design - revision 2	Tue 12/23/08
Scale vehicle completed	Fri 1/9/09

Fly Scale Model	Sat 1/10/09
CDR presentation delivered to NASA	Thu 1/22/09
CDR document delivered to NASA	Thu 1/22/09
Motor selection due to NASA	Thu 1/22/09
Flight Readiness Review (FRR)	Wed 3/25/09
Scale vehicle completed	Sat 1/31/09
Payload design - final	Fri 2/6/09
Vehicle design - final	Fri 2/6/09
Payload construction completed	Sun 3/1/09
Vehicle construction completed	Sun 3/1/09
Full scale test launch	Sat 3/7/09
Submit FRR Presentation to NASA	Wed 3/18/09
FRR document delivered to NASA	Wed 3/18/09
FRR presentation delivered to NASA	Wed 3/25/09
SLI - Huntsville	Sun 4/19/09
Rocket fair / safety check	Thu 4/16/09
SLI lunch day	Sun 4/19/09
Post Launch Assessment Review (PLAR)	Fri 5/22/09
Complete SLI feedback survey	Mon 5/4/09
PLAR delivered to NASA	Fri 5/22/09
Miscellaneous	Wed 11/19/08
NASA awards SLI grants	Mon 11/3/08
SLI team teleconference w/ NASA	Tue 10/7/08

3.1.4 Vehicle Design

The vehicle was designed to meet the needs of the payload. Part of the project this year is to use three wind turbines in the science payload. Instead of using conventional fins, the team decided to use fin tubes. This is because they are the best option for fitting three wind turbines on a rocket. The team chose to use only three of the 6 tubes because the rocket may not be aerodynamically stable if it the airflow of all 6 tubes were constricted.

The structural integrity of the rocket had to be taken into consideration when looking at the needs of the thermoelectric generator. There will need to be a square cut out of the fiberglass on the outside of the rocket to allow heat to transfer to the thermoelectric generator. The generator will be sitting on the inside of one of the tube fins. One side will be facing the motor, while the other will be attached to a heat sink. This heat sink creates a greater temperature difference between each side of the generator. According to the Seebeck effect, the greater the difference in temperature on either side of the power generator, the more power can be generated.

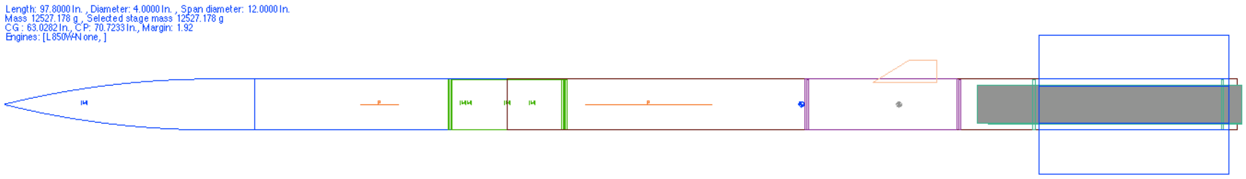


Figure 1

Figure 2 is an aft view of the rocket showing the turbines, the thermoelectric generator, and the glider.

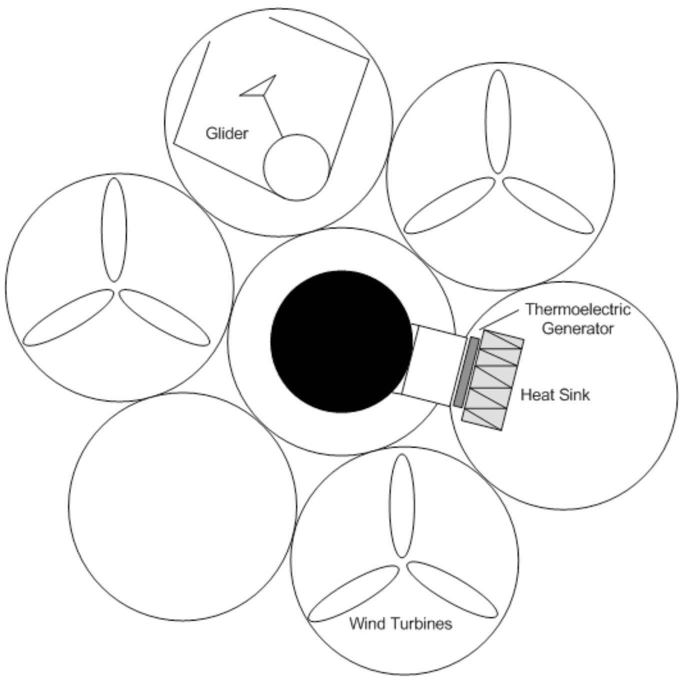


Figure 2

3.1.5 Vehicle Subsystems

3.1.5.1 Vehicle Body

The six fin tubes on the rocket will create extra weight that has to be counter-acted to create an acceptable stability margin. This means putting mass in the nose cone to bring the center of gravity forward, widening the stability margin.

3.1.5.2 Propulsion

The current motor of choice is a re-loadable Aerotech L850W. This is a 75mm motor with a total impulse of 3840N-sec and 4.5 second burn time. This motor is a good fit for the payload as it provides a long steady burn, keeping the velocity below mach, which is important to prevent the wind turbines from disintegrating.

3.1.5.3 Recovery

The proposed recovery system includes Top Flight Recovery components for the parachutes and recovery harnesses. A 72-inch main parachute and 24-inch drogue made of rip-stop nylon will safely return the rocket from flight. 9/16th inch tubular nylon cords, Kevlar chute and shock cord protectors are also included in the recovery sub-system design.

The electronics are components used as a part of the team's successful 2007-2008 SLI project. This includes PerfectFlite's miniAlt/WD and Ozark Aerospace's' ARTS dual deployment altimeters. This is a proven combination of redundancy with the added safety of using two different altimeter manufacturers.

3.1.5.4 Tracking

The team will be using a borrowed tracking device from Ed Kreul that includes a GPS unit. The GPS transmitter will be attached to the drogue recovery harness so the signal is more easily picked up beginning at apogee.

3.1.6 Verification plan

The verification plan includes several items including:

- Ongoing RockSim simulation testing
- Contacting high-powered rocket experts who have previously built and flown fin-tube rockets
- Initial test flights of Estes fin-tube rockets
- Scale test flight of a mid-powered fin-tube rocket
- Ejection charge size testing prior to full-scale launch
- A full-scale launch prior to SLI week at Marshall Space Flight Center and Briggs Farm

To date, the team launched Estes fin-tube rockets. The team built one rocket using proportionate fin-tube to body tube ratios as initially proposed with the full-scale rocket. In addition the team masked off the interior of the tube fin to simulate the initial affect of reduced air-flow through the tubes similar to the effect created by putting wind turbines and other components inside the fin tubes.

From the results of this initial testing, the team concluded that eliminating all airflow from the six tube fins moved the center of pressure (Cp) in front of the center of gravity (CG) causing the test rocket to be unstable and cartwheel in the air. Through subsequent testing, the team concluded that all six tubes could have all airflow cut off only if additional mass was added to the nose of the rocket, which kept the Cp behind the Cg.

3.1.7 Project Risks

Item / Function	Potential Risk(s)	Severity	Potential Cause(s)/ Mechanism(s) of Risk	Probability	Risk Priority	Recommended Action(s)
Project Risks		5	Size of the team is small	10	50	Adjust the project complexity size to the size and expertise of the team. Continually look to recruit new team members.
		6	Personal schedules don't allow time to complete tasks	8	48	Start early; plan ahead; limit outside activities; Include holidays and Band trip in the project plan as non-project time. Schedule regular design and construction meetings, determine the outcome or goal of every meeting. Cross-train and understand what other team members are doing so others can help and pick up tasks that need to be completed.
Scale rocket	Scale rocket not built on time	10	Unavailability of parts	1	10	Order early; Make our own
		7	Weather prohibits flight-testing	5	35	Identify multiple launch dates; complete scale rocket early
Full-scale rocket	Full scale not built on time	10	Unavailability of parts	1	10	Order early; Make our own
		7	Weight of vehicle and payload could prohibit achieving the desired height objective	5	35	Explore vehicle material alternatives including fiberglass, carbon fiber and paper/fiberglass combinations. Continue to use RockSim to simulate rocket flight tests.
		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 and contact appropriate clubs prior to launch day
Payload - Science Experiment		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; look for sponsorships to donate
		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
		10	Science experiment not completed on time.	7		Build a less complex experiment with same concept of experiment.

3.1.8 Construction Plan

According to the current project plan, construction on the half scale of the rocket will begin right after this PDR document is submitted. The team will be building a scale model using RockSim. The full-scale rocket construction will begin after CDR is complete, around 1/22/09. The construction will be done in Patrick Wagner'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 selected is the Aerotech L850W. 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 turbines are rotating. The power generated by a wind turbine is proportional to the cube of the velocity of the air.

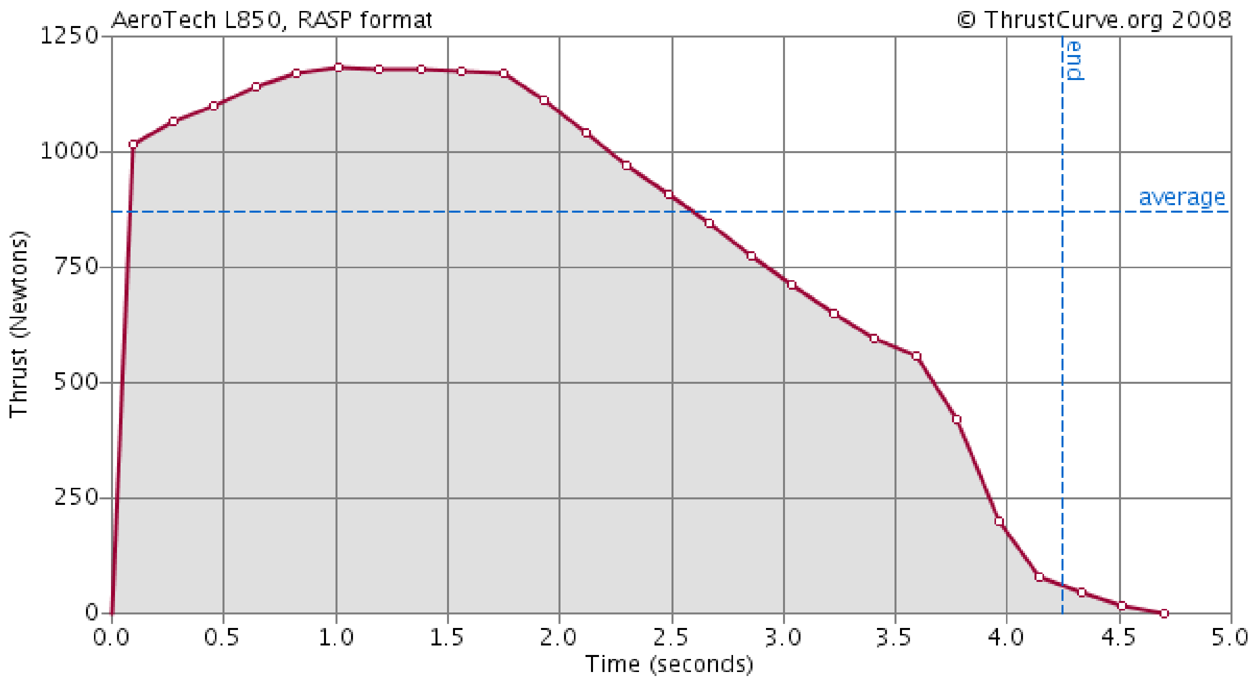


Figure 3

3.2 Payload Integration

Each turbine will be part of an assembly that will be attached to each fin tube with PEM nuts. These assemblies will be able to slide in and out of the tube fins so the team can readjust the payload when necessary. The team is going to develop a reliable a way to get the electricity from the outside of the rocket up to the payload bay. The most likely solution is running wires directly from the DC motor through the fiberglass into the motor mount cavity and then up toward the payload bay.

3.3 Launch Operation Procedures

3.3.1 Launch system and platform

- Launch system is an electrically controlled safe system and is supplied by the hosting club or organization.
- The launch pad is a heavy duty pad designed for high-powered rocketry 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

The team safety officer is Katlin.

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	Deployment failure	Rocket destroyed on impact	10	Ejection blow by	1	**10**	Use the right size Kevlar shroud; pack parachute correctly
	Deployment failure	Rocket destroyed on impact	10	E-match doesn't light	3	**30**	Use redundant e-match
	Deployment failure	Rocket destroyed on impact	10	Not enough black powder	3	**30**	Static ground testing of ejection charge sizes
	Parachute or shock cords tear	High-speed descent	10	Too much black powder	3	**30**	Static ground testing of ejection charge sizes
	Parachute does not fully deploy	High-speed descent	10	Shroud lines tangle	2	**20**	Pack parachute correctly
	Deployment failure	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

	Deployment failure	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**	Follow recommended hole sizes for port holes in the altimeter bays
	Separation of vehicle sections does not occur	High-speed descent, rocket destroyed on impact		Shear pins not properly sized for the vehicle and ejection charges calculated			Correctly calculate the necessary shear pins size to be used with the size of the rocket and ejection charges
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
	Tube Fins separate from vehicle body	Unstable flight	10	Fins not properly attached	2	**20**	Determine the proper way to attach tube fins to the main vehicle body
	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 proper building techniques with mentor guidance 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 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 review of MSDS data, safety briefings, usage instructions, use of proper safety equipment and mentor supervision will be used during all aspects of the project.

Flight hazards are also a factor with any high-powered rocket. Engine failure, recovery device failure, and rocket flight are the biggest concerns. Following proper high-powered safety launch 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. Continued design simulations under many flight conditions will help ensure the team has a sound rocket design for flight in various conditions.

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. If the team chooses the experiment that includes the glider, the material will not be biodegradable, so it could be a potential hazard to the environment and animals if the glider is not recovered after flight.

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 e-matches
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 and glider with tracking device
11. Make sure rocket is safe before retrieving altimeter telemetry and payload telemetry
12. Safely retrieve rocket
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 Review - Options Considered, Benefits and Risks

The payload has three wind turbines that are placed inside the fin tubes on the outside of the rocket. These wind turbines will produce electricity from the air passing through the fin tubes. Each of the wind turbines will have a different style and configuration of blade. Varying the blades in number, size, and pitch angle we can learn which style of wind generator is the most efficient. By having three wind turbines in one rocket, we can use a single launch for a side-by-side comparison with little difference in variables.

Part of the goal this year was to use the electricity generated in some way on the rocket. Currently the team plans on building a glider that sits in a 4^{th} tube fin. This glider will have a video camera that will be charged using the electricity from the turbines. During the flight, the glider will be released. We are currently looking into the best way to integrate a glider on a high-powered rocket.

The other element of the payload includes a thermoelectric generator. Using the Seebeck Effect it will generate electricity from the heat of the motor. For thermoelectric generators to work efficiently they need to have a large temperature difference between each side. On one side of our generator we will have a motor creating a heat source. On the other side we will have a heat sink. This heat sink will be sticking out into one of the tube fins where passing air will cool it.

4.1.2 Subsystem Details

Fan Blades

As part of the experiment we are going to use three different types of fan blades to see how the efficiency varies between designs. Each one will have a different fan swept area, number of blades, and/or pitch than the others.

Generator

For each generator we will be using a small DC Motor. It will generate electricity when the shaft is spun. This may not be the most efficient way of generating electricity but any other types of generators or motors would be too expensive or too big to fit in the rocket. Each turbine will be using the same motor.

Circuit Components

The circuit will be comprised of four Eagle Tree Systems eLogger V3 measuring and recording the output of each generator. The generators will all merge power to charge a battery on the glider to run a video camera.
Figure 4 shows the current circuit design that will be in each of the wind turbine assemblies. The circuit for the thermoelectric generator is functionally similar.

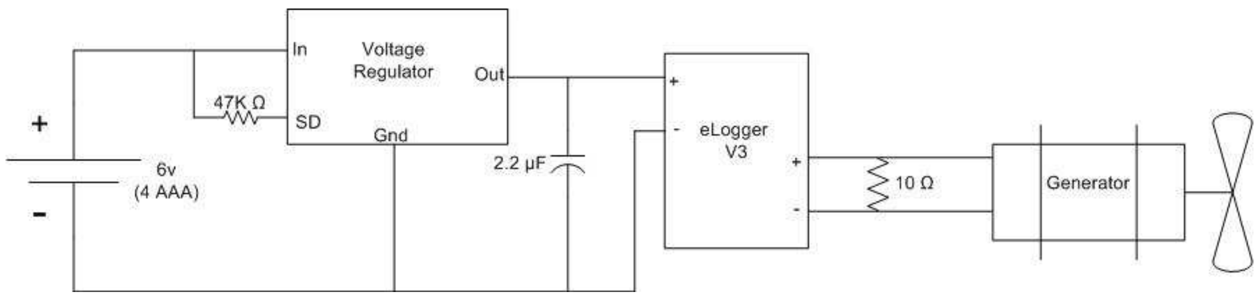


Figure 4

On Board Camera

The team will be using a BoosterVision GearCam (BV-GMCBO) camera on our rocket for video of the launch and flight. This camera's size is 20mm wide, 20mm high, and 20mm long.

Glider Camera

The team will also be using a second camera on a glider to obtain video of the glider gliding down to the ground. It will broadcast the video back to the ground. The power that will be stored on board the glider will be enough to power it for the few minutes that it will be in the air.

4.1.3 Verification plan and status

The design concept will go through a series of tests to assure reliability. The first will be a scale test launch that will replicate the weight placements, turbine blades, and stability of the full-scale vehicle. No payload electronics will be in the scale flight. The wind turbine payloads will be tested on the ground using an air compressor to spin the fan blades and circuit continuity verification will be done with a multimeter. When the rocket has been fully constructed and the payload verified, a full-scale test launch will be attempted in full flight conditions, as if it were flying in Huntsville.

.

4.1.4 Preliminary integration plan

The wind turbines and generators will be held in an assembly that fits into the tube fins. Each of the turbine assemblies will be fastened securely into the tube fins. The wires that carry the electricity generated will run through the tube fins into the rocket and up to the scientific payload bay.

4.1.5 Precision of measurement and recovery

Each of the four generators will have its own Eagle Tree Systems' eLogger V3 that will record the output in Watts, Volts, and Amperes. When the rocket returns we will be able to retrieve the data and analyze it.

4.2 Payload Concept Features and Definition

4.2.1 Creativity and originality

The experiment is unique because this concept idea has not been attempted before to the best of our knowledge, except by our team last year in SLI. The scale of the scientific payload is something that is one of kind. Energy is a topic that is a problem on a global scale. This experiment is relevant to every day needs.

4.2.2 Uniqueness and significance

The team decided to plan a science experiment based around electricity generation. The Milwaukee Journal Sentinel 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. The team needs 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. The team is interested in exploring renewable energy because it will play a major role in the future of this country.

The thermoelectric generators are also an alternative energy source that is still developing on a large scale. The team wanted to experiment with more than one new energy resource.

4.2.3 Suitable level of challenge

There are many challenges in designing and building this experiment. Even if the payload can be fully designed to meet the needs, finding the right materials can be a hassle. Many of the kinds of parts the team needs are manufactured overseas with little technical details.

With a payload of this scale it takes lots of time and development to integrate the vehicle with all of the turbines and generators. Figuring out how to mount the payload bays and where to run the wiring harnesses will take time and trial and error.

4.3 Science Value

4.3.1 Science payload objectives

There are several objectives of the payload:

- Find the most efficient turbine design.
- Compare thermoelectric generation to wind generation.
- Launch a glider from one of the tube fins during the flight that has a video camera powered by the electricity produced by the wind turbines.

- Compute the efficiency of the 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 the payload.

4.3.2 Payload success criteria

The payload will be successful if all three turbines and the thermoelectric generator produce electricity with recoverable measurements. Releasing and recovering the glider with a video record of its flight is a secondary success goal.

4.3.3 Experimental logic, approach and method

The experiment depends on many different variables that will affect 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. The custom circuitry will measure the instantaneous power output of the generator. Using equation 1, the team will be able to compute the power efficiency of the system.

$$\textbf{Effective Power} = \textbf{Cp} * 0.5 * \textbf{Swept Area} * \textbf{Air Density} * \textbf{Velocity}^3 \quad \textbf{(Eq. 1)}$$

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

4.4 Safety and Environment

4.4.1 Safety Officer

The team safety officer is Katlin.

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; use last year's circuit to reduce design risk
		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.

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. The electrical engineer advisor, Dave, will work with the team to discuss any additional risks in the circuitry.

4.4.4 Environmental concerns

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

5 Project Management

5.1 Proposed Budget

Item Description	Quantity	Cost	Total Cost	
Full Scale Rocket				
Centering ring	1	$5.00	$5.00	
Main Chute-72"	0	$40.00	$0.00	*
Drogue-24"	0	$10.00	$0.00	*
Nose Cone	1	$80.00	$80.00	
Body Tubes	11	$25.00	$275.00	
ARTS Altimeter	0	$200.00	$0.00	**
miniAlt/WD Altimeter	0	$120.00	$0.00	**
L850W Motors	1	$210.00	$210.00	
Motor Retainer	1	$52.00	$52.00	
Couplers	2	$35.00	$70.00	
Recovery Harnesses	1	$50.00	$50.00	
Motor Mount	1	$50.00	$50.00	
Reloadable Motor case	0	$238.00	$0.00	***
Black Powder	1	$5.00	$5.00	
Payload				
Ducted Fan Blades	3	$75.00	$225.00	
DC Motors	3	$40.00	$120.00	
eLogger	3	$70.00	$210.00	**
Circuit Components	1	$30.00	$30.00	
Thermoelectric Generator	1	$75.00	$75.00	*
Wireless Camera	1	$140.00	$140.00	
Half Scale Rocket				
Scale Rocket	1	$100.00	$100.00	
Scale Motor- G-80	2	$25.00	$50.00	
Building Supplies				
Hardware	1	$25.00	$25.00	
Miscellaneous Supplies	1	$75.00	$75.00	
Outreach				
Educational Material	1	$0.00	$0.00	
Travel Expenses				
Vehicle, Lodging, Meals	1	$3,000.00	$3,000.00	
			$4,847.00	

NOTES

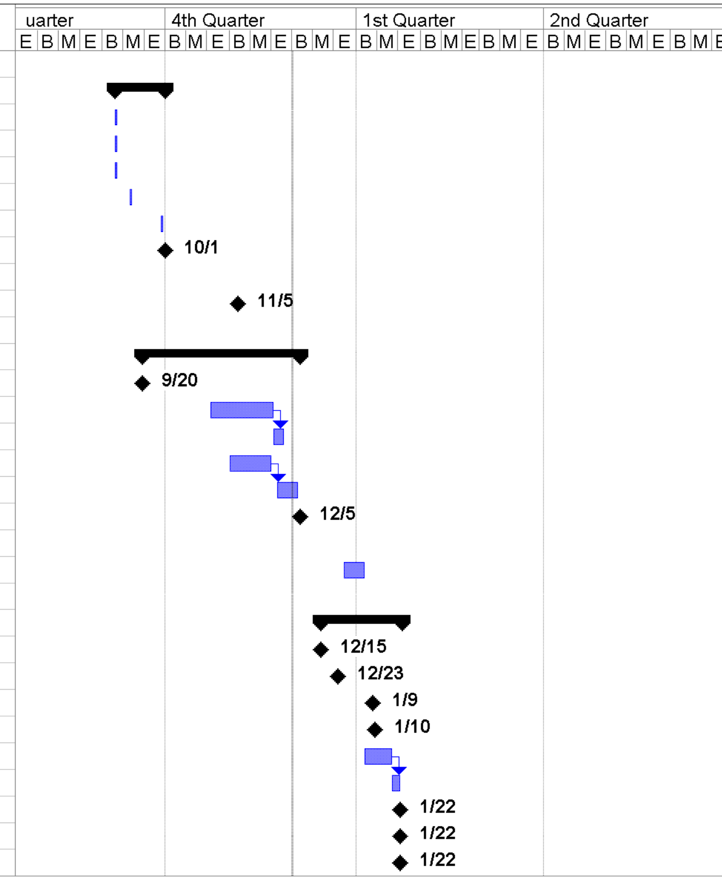
*	Potential Sponsorship
	Re-usable components from 2007-2008 SLI
**	Project
	Parts borrowed from
***	Mentor

5.2 SLI Project Plan

The detailed schedule follows:

Washington County 4-H
2008 - 2009 SLI Project

ID		Task Name	Duration	Start	Finish	% Work Complete	Predecessors
1							
2		**Request for Proposal (RFP)**	**24 days?**	**Sun 9/7/08**	**Wed 10/1/08**	**0%**	
3		Brainstorming	1 day?	Sun 9/7/08	Sun 9/7/08	100%	
4		Project assignments (Roles)	1 day?	Sun 9/7/08	Sun 9/7/08	100%	
5		Determine science experiement	1 day?	Sun 9/7/08	Sun 9/7/08	100%	
6		Initial vehicle design complete	1 day?	Sun 9/14/08	Sun 9/14/08	100%	
7		Complete draft of RFP	1 day?	Mon 9/29/08	Mon 9/29/08	100%	
8		RFP document delivered to NASA	0 days	Wed 10/1/08	Wed 10/1/08	100%	
9							
10		Establish Team Website	0 days	Wed 11/5/08	Wed 11/5/08	100%	
11							
12		**Preliminary Design Review (PDR)**	**76 days**	**Sat 9/20/08**	**Fri 12/5/08**	**0%**	
13		Vehicle concept testing	0 days	Sat 9/20/08	Sat 9/20/08	100%	
14		Payload design - revision 1	30 days	Thu 10/23/08	Fri 11/21/08	100%	
15		Vehicle design - revision 1	5 days	Sat 11/22/08	Wed 11/26/08	100%	14
16		Review PDR	20 days	Sat 11/1/08	Thu 11/20/08	85%	
17			10 days	Mon 11/24/08	Wed 12/3/08	40%	16
18		PDR document delivered to NASA	0 days	Fri 12/5/08	Fri 12/5/08	0%	
19							
20		NO WORK - Slinger Band Trip to London	10 days?	Fri 12/26/08	Sun 1/4/09	0%	
21							
22		**Critical Design Review (CDR)**	**39 days?**	**Mon 12/15/08**	**Thu 1/22/09**	**0%**	
23		Payload design - revision 2	0 days	Mon 12/15/08	Mon 12/15/08	0%	
24		Vehicle design - revision 2	0 days	Tue 12/23/08	Tue 12/23/08	0%	
25		Scale vehicle completed	0 days	Fri 1/9/09	Fri 1/9/09	0%	
26		Fly Scale Model	0 days	Sat 1/10/09	Sat 1/10/09	0%	
27		Prepare CDR	13 days	Mon 1/5/09	Sat 1/17/09	0%	
28		Review CDR	4 days	Sun 1/18/09	Wed 1/21/09	0%	27
29		CDR presentation delivered to NASA	0 days	Thu 1/22/09	Thu 1/22/09	0%	
30		CDR document delivered to NASA	0 days	Thu 1/22/09	Thu 1/22/09	0%	
31		Motor selection due to NASA	0 days	Thu 1/22/09	Thu 1/22/09	0%	



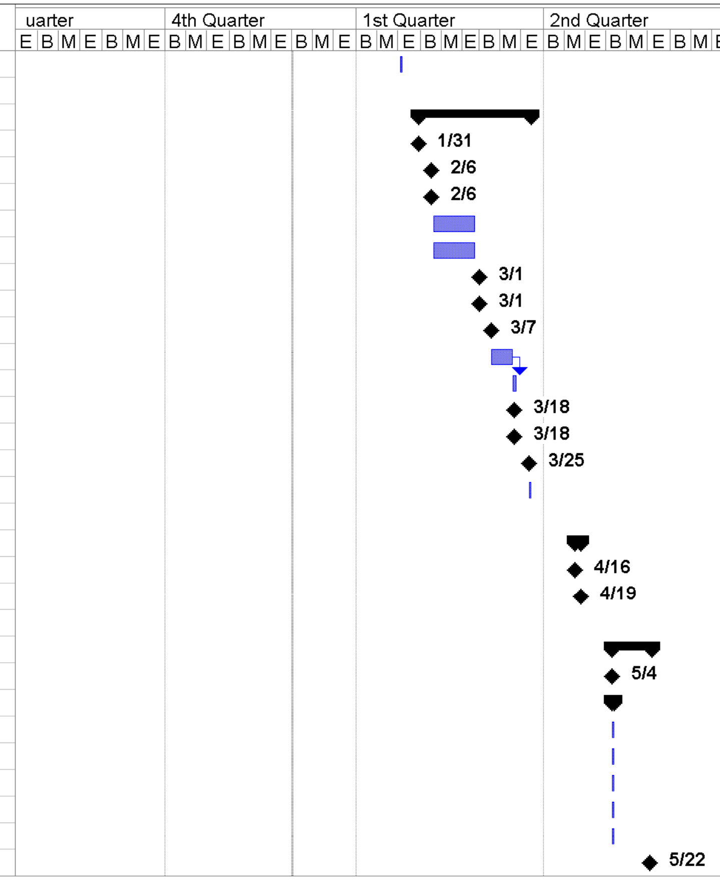
Project: Washington County 4-H 2008-2
Date: Mon 12/1/08

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

Page 1

Washington County 4-H
2008 - 2009 SLI Project

ID		Task Name	Duration	Start	Finish	% Work Complete	Predecessors
32		Submit Invoice to NASA	1 day?	Thu 1/22/09	Thu 1/22/09	0%	
33							
34		**Flight Readiness Review (FRR)**	**54 days?**	**Sat 1/31/09**	**Wed 3/25/09**	**0%**	
35		Scale vehicle completed	0 days	Sat 1/31/09	Sat 1/31/09	0%	
36		Payload design - final	0 days	Fri 2/6/09	Fri 2/6/09	0%	
37		Vehicle design - final	0 days	Fri 2/6/09	Fri 2/6/09	0%	
38		Construct payload	20 days?	Sat 2/7/09	Thu 2/26/09	0%	
39		Construct vehicle	20 days	Sat 2/7/09	Thu 2/26/09	0%	
40		Payload construction completed	0 days	Sun 3/1/09	Sun 3/1/09	0%	
41		Vehicle construction completed	0 days	Sun 3/1/09	Sun 3/1/09	0%	
42		Full scale test launch	0 days	Sat 3/7/09	Sat 3/7/09	0%	
43		Prepare FRR	10 days	Sat 3/7/09	Mon 3/16/09	0%	
44		Review FRR	2 days	Tue 3/17/09	Wed 3/18/09	0%	43
45		Submit FRR Presentation to NASA	0 days	Wed 3/18/09	Wed 3/18/09	0%	
46		FRR document delivered to NASA	0 days	Wed 3/18/09	Wed 3/18/09	0%	
47		FRR presentation delivered to NASA	0 days	Wed 3/25/09	Wed 3/25/09	0%	
48		Submit invoice to NASA	1 day?	Wed 3/25/09	Wed 3/25/09	0%	
49							
50		**SLI - Huntsville**	**3 days**	**Thu 4/16/09**	**Sun 4/19/09**	**0%**	
51		Rocket fair / safety check	0 days	Thu 4/16/09	Thu 4/16/09	0%	
52		SLI lunch day	0 days	Sun 4/19/09	Sun 4/19/09	0%	
53							
54		**Post Launch Assessment Review (PLAR)**	**19 days?**	**Mon 5/4/09**	**Fri 5/22/09**	**0%**	
55		Complete SLI feedback survey	0 days	Mon 5/4/09	Mon 5/4/09	0%	
56		**Initial draft of PLAR**	**1 day?**	**Mon 5/4/09**	**Mon 5/4/09**	**0%**	
57		Experiment post flight findings	1 day?	Mon 5/4/09	Mon 5/4/09	0%	
58		Vehicle post flight findings	1 day?	Mon 5/4/09	Mon 5/4/09	0%	
59		Outreach summary	1 day?	Mon 5/4/09	Mon 5/4/09	0%	
60		Final budget figures	1 day?	Mon 5/4/09	Mon 5/4/09	0%	
61		Review PLAR	1 day?	Mon 5/4/09	Mon 5/4/09	0%	
62		PLAR delivered to NASA	0 days	Fri 5/22/09	Fri 5/22/09	0%	

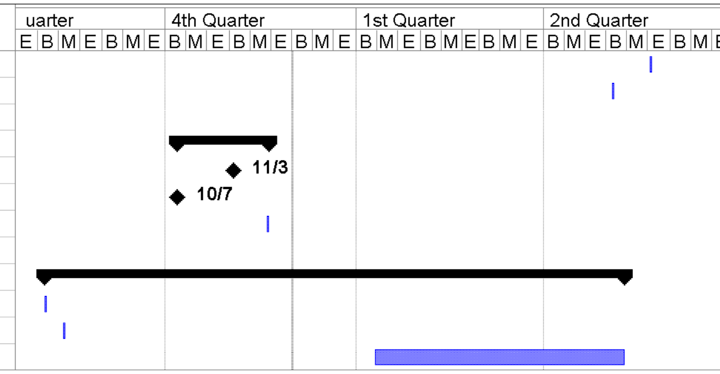


Project: Washington County 4-H 2008-2
Date: Mon 12/1/08

Page 2

Washington County 4-H
2008 - 2009 SLI Project

ID		Task Name	Duration	Start	Finish	% Work Complete	Predecessors
63		Submit invoice to NASA	1 day	Fri 5/22/09	Fri 5/22/09	0%	
64		Send thank you's to sponsoring companies	1 day?	Mon 5/4/09	Mon 5/4/09	0%	
65							
66		**Miscellaneous**	**44 days?**	**Tue 10/7/08**	**Wed 11/19/08**	**0%**	
67		NASA awards SLI grants	0 days	Mon 11/3/08	Mon 11/3/08	100%	
68		SLI team teleconference w/ NASA	0 days	Tue 10/7/08	Tue 10/7/08	100%	
69		Team website established	1 day?	Wed 11/19/08	Wed 11/19/08	100%	
70							
71		**Community Outreach**	**271 days?**	**Mon 8/4/08**	**Sat 5/9/09**	**0%**	
72		4-H summer youth programs	1 day?	Mon 8/4/08	Mon 8/4/08	100%	
73		4-H intro night	1 day?	Wed 8/13/08	Wed 8/13/08	100%	
74		4-H county rocket workshops	120 days?	Sat 1/10/09	Sat 5/9/09	0%	



Project: Washington County 4-H 2008-2
Date: Mon 12/1/08

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

5.3 Outreach

Community outreach for SLI began early this year. The team worked along with the 4-H summer youth program and conducted four workshops at local community parks in West Bend and Hartford, Wisconsin. At these workshops, the youth worked on constructing an egg holder that would protect the egg from breaking when dropped from a balcony. The youth were put into teams to build an egg compartment. They dropped them off a balcony and each team whose egg survived got a prize. In addition, the leaders did a live model rocket launch demonstration. Through those four workshops, the team worked with nearly 100 children ranging from 5 yr. olds to 5th graders.

The team also worked with the Washington County 4-H Leaders Association and conducted a workshop on August 13th as a part of a 4-H introduction program. This was a part of a recruiting workshop for children who were new to 4-H. The 10 youth that attended the workshop built and launched a rocket in one evening. The rocket launch was held as a competition to see who could launch and land their rocket closest to a cone. As a result of this workshop Isaac joined 4-H and the SLI team.

In addition to these two outreach events, the team will be helping with the county wide 4-H rocketry program. Monthly construction meetings will begin in January and the SLI team will be leading various demonstrations and techniques in preparation to build a good quality rocket for the county fair. It is expected that 23 children will participate in the rocketry program.

With these three outreach activities, the team will meet the outreach requirements and will continue to look for more opportunities to share rocketry in Washington County.

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 and heat released from the burning propellant. The team is confident that a rocket can be designed that will be able to accommodate the final payload design.

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

- 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 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 identified sub-assembly pre-flight testing for critical components including wind payload electronics testing and recovery testing of the ejection charge prior to a 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

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 the team thought they were capable of. The team is making the most of this SLI experience.