NASA Student Launch Initiative 2007-2008

Washington County (Wisconsin) 4-H Rocketry

Student Launch Initiative

Flight Readiness Review

April 1, 2008

Watt's Up?

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

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

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Summary of FRR 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, Ed Kreul, Jim Decker

1.2 Launch Vehicle Summary

The launch vehicle specifications are as follows:

Airframe:	Fiberglass
Diameter:	4.0 inches
Length:	82 inches
Weight:	20.5 lbs (motor included)
Motor:	Aerotech – 54mm, K700W
Recovery System:	Redundant dual event altimeters that will deploy an 18” drogue at apogee and 60” main parachute at 700 feet
Rail size:	Standard 8’ 10/10 rail

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 two-pound payload in the nosecone.

1.3 Payload Summary

The payload will generate electrical power by harnessing the wind energy created by the drag of oncoming air pushing against the fan blades during ascent. It will achieve this using a turbine generator mounted vertically inside the rocket. The fan blade assembly will sit atop the rocket in place of the nose cone.

2 Changes Made Since CDR

2.1 Vehicle

The CDR included a vehicle design similar to the current one. The full-scale vehicle remains approximately 8 feet long and 4 inches in diameter. It is based on the Performance Rocketry Mad Dog kit. The most significant modifications to the Mad Dog kit are being done to the upper portion of the rocket to house the scientific payload. The payload assembly described below will continue to be housed in that section.

The full-scale rocket construction has been completed since CDR. The team chose to switch the motor selection to an Aerotech K700W. It was decided that the payload’s propeller would not withstand the forces of mach. As a result the team made this decision because the Aerotech motor did not go through mach and could still obtain an altitude of 5,280. The K700W is also a longer burning motor, allowing the payload to generate electricity over a longer period of time.

The full-scale rocket was launched on March 8, 2008 and obtained an altitude of 5632 feet. Details are described in 3.1.4.2

During the full-scale launch, the rocket weathercocked off the rail, because the rocket was over stable. As a result, the team has realized the necessity for added weight in the aft end of the rocket. The team has now begun adding 1.75 pounds of epoxy and lead shot into the aft end of the rocket. This should bring the stability margin closer to 3.42.

2.2 Payload

Since Critical Design Review, we have built two versions of our payload bay. The first version was based off the design outlined in CDR. Its function was to test our concept in the wind tunnel. Afterwards, we made a revised version that functioned easier on launch day. This version included new design changes that are outlined in the payload section of the document.

2.3 Activity/Outreach

As of CDR, we had completed all of our requirements for outreach. However, we continue to have monthly countywide workshops for 34 4-H youth in our county. Every second Saturday of the month we meet with them and help them build rockets for the fair.

3 Vehicle Criteria

3.1 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 produce a measurable 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.
- The vehicle shall be in a reusable state when it returns.

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	Mon 1/21/08
Launch half-scale	Sat 1/12/08
Backup launch date	Sat 1/19/08
Full Scale Rocket	Thu 3/20/08
Payload	Thu 3/20/08
Wind tunnel testing	Fri 2/29/08
Vehicle	Fri 2/29/08
Recovery subsystem testing	Fri 2/29/08
Launch full-scale	Sat 3/1/08
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	Tues 4/01/08
SLI in Huntsville	Sun 4/27/08
Launch day	Sat 4/26/08
PLAR (Post launch analysis review)	Fri 5/23/08
PLAR Due to NASA	Fri 5/23/08
Miscellaneous	Mon 11/5/07
SLI Teams Announced	Mon 10/15/07
SLI teleconference	Tue 10/23/07
Team website live	Mon 11/5/07
Community Outreach	Sat 4/12/08

Cloverbuds rocket workshop	Sat 12/15/07
Tri-County SET workshop	Sat 1/26/08
January county-wide meeting	Sat 1/12/08
February county-wide meeting	Sat 2/9/08
April county-wide meeting	Sat 4/12/08

3.1.4 Vehicle Design

3.1.4.1 System Level Design

The vehicle design includes modifying a proven rocket from Performance Rocketry – the Mad Dog Dual Deployment. The Mad Dog was chosen because it is an established design with proven launch stability. Performance Rocketry also makes a reduced scale version – the Little Dog that has similar characteristics and was used for the half-scale flight. To accommodate the payload design an additional section of body tube was used to house the payload. The wind turbine was mounted in that body tube section – see section 4.1.

The Mad Dog has a four-inch diameter tube that is constructed of fiberglass. Fiberglass was chosen because the design team, along with our mentor, believes it will best accommodate the payload. It is a very strong material that can be modified and extended to support the payload section and carry the additional strain of the wind turbine.

Detailed flight profile simulations, altitude predictions and vehicle data are contained in the Mission Performance, section 3.1.6.

3.1.4.2 Test Results

The full-scale rocket was configured with a PerfectFlite miniAlt/WD dual event altimeter and Ozark Aerospace ARTS2 dual event altimeter. The main ejection charge used 1.75 grams and the drogue used 1.35 grams of black power. This was validated using an ejection charge calculator found on http://www.info-central.com. With this source, the team was confident the ejection charge was appropriate for the vehicle.

A static test was performed to confirm the charge sizes (see the Recovery Subsystem section below for detail.)

On March 8, 2008 the vehicle was taken to Princeton, Illinois for a test launch at a certified Tripoli launch event. The goal of the launch was to verify the rocket could obtain a altitude of at least 5,280 feet and that the vehicle was structurally stable.

We configured both altimeters to deploy the drogue chute at apogee and the miniAlt/WD was configured with a mach delay of two seconds as a safety precaution. The main was set to deploy at 700 feet. Before launch, the altimeters were tested by connecting the battery and listening for the proper “beep” sequence for the corresponding settings. The reloadable engine was prepared under the supervision of our certified mentor.

The launch was successful in reaching all of its goals. The flight was very stable but the vehicle did weather cock off the pad, which reduced the altitude. Both drogue and main parachutes successfully deployed as configured.

From the altimeter data collected, the rocket reached a flight altitude of 5,632 feet. The flight data are shown in Figure 1 and indicates that the rocket reached apogee in approximately 16 seconds and a total flight duration of 130 seconds. From the graph it can be deduced that the main parachute deployed at 700 feet as expected. The team has also concluded that the coefficient of drag is approximately .775 for the full-scale.

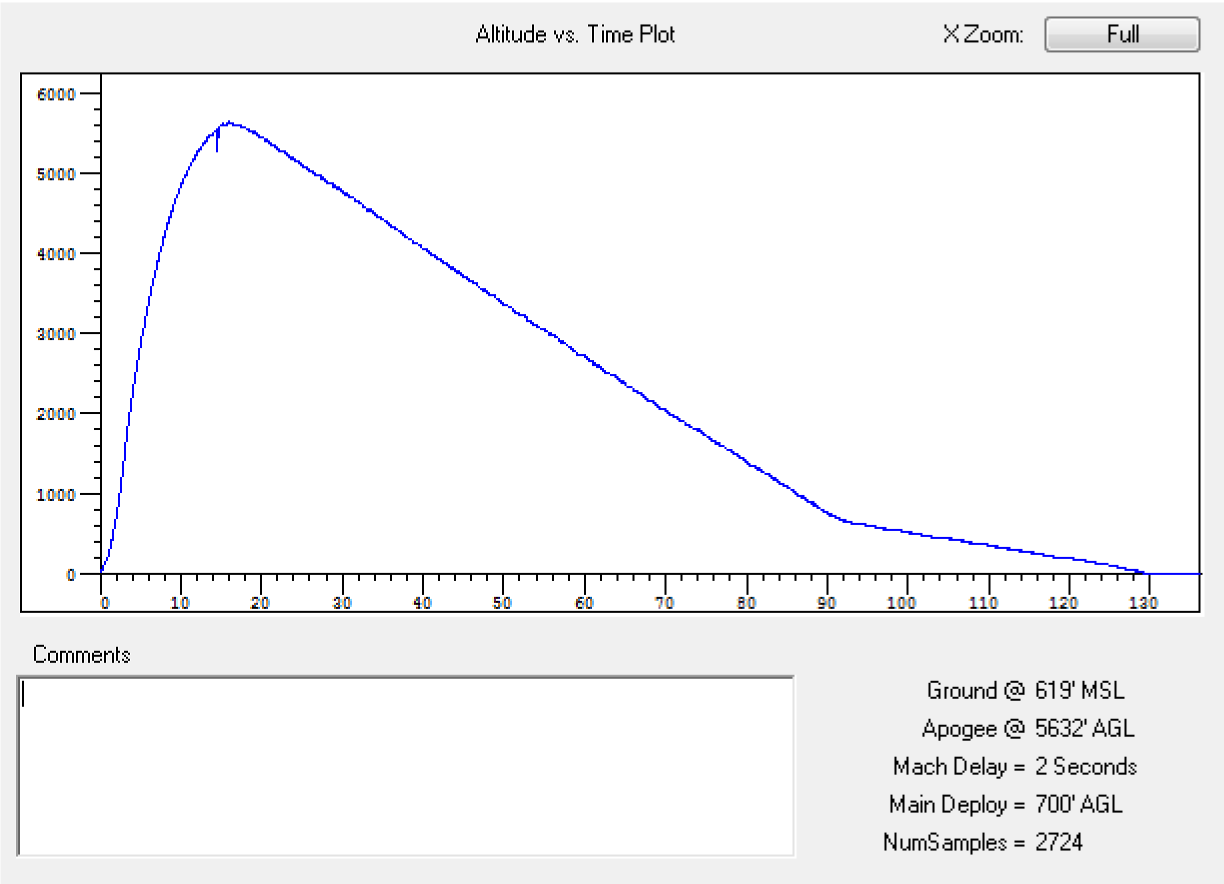

Figure 1 – Flight Telemetry

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3.1.4.3 Rocket materials, construction, workmanship, assembly

The following section describes the major sub-systems of the rocket and how overall design integrity was achieved on the full-scale rocket.

Booster

The booster section houses several major components including the engine, drogue and recovery harness. Design includes through the wall fin attachment using West System Epoxy. The West System Epoxy was strengthened around the motor mount by adding chopped carbon fiber, Kevlar pulp, and colloidal silica. The through the wall fins distribute the thrust throughout the whole rocket. Positive motor retention is being achieved using an AeroPack quick-change motor retainer. It also includes standard 10/10 rail guides using screws through the body tube. Both of these components are attached to the airframe using JB Weld. Both the West system epoxy and JB Weld are strong adhesives recommended by our mentor as adhesives used in high-powered rocketry construction. In addition, the motor mounts' forward enclosure contains an eyebolt. This is the attachment point for the drogue recovery harness. A 3/32nd inch hole is drilled in the booster section to equalize pressure in the airframe with the outside environment.

The team is currently adding 2.4 pounds of weight into the booster in order to create a more ideal stability margin. Currently the rocket has a stability margin around 3.5 calibers. The team is adding weight in order to bring the center of gravity towards the aft end. The weight will also allow the rocket to obtain an altitude of 1 mile, since it was 400 feet over during test flight.

Recovery

A major component of the recovery system is the altimeter bay that is housed in the coupler between the booster and the upper airframe. The recovery system payload bay has been made removable using 6 Pem nuts. This allows the team easier accessibility to the wiring inside the recovery payload. The altimeter bay has two mounting rods for the altimeter bay sled. The sled is constructed of G10 fiberglass and has two battery holders and two altimeters mounted to the sled using JB Weld. There are two switches mounted to the outside of the payload; so that the team can turn on and off the altimeters without having to take the rocket apart. This also reduces the risk of ejection charges firing while being loaded. The altimeter bay has forward and aft closures using double layer fiberglass bulkheads. The bulkheads have u-bolts and terminal blocks attached to the outside using JB Weld. The u-bolts will be attached to the opposite ends of the recovery harnesses for both the drogue at the aft end and the main parachute at the forward end. Altimeter specifications have been reviewed and as a result the team drilled four 1/8th inch holes into the altimeter bay so that the altimeters would function correctly.

The altimeters chosen are from different manufacturers to reduce the risk of design failure that is possible when using one manufacturer. They are an 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.

Conducting an ejection charge trial tested the recovery subsystem. The team concluded that the rocket should be tested with 1.75 grams for the main and 1.5 grams for the drogue. The test was completed successfully and safely. The team concluded from the test that 1.75 grams was the correct amount for the main but the drogue's 1.5 grams was too forceful. As a result the team agreed to use 1.35 grams for the drogue charge.

Current design specifications show the need for an 18-inch drogue made of rip-stop nylon. The main parachute of 60 inches is required and is also made of rip-stop nylon. The parachutes will be harnessed into the airframe of the rocket using solid eyebolts, ¼" Quick Links rated at 600 test pounds, and ¼" swivels rated at 600 test pounds. These are attached to a tubular nylon harness that includes a Nomex shield that protects the parachutes from the ejection charge. There is also a Nomex shield that slips over the nylon harness to protect them from the ejection charge.

Upper Airframe

The upper airframe houses the main parachute and harnesses and tracking beacon. The recovery harness is attached to the forward end of the altimeter bay and to the aft bulkhead of the payload section. A 3/32nd inch hole is drilled in the upper airframe to equalize pressure in the airframe with the outside environment.

Payload

The payload section was built from another fiberglass body tube section. It has been constructed so that the payload bay is removable. A combination of JB Weld and West System Epoxy has been used again in construction.

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

Figure 2 – Frontal View

The payload is detailed in subsequent sections of the document.

3.1.5 Project Risks

Item / Function	Potential Risk(s)	Severity	Potential Cause(s)/ Mechanism(s) of Risk	Probability	Risk Priority	Recommended Action(s)
Full Scale Rocket			Personal schedules don't allow time to complete			Start early; plan ahead; limit outside activities; recruit more people to the team
Science Experiment		7	Inability to determine expected generator RPM for any given airspeed.	8	**56**	Measure wind-speed to RPM in wind tunnel.
		9	Inability to resolve circuit flaws before launch at Huntsville	6	**54**	Start early; test; engineer for worst-case power generation
		9	Circuit does not generate power during testing	4	**36**	Reconsider design
Budget		10	Not receiving funding from NASA	4	**40**	Make sure we have good communication with the 4-H treasurer and NASA Procurement

3.1.6 Mission Performance

Figure 3 is the current RockSim design diagram for the full-scale vehicle.

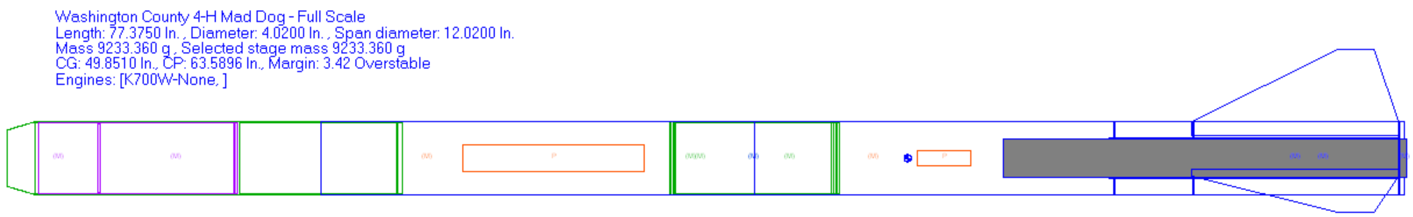


Figure 3 – Full-scale Design

The following key specifications are included in the current design:

Length	**77 inches**
Weight	**20.3 pounds**
Center of Gravity (Cg)	**49.851 inches (from the nose of the rocket)**
Center of Pressure – (Cp)	**63.5895 inches (from the nose of the rocket)**
Stability Margin	**3.42 (current measure with motor)**
Coefficient of Drag – (Cd)	**.775 (based on test launch)**
Preliminary Motor Selection	**Aerotech K700W**

The weight of the full-scale is 20.3 pounds. That includes the 2-pound scientific payload located in the nosecone. The current motor is the K700W from Aerotech. The thrust curve for this motor is shown in Figure 4.

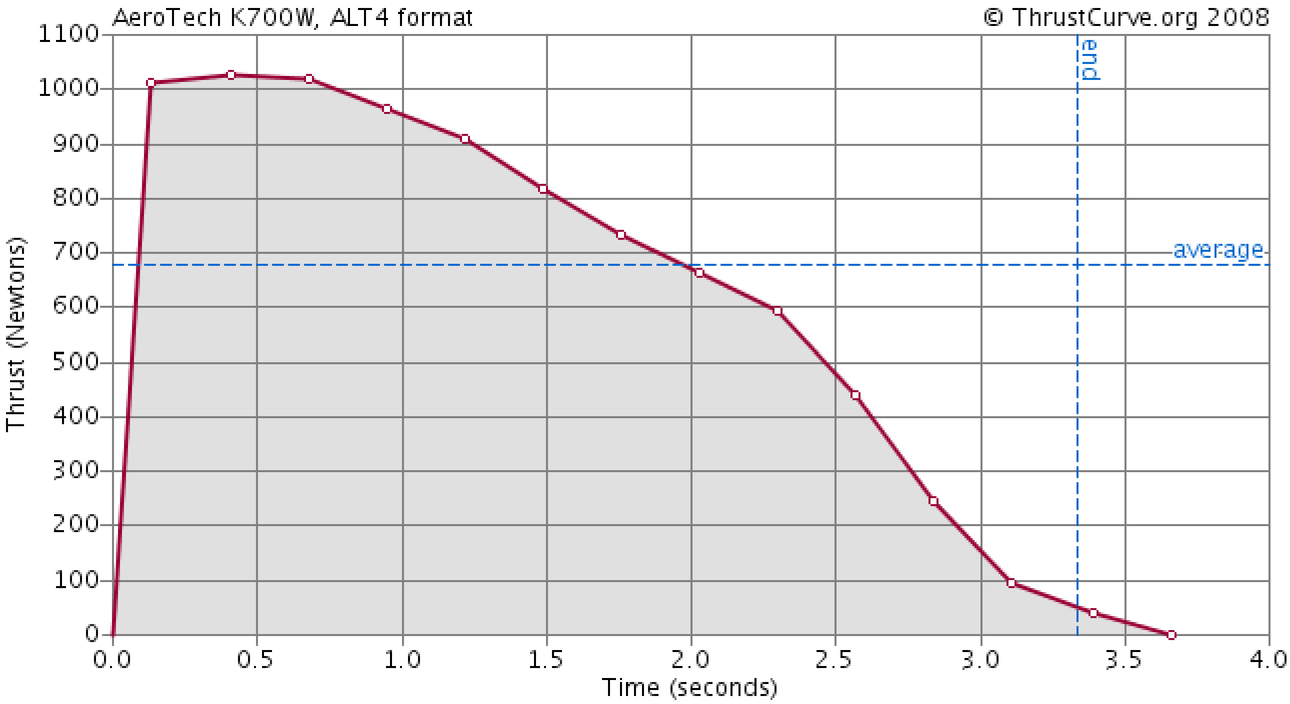


Figure 4 – Motor Thrust Curve

The results from a representative simulation are as follows:

Washington County 4-H Mad Dog - Full Scale - Simulation results

Engine selection

[K700W-None]

Simulation control parameters

- Flight resolution: 800.000000 samples/second
- Descent resolution: 1.000000 samples/second
- Method: 4th Order runge-kuta.
- End the simulation when the rocket reaches the ground.

Launch conditions

- Altitude: 605.00000 Ft.
- Relative humidity: 64.000 %
- Temperature: 70.000 Deg. F
- Pressure: 0.76 m

  Wind speed model: Custom speed range
  - Low wind speed: 5.0000 MPH
  - High wind speed: 11.0000 MPH

  Wind turbulence: Some variablility (0.04)
  - Frequency: 0.040000 rad/second
- Wind starts at altitude: 10.00000 Ft.
- Launch guide angle: 0.000 Degrees from vertical
- Latitude: 34.700 Degrees

Launch guide data:

- Launch guide length: 96.0000 In.
- Velocity at launch guide departure: 49.6429 MPH
- The launch guide was cleared at : 0.258 Seconds
- User specified minimum velocity for stable flight: 29.9996 MPH
- Minimum velocity for stable flight reached at: 36.0023 In.

Max data values:

- Maximum acceleration:Vertical (y): 341.912 Ft./s/sHorizontal (x): 5.839 Ft./s/sMagnitude: 342.763 Ft./s/s
- Maximum velocity:Vertical (y): 457.7971 MPH, Horizontal (x): 10.6415 MPH, Magnitude: 460.1935 MPH
- Maximum range from launch site: 726.84523 Ft.
- Maximum altitude: 5284.37998 Ft.

Recovery system data

- P: Main parachute Deployed at : 58.929 Seconds
- Velocity at deployment: 66.0320 MPH
- Altitude at deployment: 799.91226 Ft.
- Range at deployment: -200.77043 Ft.
- P: Drogue parachute Deployed at : 17.488 Seconds
- Velocity at deployment: 28.2405 MPH
- Altitude at deployment: 5284.37998 Ft.
- Range at deployment: -726.84523 Ft.

Time data

- Time to burnout: 3.594 Sec.
- Time to apogee: 17.488 Sec.
- Optimal ejection delay: 13.894 Sec.
- Time to wind shear: 0.285 Sec.

3.2 Payload Integration

We will have screw mounts in the forward airframe and coupler to attach the turbine blade assembly. The entire payload (turbine blades, generator and circuit board assembly) is housed within a coupler and that slides into the payload tube from the bottom. The assembly is attached from the outside with 6 pem nuts and screws. The venting ducts will be right below the fans so as much air as possible will be sent right through the tubes and out of the rocket. The duct holes in the outer tube and in the inner coupler will be required to be in alignment following the insertion of the payload bay.

Since we are using a normal fiberglass airframe and a corresponding coupler tube for housing the payload, there should be no problem in fitting the coupler inside of the airframe.

3.3 Vehicle Final Assembly Procedures

3.3.1 Pre-Launch Checklist

This is the pre-launch checklist as required as part of the vehicle launch operations. This checklist is to be used on launch day while preparing the vehicle rocket for flight

3.3.1.1 Motor Preparation

- ❑ Prepare motor per packaged instructions for launch
- ❑ Select correct size igniter for engine. Inspect for continuity, resistance, and check pyrogen for cracks or flaws
- ❑ Secure motor and igniter for later installation into rocket
- ❑ DO NOT install igniter until rocket is secure on the pad

3.3.1.2 Recovery System

Recovery System - Drogue Chute

- ❑ Check shock cords for cuts, burns, and tangles
- ❑ Check all shroud lines -- no tangles
- ❑ Check drogue chute for tears and burns
- ❑ Check ejection charge protection for tears

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

- ❑ Avionics bay shock cord to drogue
- ❑ Booster shock cord to drogue
- ❑ Remove blue tape and rubber band used in packing

- *Pack drogue chute in, keep lines even and straight*

- ❑ Fold drogue chute per manufacturer's instructions
- ❑ Insure shroud lines are free from tangles
- ❑ Place drogue in Nomex shield
- ❑ Insure all quick links are secure

- ❑ Insert drogue ejection charge protection/chute into aft recovery compartment

Recovery System - Main Chute

- ❑ Check shock cords for cuts, burns, and tangles
- ❑ Check all shroud lines -- no tangles
- ❑ Check main chute for tears and burns
- ❑ Check ejection charge protection for tears

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

- ❑ Nose Cone shock cord to drogue
- ❑ Avionics bay shock cord to drogue
- ❑ Remove blue tape and rubber band used in packing

- *Pack main chute in, keep lines even and straight*

- ❑ Fold main chute per manufacturer's instructions
- ❑ Insure shroud lines are free from tangles
- ❑ Place main in Nomex shield
- ❑ Insure all quick links are secure
- ❑ Insert ejection charge protection
- ❑ Insert main chute into forward recovery compartment

3.3.1.3 Electronics

Prepare avionics #1

- ❑ Be sure all arming switches are off
- ❑ Ohmmeter test of *NEW* battery under load
- ❑ Install battery in altimeter
- ❑ Secure battery in place with positive battery retention system
- ❑ Altimeter properly programmed and verified
- ❑ Ready avionics bay for altimeter
- ❑ Install altimeter in rocket
- ❑ Insure all pyrotechnics are in disarmed mode during electronics final installation

Prepare avionics #2

- ❑ Be sure all arming switches are off
- ❑ Ohmmeter test of *NEW* battery under load
- ❑ Install battery in altimeter
- ❑ Secure battery in place with wire tie
- ❑ Altimeter properly programmed and verified
- ❑ Ready avionics bay for altimeter
- ❑ Install altimeter in rocket
- ❑ Insure all pyrotechnics are in disarmed mode during electronics final installation

3.3.1.4 Pyrotechnics

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

Pyrotechnics, drogue

- ❑ Prepare aft deployment pyrotechnic device and ready for installation into rocket
- ❑ Load aft charge into rocket, insure at all times the devices are safe until final launch readiness
- ❑ Connect aft pyrotechnic leads to electronic deployment devices drogue chute connections
- ❑ Utilizing external disarming mechanisms to insure all electronically discharged pyrotechnics are disabled until final launch readiness

Pyrotechnics, main

- ❑ Prepare forward deployment pyrotechnic device and ready for installation into rocket.
- ❑ Load forward charge into rocket, insure at all times the devices are safe until final launch readiness
- ❑ Connect forward pyrotechnic leads to electronic deployment devices main chute connections
- ❑ Utilizing external disarming mechanisms to insure all electronically discharged pyrotechnics are disabled until final launch readiness

3.3.1.5 Motor Installation

- ❑ Install motor
- ❑ Install motor retaining devices
- ❑ Insure all electronic deployment devices are in the non-dischargeable safe mode

3.3.1.6 Final Launch Preparations

Load Rocket on Pad

- ❑ Prepare launch pad
- ❑ Load rocket on launch rail

Prepare Igniter

- ❑ Insert igniter. Be sure it is completely forward and touching fuel grain
- ❑ Secure igniter in position
- ❑ Assure that launcher is not hot. Disconnect battery from relay box. Assure that key IS NOT remote device and that arming switch is off
- ❑ Attach leads to ignition device
- ❑ Be sure all connectors are clean
- ❑ Be sure they don't touch each other or that circuit is not grounded by contact with metal parts
- ❑ Check tower's position and be sure it is locked into place and ready for launch
- ❑ Assure that key IS NOT remote device and that arming switch is off

- ❑ Connect battery to relay box

Final Launch Sequence

- ❑ Arm all devices for launch.
- ❑ Insure Flight Witnesses are in place and ready for launch
- ❑ Signal LCO & RSO that rocket is ready for launch

Misfire Procedures

- ❑ Safe all pyrotechnic to pre-launch mode
- ❑ Remove failed igniter
- ❑ Resume checklist at "Final Launch Preparations/Prepare Igniters"

3.3.1.7 Post-Recovery Checklist

This is the post-flight checklist as required as part of the flight. This checklist includes steps required to ensure the rocket is in a safe condition after completion of a flight

Normal Post Flight Recovery

- ❑ Check for non-discharged pyrotechnics.
- ❑ Safe all ejection circuits
- ❑ Remove any non-discharged pyrotechnics.

Flight Failure Checklist

- ❑ Disarm all non-fired pyrotechnic devices
- ❑ Continue Normal Post Flight Recovery procedures

Launch system and platform

- ❑ Launch system is an electrically controlled and safety 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 Vehicle Launch Operations

This is the launch operations checklist. This checklist is to be used on launch day for vehicle launch.

- ❑ Determine flight conditions (temperature, wind, barometric pressure, etc.)
- ❑ Prepare the rocket for flight per the flight preparation instructions above
- ❑ Set rocket on launch pad
- ❑ Clear the launch area in case of pre-mature ignition of ematches
- ❑ Arm the electronics
- ❑ Arm the igniter
- ❑ Second call to clear the launch area
- ❑ Countdown to launch
- ❑ Launch Rocket
- ❑ In case of a misfire, follow mis-fire procedures above

- Locate rocket with tracking device
- Safely retrieve rocket
- Make sure rocket is safe before retrieving altimeter telemetry and payload telemetry
- Perform download of telemetry data for study and validation

3.5 Safety and Environment

3.5.1 Safety Officer

Our team safety officer is Katlin Wagner.

3.5.2 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 are 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

3.6 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. The Material Safety Data Sheets on all of these materials are at http://www.4hrocketry.com/materialsafetydatasheets.

Flight hazards are a large consideration with a project of this size. Engine failure, recovery device failure, and stable 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.

3.7 Environmental Concerns

The team has the potential of using several different launch sites in the Southeastern 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 addition, the team will consult with sponsoring clubs to ensure fire hazards risks are minimized and proper fire equipment is on hand at all launches.

4 Payload Criteria

4.1 Payload Design

The experiment uses an assembly that can generate electricity from the oncoming flow of the wind against the rocket. It contains:

- Wemotec Mini Fan 480 – The ducted fan assembly - 2.5“ blades
- eLogger V3 Data Recorder – measures RPM, Watts, Temperature, Volts, Amps
- Maxon– 15 Watt brushed DC motor

Payload assembly is built inside of a standard tube coupler; slides into short section of 4” fiberglass tube. Four 1.5” air ducts are spaced around the outside of the payload tube. The payload is about 11” long.

4.1.1 Experiment Design of Payload

Fan Blades

The fan blades are part of a pre-assembled ducted fan commonly used in RC aircraft. It is mounted on 4 plywood blocks that have 4 wood screws securing it to the payload. In our test launch, the fans reached over 37,000 RPM. These blades are proven to work at high speeds. The blade assembly fits within a tube coupler, which has an inside diameter of 3.7 inches. The fan blades are directly connected to the motor shaft.

Generator

Our generator is a 15-watt Maxon REmax-29 motor. It has a small shaft coming out of one end, which is attached to the threaded adapter. The fan blades are screwed onto this threaded adapter.

All motors are rated for a maximum number of RPM that they can handle. Our motor was specifically selected for low torque and high output. A disadvantage of our motor, however, is that it is only rated for 11,000 RPM. We are going to be going over 3 times this. After the testing we have performed on this motor, we think it will handle it because it will only be stressed for a short period of time.

Circuit Components

The circuit's main component is the Eagle Tree Systems eLogger V3, which is used to measure the electricity the generator produces. The resistor wired to the eLogger acts as a load on the circuit. The generator is the electrical source. To collect data we also have a RPM sensor by the fan blade shaft. To do this we put 2 small magnets in the shaft and epoxied the sensor perpendicular to it to sense the magnetic fields as they spin by. A temperature sensor is located below the fan blades.

A design concern is limiting – or measuring – the amount of generated current used by the data logger to carry out its operations. The circuit has to be able to handle more than the maximum current output of the generator so that it does not overload in mid-flight. Figure 5 is a circuit diagram of the electrical components of the payload. The eLogger must be hooked up to four lithium ion batteries providing 6 volts so it can power itself to record data. If this was not done, the eLogger would try to use the power generated from the motor, and we would not be able to measure any data until the voltage exceed 4.5v.

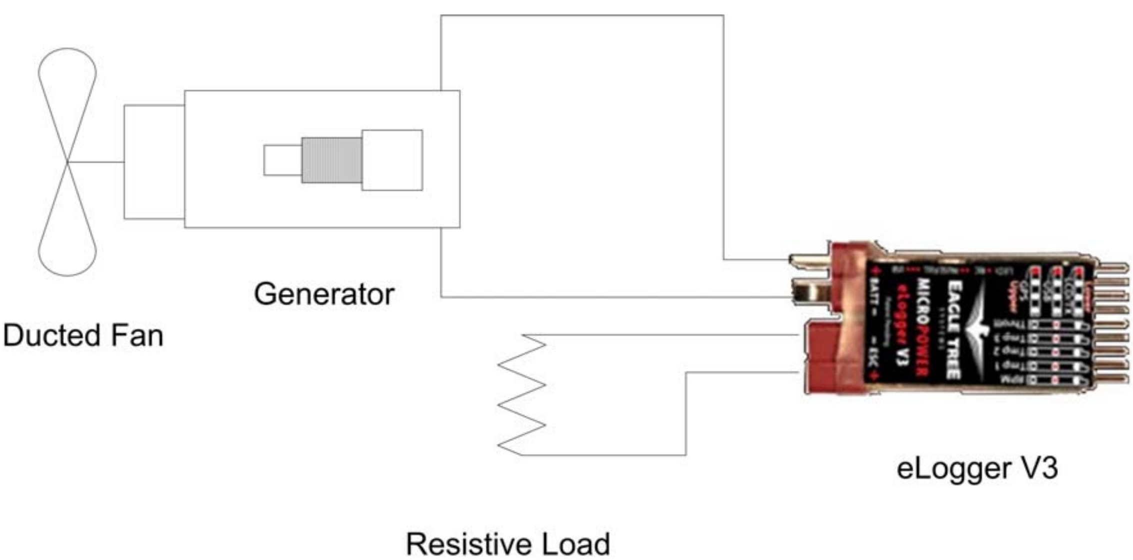


Figure 5 - Circuit Diagram

Payload Housing

The payload consists of one inner coupler assembly that contains all of the electronics and ducted fan parts. It slides into the airframe tube from the back (bottom) and is secured from the sides. The subassembly is attached to the airframe with screws and pem nuts at six points.

Ducting

The ducts direct the air to the outside of the rocket. This increases maximum airflow through the fan. However, even with the ducts there will be some pooling of air behind the fans because of the velocity of the rocket. If there are no vents then the air cannot properly go through the fan and it will create unwanted drag, reducing the RPM of the fan blades.

The ducting consists of four holes passing through both the inside and outside tubes. Each is 1.5” in diameter. The air flows through the fans, around the generator and out the sides. Their size was calculated by taking the swept area of the fan blades, multiplied it by 1.5 (so we would get 150% of original area) and dividing it by four. That came out to be 1.5” holes.

4.1.2 Workmanship

We have secured the payload with six pem nuts to keep it tight. In addition, the payload section has a boat tail JB welded onto the front of the tube to direct air towards the fan. This also doubles as a secure block that butts up against the payload sleeve. The entire payload structure is made from fiberglass and is held together by JB Weld. Since it has a coupler and a tube on the outside its walls are twice as thick.

The electrical part of the payload took a lot of soldering. We took time to make sure it was wired correctly. We have also learned new soldering techniques. We have reduced the chance of the circuit shorting by using liquid tape and electrical tape on all exposed wires.

To run tests in the wind tunnel we built a prototype of the payload. Through our wind tunnel testing, we found that we could make a few modifications to the design to make it more efficient. These included adding a switch so we can cut the amount of time between hooking up the circuit and recovering the rocket. We added 2 more mounting points on the fan assembly to keep it from shaking during flight. In the prototype our circuit components were loose inside the sleeve. This could have caused it to short or damage internal components from the shaking. To solve this problem we drilled holes in the fiberglass board of the final payload. These holes let zip ties rap around the components so they do not move as shown in Figure 6.

Figure 6- Payload Bay

4.1.3 Precision of Measurement

The on-board data collection system is compromised of the Eagle Tree System's eLogger V3. It is has the ability to measure current, volts, watts, temperature, and blade RPM. This was chosen because the electric output of the generator needs to be measured and RPM of the fan needs to be recorded. The base unit weighs only 20 grams. The wiring harnesses for the data collected will add a small amount of weight. Post-flight the eLogger connects via USB to a laptop computer to upload the data recorded during the flight. The software that comes with the eLogger provides virtual playback and graphing of volts, amps, watts, and RPM over time.

The eLogger specifications include:

- Voltage: 5V-70V with 0.02V resolution
- Current: up to 100A with 0.02A resolution
- Current Draw: 30mA with no sensors
- Temperature: 0 – 424° F
- RPM: 100-50,000+

- Size: 2.25” x 1” x 0.5”
- Logging Rate: 1 – 10 samples per second

The eLogger can run at full fidelity of logging all inputs at 10 samples per second. However, this takes up much of its internal memory. We have opted to only record four samples per second because it still gives us a good amount of data without running out of memory. If we use up all the memory, the old data will continuously be deleted as new data replaces it. With our solution, we hope to avoid this.

4.1.4 Testing and Analysis Results

We built a prototype out of paper tubing to test the concept before making a final design out of fiberglass. It also gave us a chance to make improvements to the design that was not seen on paper. We tested our payload prototype in a wind tunnel at the University of Wisconsin Madison with Dr. Riccardo Bonazza. The wind tunnel was capable of speeds up to about 200 miles per hour. We brought it to full speed to try to get as much electricity as possible out of the motor and to test the strength of the fan assembly. We took data points at certain times and recorded the velocity. We then plotted it as shown in Figure 7.

After test launching the rocket, we learned more about how the payload will act in flight. Once we recovered the rocket after launch, we found that the fan blades had come out of the fan assembly. This was because one of our nuts unscrewed itself from the centrifugal forces. The data recorded from the eLogger measuring RPM of the fans, showed the blades came out at ejection of the drogue chute. In the graph below, we marked the spot where the fan blades peaked in RPM which was right at burnout when the rocket was going at maximum acceleration.

In the wind tunnel the data points are linear. This is because we slowly brought up the speed and the air coming out did not pool up behind the fans causing them to slow down. During the launch we think that it went so fast the air got caught up and created more pressure behind the fans and slowed them down.

After looking at the electrical data recorded in the wind tunnel and after the test launch we found that they gave the same exact output according to the eLogger. We have tried testing the elogger with a power source and found that it functioned as it should have. This leads us to the conclusion that the generator is not producing electricity. Additional bench testing of the payload is being performed to diagnose the issue.

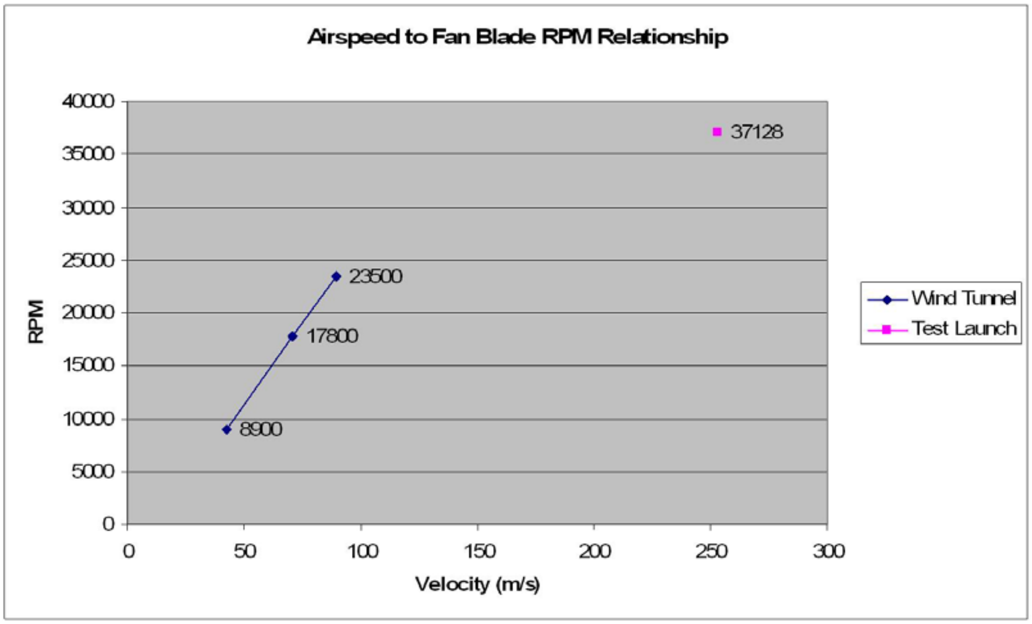


Figure 7- Test Results

4.1.5 Flight Performance Predictions

We expect the rocket to have a stable flight and generate a small amount of electricity during flight. The circuit is under going modification and testing to make sure it will record the current during flight.

4.1.6 Assembly of Payload

Screw mounts are used in the forward airframe and coupler to attach the turbine blade assembly. The entire payload (turbine blades, generator and circuit board assembly) is housed within a coupler sleeve and slides into the payload tube from the bottom. The sleeve is attached from the outside with six screws. The venting ducts are immediately below the fans so as much air as possible is sent right through the holes and out of the rocket. The duct holes in the outer tube and in the inner coupler are automatically aligned when the six screw holes in both tubes are aligned and secured.

To secure the fan assembly we had to drill wood screws through the inner coupler. The holes are recessed so it still slides into the outer tube.

4.1.7 Application of Engineering, Functionality, and Feasibility

Our payload is built for strength and the ability to accomplish our goal. It has been engineered considering all of the tasks and forces it must meet. Zip ties hold down the circuit components so they do not move during launch. The batteries are high-end lithium ion so they do not fail before we recover the data. They also were chosen for their relatively light weight compared to other battery technology. The fan assembly is secured by four wood screws so it does not rock during flight. With massive amounts of air coming through the fan blades, we had to design the payload to handle the pressure. For venting, we cut four 1.5” holes in the sleeve and outer tube to let air pass through.

We also fiberglassed a fitted paper cone to redirect airflow outwards, as show in figure 8. This was JB welded to the upper bulkhead.

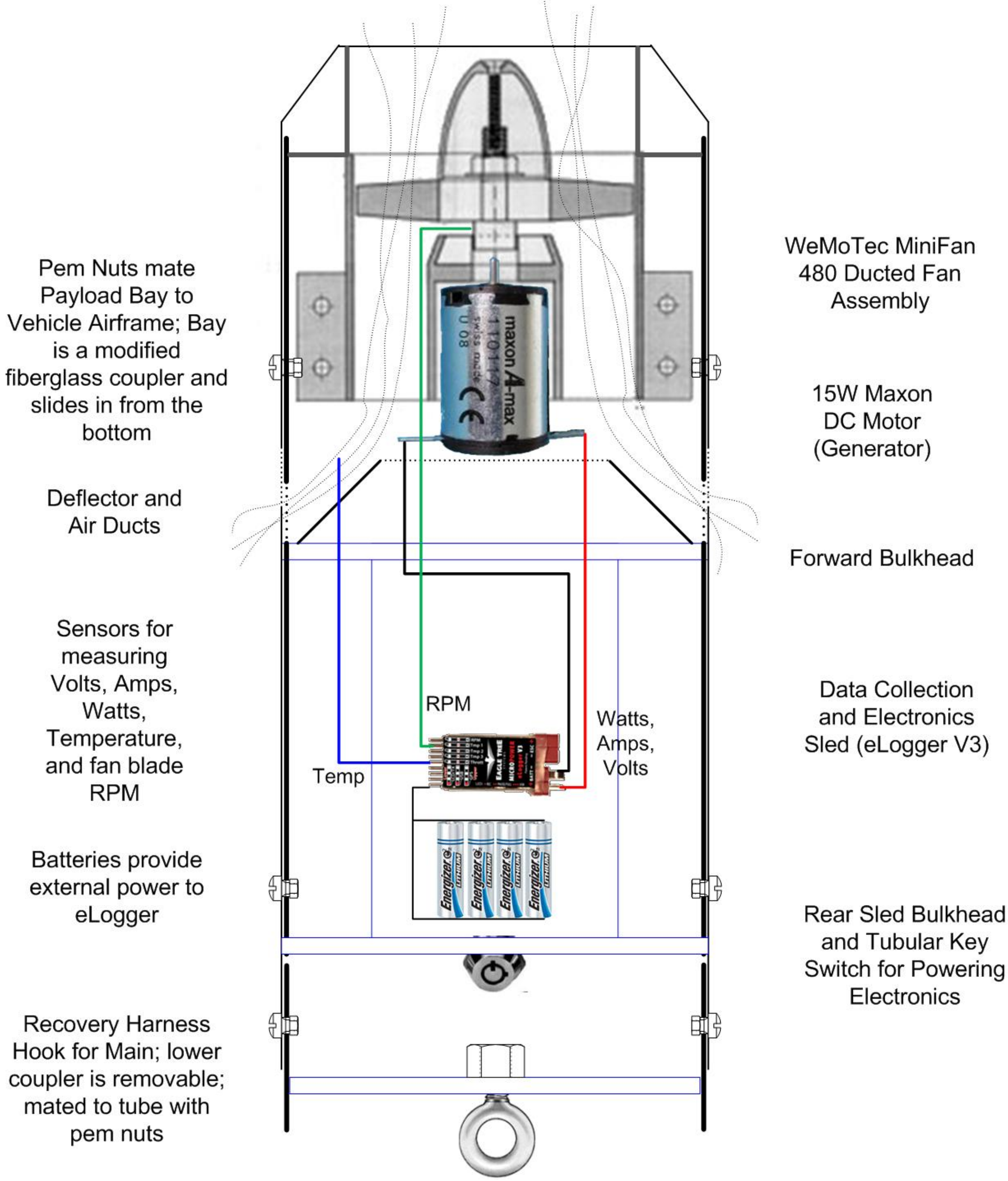


Figure 8- Payload Schematic

4.1.8 Flight Preparation Procedures

To make sure the payload will function in flight we must go through a checklist of all the things that must be done to prepare it for launch.

Pre-Flight Checklist

- Secure motor into the fan assembly
- Attach Fan blades to the motor
- Test batteries – must be at least 6 volts
- Mount the fan assembly in the coupler tube –with 4 flat head wood screws
- Secure wires and eLogger onto the sled
- Wire eLogger and components
- Double check everything is secure and connected correctly
- Check the circuit
- Slide in coupler and screw into pem nuts
- Add clay around the top of fan assembly and around the motor
- Turn on switch to power electronics
- Secure airframe coupler (for main parachute) to bottom portion of airframe tube

4.2 Payload Concept Features and Definition

4.2.1 Creativity and originality

The experiment the team chose is unique because, to our knowledge, no one has ever attempted to put this type of payload in a high-powered rocket before. The extra drag and turbulence from the irregular nose is the main issue. It can affect the stability and performance of the rocket greatly. The team also has to build an electrical circuit into the payload.

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. The United States 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.

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 the 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 the team predicts.

4.3.3 Experimental logic, approach and method

The 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 variables 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 4, the power efficiency of the system can be computed.

A wind turbine extracts energy from moving air by slowing the wind down and converting the extracted energy to mechanical energy by way of a spinning shaft. The shaft then converts the energy into electrical energy using an alternator or generator. The power in the wind available for extraction depends on both the wind speed and the area that is swept by the turbine blades. Wind is made up of moving air molecules. Although each molecule's mass is very small, it is the movement of this mass that results in the kinetic energy that we are attempting to harness. Any moving object with mass carries kinetic energy in an amount given by equation 1:

$$\textbf{Kinetic Energy} = 0.5 * \textbf{Mass} * \textbf{Velocity}^2 \qquad \text{(Eq. 1)}$$

where the mass is measured in kg, the velocity in m/s, and the energy is given in joules.

Air has a known density (around 1.23 kg/m^3 at sea level at 15°C), so the mass of air hitting the wind turbine (which sweeps through a fixed area) each second is given by the following equation:

Mass/sec = Velocity * Area * Air Density

(Eq. 2)

where the air density is in kg/m^3. The power (i.e. energy per second) in the wind hitting a wind turbine with a certain swept area is given by substituting the *mass per second* calculation into the standard kinetic energy equation resulting in the following equation:

Power = 0.5 * Swept Area * Air Density * Velocity^3

(Eq. 3)

where **Power** is in watts (or joule/second),

Swept area is pi*r^2 (r == radius of the swept area, or blade length, in meters),

Air density in kilograms per cubic meter, and

Velocity in meters per second.

This equation shows that when the swept area of the turbine doubles, the power also doubles, but when the wind speed doubles, the power available increases by a factor of 8.

It is not possible to extract ALL of the energy in wind and convert it to electricity. In 1919 a German physicist, Albert Betz, calculated that there's a limit to how much power a turbine blade can extract from the wind. He found that no wind turbine can convert more than 16/27 (or 59.26%) of the kinetic energy of the wind into mechanical energy turning a shaft. This fact is now known as the Betz Limit or Betz' Law. Beyond the Betz Limit of 59.26%, more and more air tends to go around the turbine rather than through it, with air pooling up in front. So 59.26% is the absolute maximum that can be extracted from the available power.

There are additional losses as well. Small wind turbine blades are never 100% efficient, even when running at their optimal speed and no generator is 100% efficient in converting the energy in a rotating shaft to electricity due to friction losses from bearings and gearing, and due to magnetic drag and electrical resistance losses in the generator. Even the best commercial wind turbines today only convert between 35-45% of the energy in the wind.

Modifying Equation 3 for the power efficiency of the machine:

Effective Power = Cp * 0.5 * Swept Area * Air Density * Velocity^3

(Eq. 4)

Where Cp is the power efficiency.

5 Safety and Environment

5.1 Safety Officer

The team safety officer is Katlin Wagner.

5.2 Vehicle Safety

5.2.1 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.
	Altimeters fire while on the launch pad.	Injury to Personnel.	10	Static discharge; handling of rocket while armed	1	**20**	Use external safing switches; arm altimeters as last step of launch pad procedures
	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 are 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; set mach delay
Propulsion	CATO	Rocket does not reach desired altitude.	10	Faulty motor.	1	**10**	Ensure motor is assembled correctly and forward enclosure is on tightly.
	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 fiberglass centering rings

5.2.2 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, JB Weld, and fiberglass dust. 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. Handling of the black powder and the rocket motors also poses a risk. 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 soundest rocket design being placed on the pad at launch time.

5.2.3 Environmental Concerns

The team has the potential of using several different launch sites in the Southeastern Wisconsin / Northern Illinois area. These launch sites are multi-use recreational sites used by different groups and organizations. All site restrictions posted will be followed and proper safety equipment will be checked to make sure it is onsite.

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

5.3 Payload Safety

5.3.1 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	Fan Falls Out	4	**28**	Put loc-tight on the screw to assure security
		Experiment is unseccessful	6	The motor mount screw come out	4	**24**	Put loc-tight on the screw to assure security
		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.

5.3.2 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 team's electrical engineer advisor, Mr. Decker, will train us on any additional risks in the circuitry.

5.3.3 Environmental concerns

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

6 Project Management

6.1 Budget plan

Qty	Item Description	Manufacturer	Cost
Full-scale Rocket			
1	Full-scale Rocket	Performance Rocketry	$150
1	Centering Ring	Public Missiles	$5
1	Main Chute - 60”	Top Flight Recovery	Donated
1	Drogue -18”	Top Flight Recovery	Donated
1	Coupler	Loc Precision	$4
1	Motor Retainer	Aero Pack	$34
1	54mm Motor Mount	Public Missiles Ltd.	$50
1	Recovery Harness	Giant Leap	$60
	Miscellaneous Nuts and Bolts for Payload	Various	$25
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 - 36”	Top Flight Recovery	Donated

1	Drogue -18"	Top Flight Recovery	Donated
1	Motor Retainer	Aero Pack	$29
1	Recovery Harness	Giant Leap	$60
	Miscellaneous Nuts and Bolts for Payload	Various	$25
Propulsion			
1	I218R	Animal Motor Works	$30
2	K700W	Animal Motor Works	$200
Payload			
1	3" RC Ducted Fan Assembly	RC Motor Fan	$65
1	1.5" RC Ducted Fan Assembly	RC Motor Fan	$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 (offset by fee)
2	Educator packs (24 count) of A3/4T	Estes	$75
18	Triskelion Kits	Fliskits Inc.	$155 (offset by fee)
1	Educator pack (24 count) of B6-4	Estes	$50
	Miscellaneous supplies	Various vendors	$30
Miscellaneous Items			
	Building supplies (epoxy, JB Weld, syringes, gloves)		$200
High-Level Cost Estimate:			$2201

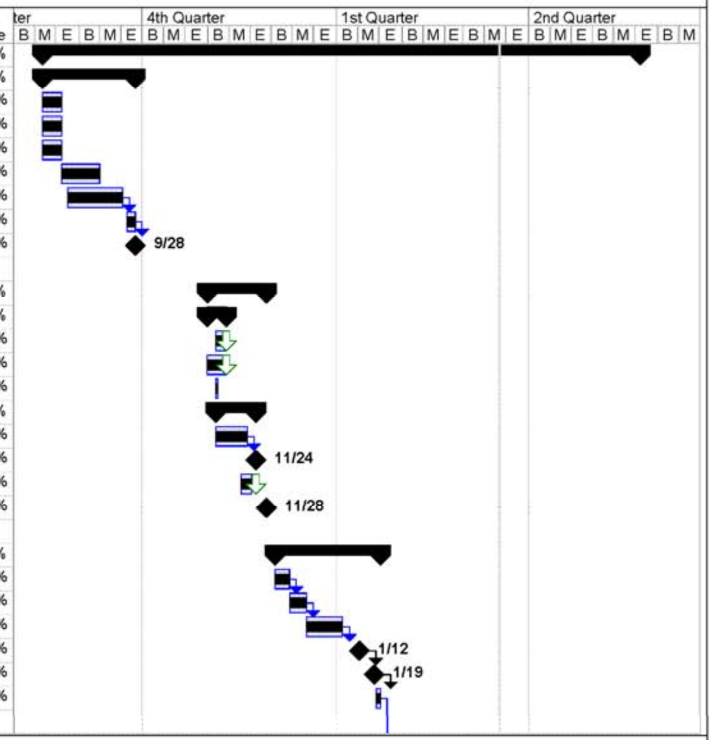
6.2 SLI Project Plan

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**	**82%**
2	**RFP (Request for Proposal)**	**44 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	0 days	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**	**100%**
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**	**18 days?**	**Mon 11/5/07**	**Sat 11/24/07**	**100%**
17	Re-work initial design	15 days	Mon 11/5/07	Mon 11/19/07	100%
18	Review design with team	0 days	Sat 11/24/07	Sat 11/24/07	100%
19	Payload - vehicle integration	5 days?	Sat 11/17/07	Wed 11/21/07	100%
20	PDR due to NASA	0 days	Wed 11/28/07	Wed 11/28/07	100%
21					
22	**Half Scale Rocket**	**49 days**	**Mon 12/3/07**	**Mon 1/21/08**	**100%**
23	Finalize design	7 days	Mon 12/3/07	Sun 12/9/07	100%
24	Order parts	8 days	Mon 12/10/07	Mon 12/17/07	100%
25	Construction	16 days	Tue 12/18/07	Thu 1/3/08	100%
26	Launch half-scale	0 days	Sat 1/12/08	Sat 1/12/08	100%
27	Backup launch date	0 days	Sat 1/19/08	Sat 1/19/08	100%
28	Validate Results	2 days	Sun 1/20/08	Mon 1/21/08	100%
29					



Project: 4-H SLI Project FRR v1
Date: Tue 3/18/08

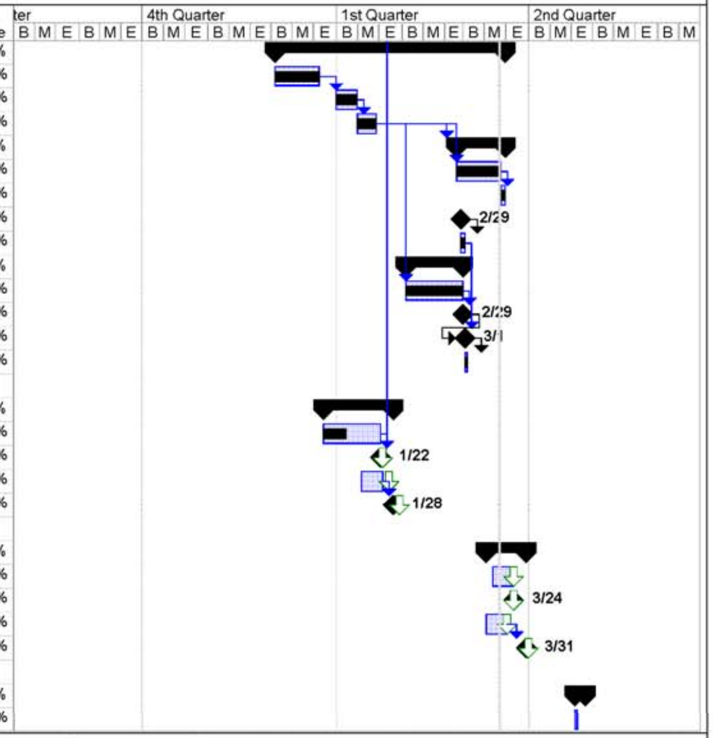
Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Page 1

Washington County 4H
SLI Project

2007-2008

ID	Task Name	Duration	Start	Finish	% Complete
30	**Full Scale Rocket**	**108 days?**	**Mon 12/3/07**	**Thu 3/20/08**	**100%**
31	Finalize payload design	21 days?	Mon 12/3/07	Sun 12/23/07	100%
32	Finalize rocket design	10 days	Tue 1/1/08	Thu 1/10/08	100%
33	Order parts	9 days	Fri 1/11/08	Sat 1/19/08	100%
34	**Payload**	**23 days**	**Wed 2/27/08**	**Thu 3/20/08**	**100%**
35	Construction	21 days	Wed 2/27/08	Tue 3/18/08	100%
36	Electronics testing	2 days	Wed 3/19/08	Thu 3/20/08	100%
37	Wind tunnel testing	0 days	Fri 2/29/08	Fri 2/29/08	100%
38	Analyze results	2 days	Fri 2/29/08	Sat 3/1/08	100%
39	**Vehicle**	**27 days**	**Sun 2/3/08**	**Fri 2/29/08**	**100%**
40	Vehicle Construction	27 days	Sun 2/3/08	Fri 2/29/08	100%
41	Recovery subsystem testing	0 days	Fri 2/29/08	Fri 2/29/08	100%
42	Launch full-scale	0 days	Sat 3/1/08	Sat 3/1/08	100%
43	Analyze Results	1 day?	Sun 3/2/08	Sun 3/2/08	100%
44					
45	**CDR (Critical Design Review)**	**33 days**	**Wed 12/26/07**	**Mon 1/28/08**	**29%**
46	Create CDR document	27 days	Wed 12/26/07	Mon 1/21/08	40%
47	CDR due to NASA	0 days	Tue 1/22/08	Tue 1/22/08	0%
48	Create CDR presentation	10 days	Sun 1/13/08	Tue 1/22/08	0%
49	CDR presentation to NASA	0 days	Mon 1/28/08	Mon 1/28/08	0%
50					
51	**FRR (Flight Readiness Review)**	**19 days**	**Wed 3/12/08**	**Mon 3/31/08**	**0%**
52	Create FRR document	10 days	Sat 3/15/08	Mon 3/24/08	0%
53	FRR Due to NASA	0 days	Mon 3/24/08	Mon 3/24/08	0%
54	Create FRR presentation	10 days	Wed 3/12/08	Fri 3/21/08	0%
55	FRR Teleconference w/ NASA	0 days	Mon 3/31/08	Mon 3/31/08	0%
56					
57	**SLI in Huntsville**	**5 days?**	**Wed 4/23/08**	**Sun 4/27/08**	**0%**
58	Travel	1 day?	Wed 4/23/08	Wed 4/23/08	0%



Project: 4-H SLI Project FRR v1
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Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

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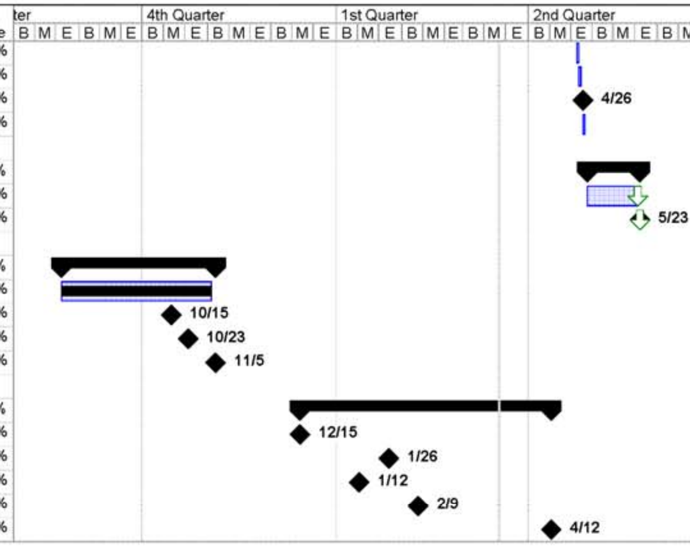
Washington County 4H
SLI Project

2007-2008

ID		Task Name	Duration	Start	Finish	% Complete
59		Rocket fair	1 day?	Thu 4/24/08	Thu 4/24/08	0%
60		Hardware Check	1 day?	Fri 4/25/08	Fri 4/25/08	0%
61		Launch day	0 days	Sat 4/26/08	Sat 4/26/08	0%
62		Return home	1 day?	Sun 4/27/08	Sun 4/27/08	0%
63						
64		**PLAR (Post launch analysis review)**	**19 days**	**Tue 4/29/08**	**Fri 5/23/08**	**0%**
65		Create PLA document	18 days	Tue 4/29/08	Thu 5/22/08	0%
66		PLAR Due to NASA	0 days	Fri 5/23/08	Fri 5/23/08	0%
67						
68	✓	**Miscellaneous**	**73 days?**	**Fri 8/24/07**	**Mon 11/5/07**	**100%**
69	✓	Identify Level 2 mentor	71 days?	Fri 8/24/07	Fri 11/2/07	100%
70	✓	SLI Teams Announced	0 days	Mon 10/15/07	Mon 10/15/07	100%
71	✓	SLI teleconference	0 days	Tue 10/23/07	Tue 10/23/07	100%
72	✓	Team website live	0 days	Mon 11/5/07	Mon 11/5/07	100%
73						
74		**Community Outreach**	**118 days**	**Sat 12/15/07**	**Sat 4/12/08**	**0%**
75	✓	Cloverbuds rocket workshop	0 days	Sat 12/15/07	Sat 12/15/07	100%
76	✓	Tri-County SET workshop	0 days	Sat 1/26/08	Sat 1/26/08	100%
77	✓	January county-wide meeting	0 days	Sat 1/12/08	Sat 1/12/08	100%
78	✓	February county-wide meeting	0 days	Sat 2/9/08	Sat 2/9/08	100%
79		April county-wide meeting	0 days	Sat 4/12/08	Sat 4/12/08	0%



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

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7 Outreach Summary

Community outreach currently includes two activities. There was a meeting conducted on December 15, 2007 for the Washington County Cloverbud workshop. Cloverbuds is designed for 4-H youth in 1st through 3rd grade. There were approximately 40 kids in attendance that constructed and launched a Watchamacallit from Fliskits. In addition to learning basic construction techniques and rocket safety the kids were able to launch their newly constructed rocket using Estes ½ A3-4T 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 leading the Washington County 4-H countywide aerospace leaders to conduct a workshop on January 26, 2008. The workshop will be geared towards 5th grade (and older) youth to expose them to rocketry at the Tri-County workshop in Sheboygan, Wisconsin. At this workshop kids will be constructing and launching a Triskelion from Fliskits. This workshop will teach youth and parents how to construct and fly a model rocket and the 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. Our county 4-H rocketry program currently has 31 youth enrolled in rocketry and aerospace related projects.

8 Conclusion

As of FRR we are making the final adjustments for the launch in Huntsville. The circuit is being redesigned to efficiently generate and measure electricity. The team is confident that they will be ready to launch.

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