NASA Student Launch Initiative 2008-2009

Technical Proposal

Submitted To:

NASA/George C. Marshall Space Flight Center
Procurement Office, PS22
NASA Marshall Space Flight Center
Huntsville, AL 35812

Go GREEN
Generate REnewable ENergy

Submitted By:

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

In Response To:

Request for Proposal
for the
2009 NASA Student Launch Initiative (SLI),
Design, Development & Launch of a Reusable Rocket & Science Payload

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1 Washington County 4-H Team Information

1.1 Title of Project

Go GREEN - Generate REnewable ENergy

This year the project is building off what we learned last year in SLI. We are tripling the number of wind turbine generators, converting the available wind energy more efficiently, and are adding thermoelectric heat exchangers that will capture a small portion of the waste heat energy of the rocket motor. The three wind turbine generators will be mounted inside tube fins on the outside of the rocket and thermoelectric heat exchangers will be attached to the motor mount. This generated electricity will be used to power an on board flight camera which will transmit live video back to a receiver on the ground.

1.2 Organization Details

4-H is a national youth leadership and educational program coordinated in Wisconsin by the UW-Extension Service. Youth who are nine or in third grade to eighteen years old may enroll in 4-H. Parents and adults are encouraged to be leaders. 4-H is open to anyone regardless of race, color, creed, sex, national origin, disability, religion or ancestry. Over 80% of the youth in 4-H are from town and urban areas. 4-H is the largest youth organization in Wisconsin with 150,000 youth members and 30,000 adult volunteers.

4-H Club members enroll in projects, exhibit at the county fair, keep a record book, help organize programs, elect club officers, and conduct meetings with guidance from other youth and adult leaders.

A 4-H project is an area of investigation that members sign up for. They can pursue anything they might choose to do or like to learn about. Projects are selected based on the member's individual interests. Members receive project literature to use as a reference, and with guidance from adult and youth leaders they work throughout the year on different activities in the project. Finally, the members can exhibit items at the county fair that show what they did or learned in the project.

The Washington County 4-H Rocketry Program was formed to promote aerospace and rocketry and supports the partnership between 4-H and the National Association of Rocketry (NAR). Our county's rocketry project meets once per month from January through May, and more frequently in the summer, where the basics of model & mid-powered rocketry are covered, along with proper rocket construction techniques. Experienced rocketeers learn how to design and build rockets of their own design.

Contact information for the SLI team:

Washington County (WI) 4-H Rocketry
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814 Century Court
Slinger, WI53086

Team Email: 4hrocketry@gmail.com

4-H PLEDGE

4-H'ers everywhere are linked in many ways, especially by the 4-H pledge that they all recite:

I pledge...

My HEAD to clearer thinking,
My HEART to greater loyalty,
My HANDS to larger service,
My HEALTH to better living for my club, my community, my country, and my world.

4-H MOTTO

"To Make The Best Better"

1.3 Administrative Staff

The 4-H rocketry program is administered through the Washington County (Wisconsin) 4-H Youth Leaders Association. Ms. Kandi O'Neil is the 4-H Youth Development Educator coordinating the 4-H program in Washington County through the UW-Extension in the State of Wisconsin.

Two adult leaders, Mr. Doug Pedrick and Mr. Patrick Wagner, lead the 4-H Rocketry Program. In conjunction with the Youth Leaders Association and Ms. O'Neil, they administer all aspects of the rocketry program including promotion, planning, coordination, budgeting, youth meetings, launch dates, and fair projects.

1.4 Mentors

Mr. Doug Pedrick

Mr. Pedrick is a National Association of Rocketry (NAR) member, has been a 4-H rocketry leader for 5 years, and is co-leader of the Washington County, Wisconsin 4-H Rocketry program. He has been involved in rocketry on and off for the past 35 years. He is also an avid woodworker (with a basement full of power tools) and an amateur astronomer. When not mentoring 4-H members, he works as a Senior Software Architect for GE Healthcare.

Email: doug@4hrocketry.org

Phone: 414.531.6094

Mr. Patrick Wagner

Mr. Wagner is a NAR member, has been a 4-H rocketry leader for 3 years, and is co-leader of the Washington County, Wisconsin 4-H Rocketry program. His interest in rocketry started In 6th grade as a youth and started again through his involvement as an adult leader in the 4-H program. He is an avid outdoorsman enjoying fishing, hunting and archery. He is a manager in the Delivery Excellence and Quality (DEQ) division of the IT department at Northwestern Mutual.

Email: pat@4hrocketry.org

Mr. Ed Kruel

Ed is Tripoli and NAR Level 3 certified and brings a great deal of experience, enthusiasm, and general wackiness to the team.

1.5 Student Team Members

Ben

Ben is a sophomore at Slinger High School in Slinger, WI. He has been building rockets in 4-H for over 6 years and has been on three 4-H TARC teams that have participated at the national finals. Through his involvement in 4-H, he also has had experience in woodworking and using shop tools safely. He plays tenor saxophone in the high school band, is a cast member in the school musical, is on the debate and Science Olympiad teams, and is the current Vice President of the Hi-Lite Happy Workers 4-H Club. He plans to pursue a career in mechanical or aerospace engineering.

Katlin

Katlin is a sophomore at Slinger High School in Slinger, WI. She has been building rockets in 4-H for 5 years and has been on two 4-H TARC teams that have participated at the national finals in Great Meadow, Virginia. In addition to rocketry, Katlin has been involved in several 4-H projects including being a youth leader for 3 years in the Shooting Sports program. She attended 4-H space camp in Huntsville Alabama in April 2007, and has attended the Wisconsin 4-H Leadership Conference in 2007. She also, enjoys hunting with her father during the fall season. She enjoys playing being a part of the Slinger High School Color Guard Squad and being able to take a part in Student Council. In the future, she hopes to pursue a career in Aerospace Engineering!

Isaac (Iceman)

Isaac is an 8th grader at Silverbrook Middle School in West Bend, WI. This is his first year in 4-H rocketry and may join TARC too. He plays hockey in the winter and baseball in the summer. His favorite subject at school is math. Isaac has been skating since he was 1 ½ years old and has been playing on a travel ice hockey team since he was four, and that is how he got the nickname Iceman. He enjoys playing any of the forward positions in hockey and outfield and catcher in baseball. He hopes to go to college, be a professional hockey player and become an engineer. He is looking for a degree at Michigan Tech or UW-Madison.

1.6 Team Roles

Since we are a moderately small team, there is a risk that the amount of work could be overwhelming. However, two of us were in SLI last year, and we are confident that our new team member will be able to make significant contributions to the project. We feel we are fully aware of the amount of time required to be successful and are committed to this project. Team member roles on this project are shown in Figure 1.

Role	*Team Member*
Project Manager	Katlin
Vehicle Design	Ben, Isaac
Rocket Construction	Ben, Isaac
Payload Specialist	Isaac, Ben
Outreach	Katlin
Safety Manager	Katlin
Web Designer	Katlin

Figure 1. Team Roles

2 Facilities and Equipment

2.1 Facilities

Since we are a 4-H group, we do not have the luxury that most school teams enjoy, where they have access to shop equipment, conference rooms, sheds, computers, etc. Instead, we will rely on facilities, tools, equipment, and computer resources owned by the families of the team members. Primary design activities will take place in the homes of our mentors, Mr. Pedrick and Mr. Wagner.

Figure 2. Rocket Construction Facility

Our high-powered rocket launches will take place at Princeton, Illinois. These launches are conducted by Tripoli or NAR sections, who are responsible for enforcing all flight safety rules.

Our scale rocket launches will take place at the Erin Soccer Fields, Town of Erin, Wisconsin, provided we use a G powered motor or less. If the scale rocket exceeds 1 lb in weight, we will notify the FAA as required.

2.2 Equipment and Supplies

Mr. Pedrick or Mr. Wagner owns the tools necessary to construct, test, and launch the rocket(s). These include, but may not be limited to, the following:

- Table Saws
- Band Saws
- Dremel Tool and Accessories
- Drill Press
- Electric Hand Drill
- Hand Sander
- Belt Sander
- Soldering Iron

- Exacto Knives
- Utility Knives
- Scissors
- Pliers
- Wrenches
- Screwdrivers
- Standard rail launcher

2.3 Computer Equipment

Each team member has access to modern PC equipment, email, instant messaging, and hi-speed Internet access.

2.3.1 Rocket Design

The primary workstation for rocket design shall, at a minimum, consist of:

Hardware

- Dell Dimension 5100, Pentium 4, 3GHz, 1GB RAM, Microsoft XP SP2
- Cable modem (5Mbit downlink, 784Kbit uplink)

Software

- Rocksim 8
- MS Word
- MS Excel
- MS PowerPoint
- MS Outlook
- MS Project
- Gimp
- Adobe Acrobat/Reader
- SnagIt

2.3.2 Website

We will be using our team website from last year, at http://www.4hrocketry.org; a domain that is hosted by Google and maintained by the team.

2.3.3 Architectural and Transportation Barriers Compliance Board Electronic and Information Technology Accessibility Standards

Section 508 was enacted to eliminate barriers in information technology, to make available new opportunities for people with disabilities, and to encourage development of technologies that will help achieve these goals. According to the Statement of Work, there are three sections that apply to this contract:

- 1194.21 Software applications and operating systems. (a-l)
- 1194.22 Web-based intranet and internet information and applications. 16 rules (a-p)
- 1194.26 Desktop and portable computers. (a-d)

As part of this effort we are not delivering any software application, operating system, desktop, or portable computers so those sections do not apply. One of our deliverables is a team website, so section 1194.22 does apply. All documents and presentation deliverables will be created in Adobe PDF format. Adobe's position on assistive technologies:

> Adobe® Reader® 9 is free software you can use to read and access the information contained within PDF files. Adobe Reader 9 contains many capabilities specifically designed to make it easier for people with disabilities to read PDF files, regardless of whether the files have been optimized for accessibility. It leverages accessibility functions built into Windows® and Mac OS systems and allows adjustment of user preferences to optimize the reading experience for a variety of disabilities.

The PDF generator that we use has the ability to specify if accessibility tags should be included in the document. We will utilize that feature.

2.3.4 Video Teleconferencing

Our video teleconferencing will be conducted in the home of one of our mentors using their hi-speed Internet link, Windows XP desktop computer, microphone headsets, and web camera. No corporate level firewall will be involved in the link, only the firewall resident in the router and software firewall running on the desktop computer. We will use a free videoconferencing service called VSee (http://www.vseelab.com).

3 Safety

3.1 NAR Mentors

This year Ed Kruel will be returning to the team to mentor us once again with the design and construction of the rocket. Ed is Level 3 certified. Doug Pedrick and Pat Wagner are also NAR members, but not certified.

3.2 Construction Safety

Most of the construction will be done in Mr. Wagner's basement.

Before we begin construction of the rocket, we will be having a 1 hour safety briefing where we will review all power tool safety and discuss safe hazardous chemical handling for items such as: epoxy, solvents, paint, soldering flux and cyanoacrylate glue. In addition, we will also be covering basic shop safety.

While constructing our rocket we will be using a number of power and hand tools. The safety of the team is always a top priority. By being trained on the proper use of each tool, reading the operators manual, keeping focused on the task at hand, wearing proper eye and ear protection, maintaining a clutter-free work environment, and having adult supervision we can safely use the power tools necessary to build the rocket. For emergency measures, there will always be a first-aid kit nearby. This will be sufficient for minor injuries. In case of a fire we will also have a fire extinguisher in the room where we are constructing the rocket. The work area is roughly 32 x 28 feet in size, which will leave plenty of space for working on the rocket and maintaining a clutter free environment. Many of the power tools the team is going to be using may cause damage to the ears. To prevent permanent hearing damage the operator shall always wear sufficient ear protection.

The main bonding component that team will be using is epoxy. Users will wear gloves to avoid chemical burns and safety goggles with side guards to prevent eye injuries. The garage will be ventilated properly to avoid respiratory irritation. The members will also be instructed to not wear jewelry or loose fitting clothing while using tools and constructing the rocket. It will be the responsibility of our Safety Manager, Katlin Wagner, to enforce all safety rules, but it will be everyone's responsibility to identify and remedy safety issues. Figure 3 lists most of the tools we expect to use and risks typical of their use.

All relevant material safety data sheets (MSDS) are located on our website at http://www.4hrocketry.org/materialsafetydatasheets. All team members have reviewed and will follow all safety precautions listed in those documents.

Tool	Risk
Band Saw	Cut, Sawdust in Eye
Belt Sander	Cut, Scrape, Sawdust in Eye
Blades	Puncture, Cut
Cyanoacrylate (Super Glue)	Burn, Respiratory Irritation
Dremel	Cut
Drill Press	Puncture, Cut, Scrape
Drill Bits	Puncture, Cut, or Eye Injury due to broken bit
Electric Matches	Burn
Power Sander	Cut, Scrape, Sawdust in Eye
Epoxy	Respiratory Irritation, Eye Injury
Hand Tools	Puncture, Cut, Scrape
Electric Drill	Puncture, Cut, or Eye Injury due to broken bit
Soldering Iron	Burn
Table Saw	Cut, Sawdust in Eye
Wire Cutters/ Strippers	Cut

Figure 3. Tool Risk

3.3 Launch Safety

Launch safety would be governed by the rules of the NAR model rocketry and NAR High Powered safety code. See Appendix B and C. All FAA notification rules will be strictly adhered to. At each test launch of the full scale rocket we will have at least one NAR Level 2 mentor present. At the half-scale launches we will have our two NAR mentors, Mr. Pedrick and Mr. Wagner.

All necessary safety precautions will be made for the electronics bay and resident ejection charges.

Before each launch we will ensure that we have a fire extinguisher and first-aid kit present, we will review all launch safety rules, and we will go over our pre-flight checklist.

3.4 Payload Safety

The scientific experiment will contain electrical components including DC generators, wiring, and possibly capacitors and batteries. Care must be taken with these components in the event that they retain excessive voltage.

4 Technical Design

4.1 Requirements, Constraints, and Design Challenges

The primary rocket requirements are derived from the statement of work, and constrained by additional design principles:

- The rocket shall reach 5280 feet above ground level (AGL).
- The rocket shall carry a scientific payload.
- The rocket and its scientific payload shall withstand the aerodynamic forces of lift off, parachute ejection, and touchdown.
- The rocket and scientific payload shall be recoverable and reusable.
- Data from the scientific payload will be collected, analyzed, and reported using the scientific method.
- Rocket launch preparation shall not exceed 4 hours.
- The maximum total motor impulse shall not exceed 4000 Newton-seconds and shall be supplied by commercially available ammonium per chlorate composite propellant (APCP) motors.
- The rocket shall contain a tracking device for recovery after launch.
- The rocket will use a standard rail.

The biggest design challenge that the team faces is incorporating the scientific experiment into the rocket. The experiment requires attaching three wind turbines inside of fin tubes. Small thermoelectric devices will also be mounted to the motor mount. Integrating the necessary wiring harnesses from both of these power sources will present a big challenge.

Our scientific payload is going to have wind turbines centered in the three of the six tube fins. The turbines will affect the rocket's coefficient of drag (Cd), and since Rocksim cannot easily simulate this additional component, we will have to find other ways of determining Cd. We hope to test our rocket in a wind tunnel and to have test flights in order to observe the aerodynamic behavior.

4.2 Rocket Design

The rocket is designed around the experiment so that the payload will perform to expectations. Last year we bought a kit and had to work the payload to fit the rocket design. This year since the payload will play an even more critical role in the flight of our rocket we are specifically designing our rocket around the needs of the payload. Since we are going to have to have fans on the outside of the rocket, we thought that this year the best place to place them is inside tube fins on the lower body of the rocket. The tubes will provide lift and stability in place of normal fins. An unknown is how wind turbines will impact the aerodynamics of the rocket. Last year, we had a problem with moderate weathercocking of the rocket – a rocket that had one wind turbine in place of the nose cone. We concluded that the weathercocking was due to unbalanced airflow of the wind turbines 'exhaust' out one side of the airframe. By employing a tube fin design, we believe that we have eliminated that issue.

4.2.1 Airframe

The airframe is going to be constructed from fiberglass and will be 5" in diameter. We wanted to have it large enough to be able to use different diameter motors and have enough room for the electronics. We used fiberglass before and found it to be very strong and still workable. The preliminary design is shown in Figure 4 and shows the rocket to be slightly more than 8' in length, while weighing around 19 pounds without motor or casing.

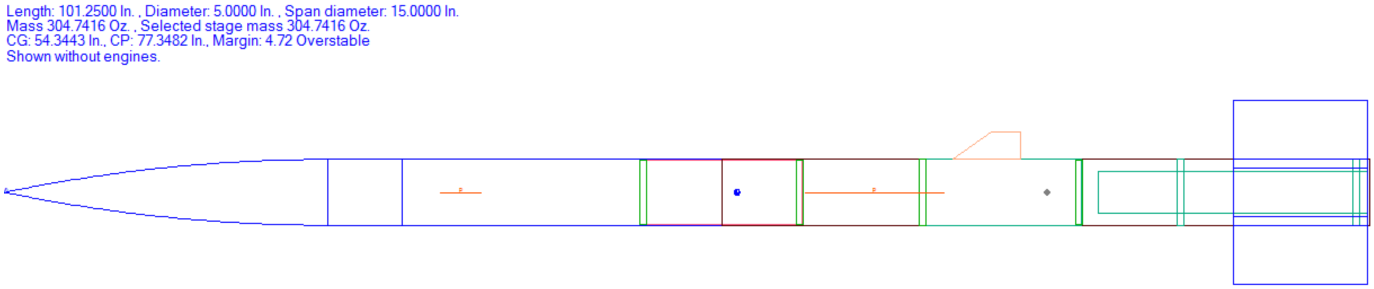

Figure 4. Preliminary Vehicle Design

4.2.2 Fins

Since we are using six tube fins, geometrically they all have to be the same diameter as the body tube. They will be reinforced because of the great amount of drag enacting on the entire surface area of the fin. Three out of the six tubes will support the fan generators. We are making the tubes long enough to fit the entire fan assembly inside, and to provide sufficient lift in place of normal fins.

4.2.3 Payload

The payload will be located right above the motor mount. Because the thermoelectrical devices and the fan generators are both located at the bottom of the rocket, this makes it the best position to fit the payload bay so we have minimal distance between the payload bay and the electrical sources. An exploded view is shown in Figure 5.

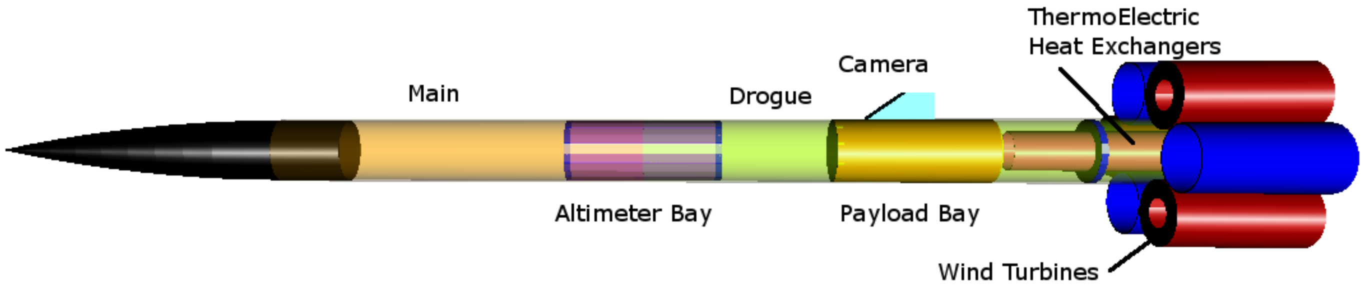

Figure 5. A 3-D look at the inside of the rocket

4.2.4 Altimeter Bay and Recovery

The altimeter bay fits in a coupler between the top and bottom airframe tubes. It will have a parachute and redundant e-matches on either side that will deploy a drogue and a main parachute at the appropriate time. We will be using the MAWD and ARTS altimeters for redundant ejections. This is an extra measure to make sure our parachutes will deploy.

4.2.5 Thrust Curve of AeroTech L850W

We're currently targeting an AeroTech L850W as our motor. But since the rocket's total mass and Cd are just educated guesses at this point, the motor selection is subject to change as the project progresses.

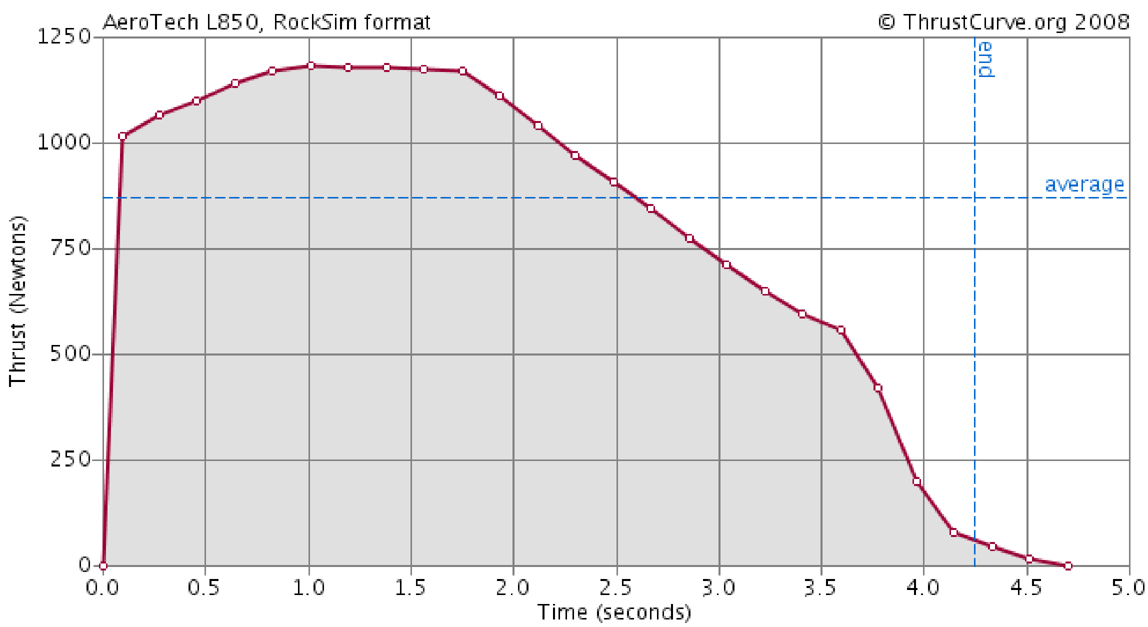

Figure 6. Thrust Curve of AeroTech L850W

4.3 Science Experiment and Payload Design

4.3.1 Payload

Like last year, the team has decided to plan a science experiment based around electricity generation. The Milwaukee Journal Sentinel recently reported that Wisconsin emits greenhouse gases at a rate that is about one-third higher than the national average. Wisconsin utilities rely heavily on coal-burning power plants, with several more currently under construction. We need to start looking seriously at renewable and alternative energy sources instead of relying primarily on fossil fuels. Renewable energy is most attractive since it is extracted from natural resources that are continuously replenished. These include wind, sunlight, tides, and geothermal heat. All of these naturally occurring types of energy can be harnessed to generate electricity. We are interested in continuing to explore renewable energy because it will play a major role in the future of this country. In the year that has passed since we originally conceived this idea for SLI 2008, alternative energy has become a hot topic as the price of crude oil has skyrocketed.

We are proposing to place three wind turbines inside the tube fins on the outside of the rocket, propelled by the air stream flowing through the fins that will drive small generators creating electricity. In last year's proposal, we wrote a section on wind blade theory describing theoretical mechanics of a wind turbine, which we included in Appendix A.

We will also have thermoelectric heat exchangers that will capture the heat of the motor and turn it into electricity. Thermoelectric power generators convert heat energy to electricity. When a temperature gradient is created across the device, a DC voltage develops across the terminals. Figure 7 depicts this process.

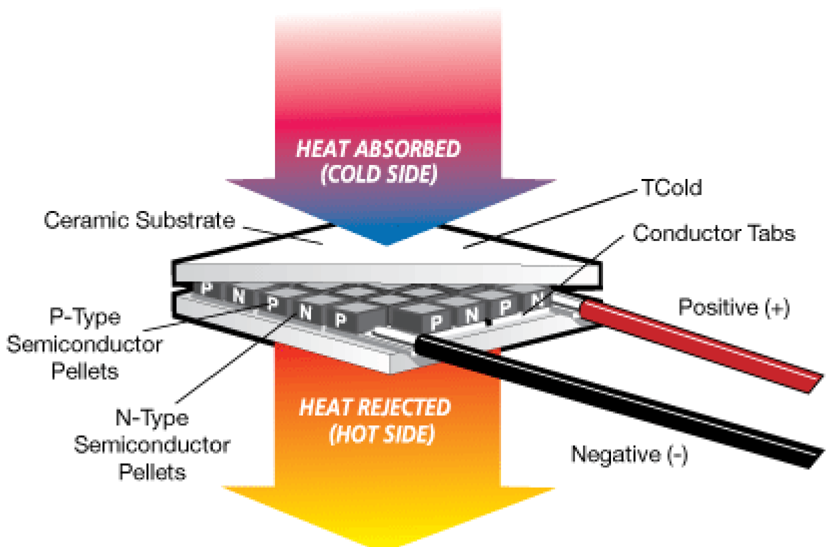

Figure 7. Thermoelectric Power Generation (courtesy Tellurex)

We don't envision generating a lot of power (compared to the wind turbines) from the thermoelectric devices, but that's not the point. We really just want to generate electricity from multiple sources. We expect to generate between 2-5W of power from thermoelectric sources.

Last year's experiment simply generated and measured electricity. Advancing on that concept this year we looked to do something useful with the generated power. Using the electricity generated from the thermoelectric heat exchangers and the turbines we will power a small video camera and transmitter that will broadcast live on-board video of the launch back to a receiver on the ground. Success or failure will be known immediately based on whether we get video reception or not.

This year we will try to surpass last year's accomplishments. We are going to triple the number of turbines and increase the efficiency so we can generate a sufficient amount of power. We will also add to the project by using thermoelectric heat exchangers to capture some of the heat given off by the motor. We anticipate the power generated by the heat exchangers to come online much sooner than that generated by the wind turbines. Figure 8 shows an aft view of the rocket.

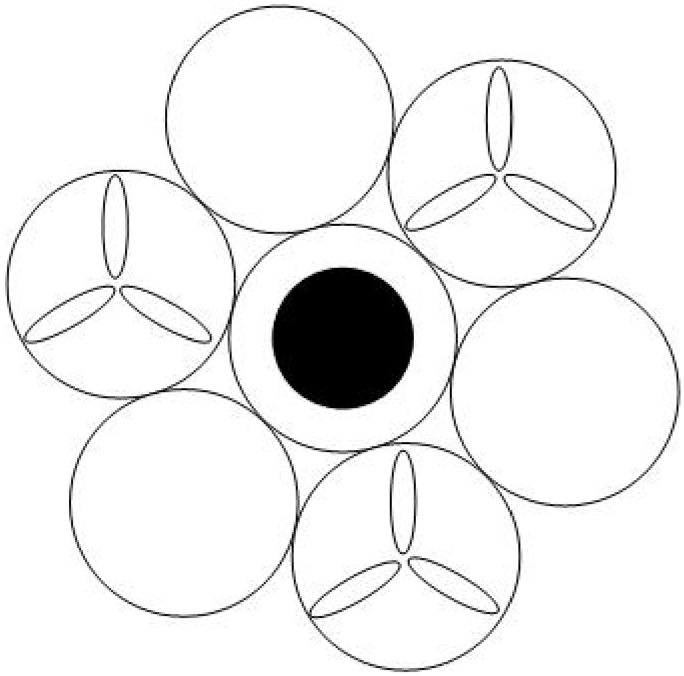

Figure 8. Turbine blade view.

4.3.2 Payload Bay Design

The payload bay will be located just above the motor mount. It is located there since all of our electricity will be coming from the motor and fin area, this would be the closest location we could locate it. The wires will be running up to the payload through the upper centering ring and the payload bulkhead. We are taking the power from the three fan blades and heat exchangers and using it to power the on-board video camera.

4.3.3 Altitude Measurement

We will use the MAWD altimeter to measure the altitude that our rocket went. It is more accurate than the ARTS and it is the best altimeter that we have to use for measuring altitude.

4.3.4 Onboard Video

We are using a BoosterVision (http://boostervision.com) camera that is 20mm long by 20mm wide with a 20mm diameter. The camera will send the video back to the ground to a wireless receiver. It has a 62-degree field of vision and can send the video from above 4000 feet when it is going straight up. Our test flights will tell if it gets reception from a mile high. If not we may have to maximize the signal. The camera and transmitter will be powered solely from the electricity generated during the flight.

4.4 Motor Selection and Motor Retention Design

We are planning to use an Aerotech L850W motor. We chose this because it burns for a moderately long time with a lower thrust curve. We want to avoid going through Mach because the fan blades cannot survive that kind of stress. A longer burning motor also generates electricity at a steadily increasing rate instead of a rapid spike. A spike in the speeds can over rev the generator and fan blades. Slower speeds create less stress on the components.

Like last year, we will use an Aero Pack Quick Change Motor Retainer.

5 Outreach

5.1 Student/Educational Outreach

The Washington County 4-H rocketry program reaches youth through a countywide rocketry program. We are planning to do a minimum of six workshops that include helping students build a rocket for their county fair project. Ben and Katlin have already worked through the summer with 4-H summer playground programs reaching out to approximately 100 youth at four county planned activities at local community parks.

We also conducted a rocketry workshop in August, which was attended by about 10 youth. They built and launched a small rocket in one evening session.

Through 4-H Aerospace Outreach programs, we continue to attract many kids to 4-H Rocketry. Isaac was one of these youth and has joined our team this year.

5.2 Industry and Academic Partnership

Our SLI team was featured last year in the Milwaukee Journal-Sentinal newspaper, and in a news video on a Milwaukee TV channel. Our group has made many calls to teachers, Level 2 NAR members, and electrical engineers in an effort to establish relationships. We have contacts at auto body and paint shops of the possibility of them donating their services to paint the rocket. Last year we utilized the wind tunnel at the University of Wisconsin-Madison and may do so again if necessary.

We have plans to talk to businesses involved in the aerospace and technology industries to see if they will donate supplies or money to the team. We will always be looking for ways to lower our budget by using our local resources throughout the whole process.

5.3 Sustaining a Rocket Program in Washington County

The foundation to sustaining a rocket program is already in place and showing results in Washington County. Doug Pedrick has worked with the Washington County extension to create and improve a county rocketry program. We are again planning to have two teams in the Team America Rocketry Contest (TARC).

6 Project Plan

6.1 Timeline

Washington County 4-H 2008-2009 SLI Project Plan:

Project Start Date: Mon 9/1/08
Project Finish Date: Fri 5/22/09

6.2 Project Milestones

Name	Finish_Date
Request for Proposal (RFP)	Thu 10/23/08
RFP document delivered to NASA	Wed 10/1/08
NASA awards SLI grants	Wed 10/22/08
SLI team teleconference w/ NASA	Thu 10/23/08
Establish Team Website	Wed 11/5/08
Preliminary Design Review (PDR)	Sun 1/4/09
Vehicle concept testing	Sun 10/5/08
PDR document delivered to NASA	Fri 11/28/08
Critical Design Review (CDR)	Thu 1/22/09
Scale vehicle completed	Mon 12/1/08
Fly Scale Model	Mon 12/15/08
Payload design - revision 2	Wed 12/10/08
Vehicle design - revision 2	Mon 12/15/08
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

6.3 Proposed Budget

Item Description	Quantity	Cost	Total Cost	
Full Scale Rocket				
Centering ring	1	$5.00	$5.00	
Main Chute-60"	0	$40.00	$0.00	*
Drogue-18"	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	**
MAWD Altimeter	0	$120.00	$0.00	**
L850W Motors	2	$200.00	$400.00	
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 casing	1	$238.00	$238.00	
Black Powder	1	$5.00	$5.00	
Payload				
Ducted Fan Blades	3	$75.00	$225.00	
DC Motors	3	$40.00	$120.00	
eLogger	0	$100.00	$0.00	**
Circuit Components	1	$30.00	$30.00	
Thermoelectric Generator	3	$75.00	$225.00	*
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	$300.00	$300.00	
Travel Expenses				
Vehicle, Lodging, Meals	1	$3,000.00	$3,000.00	
			$5,515.00	

NOTES

* Potential Sponsorship

** Re-usable components from 2007-2008 SLI Project

6.4 Educational Standards

The State of Wisconsin's Department of Public Instruction authors educational standards. The applicable standards are high-school level science, mathematics, and language/reading. The standards are broken down into Advanced, Proficient, and Basic criteria. We have focused on the Advanced and Proficient standards only.

We will utilize physics in the payload experiment and in the designing of the rocket. The following are the science educational standards for advanced students in Wisconsin. Understanding unifying themes in science such as systems, evidence, models, or form and function:

- Using scientific inquiry processes and procedures, such as hypotheses, models, data collection, analysis, and interpretation
- Using scientific knowledge and reasoning when making and evaluating decisions
- Analyzing the costs, benefits, or consequences associated with an innovation
- Analyzing how organisms depend on and contribute to the stability of ecosystems or total systems such as the Earth
- Analyzing the properties of energy and characteristics of energy sources, and explaining the advantages or disadvantages of an energy source for specific uses
- Identifying the relative organization of the solar system and the universe
- Identifying and explaining the role of organs in human systems

6.4.1 State of Wisconsin Education Standards - Language

These are the standards in Wisconsin for the students in the proficient level for Language. We will require these skills to create the proposal, review documents, briefing materials, and other reports.

- Determining appropriate reference material and methods of gathering or documenting information about a topic when preparing to write
- Composing a response to a prompt that shows adequate control of writing features such as purpose and focus, organization and coherence, development of content, sentence fluency, and word choice
- Improving coherence in a piece of writing by inserting detail sentences in an appropriate location, identifying sentences that are off-topic and should be deleted, or identifying an appropriate concluding sentence
- Combining ideas to improve sentence variety in a composition, to subordinate ideas, or to remove excessive coordination
- Revising language to be consistent with the style and tone of a piece of writing
- Correcting errors in sentences, including verb formation and grammar
- Editing fragments or run-on sentences to create complete, correctly-written sentences

6.4.2 State of Wisconsin Education Standards - Mathematics

These are the educational standards in Wisconsin for the mathematics. We use math in the design process and in the scientific equations to compute kinetic energy and power conversion.

> At the beginning of tenth grade, students performing at the proficient level convey mathematical ideas in a variety of ways and provide justifications and details to support their solutions and reasoning. Students solve a variety of problems using familiar percents. They locate and plot coordinates of geometric figures transformed in a coordinate plane and apply angle relationships in

a circle to solve real-world problems. Students use the Pythagorean Theorem and distance and mid-point formulas. They convert between units of measurement, apply tools of measurement to solve problems, and calculate the area of two-dimensional shapes. Students determine missing information using Venn diagrams, create scatter plots with appropriate scales and labels, and interpret the graph of quadratic relationships between two real-world quantities. They solve multi-step linear and non-linear equations and inequalities. They determine and extend patterns involving real-world contexts.

6.4.3 State of Wisconsin Education Standards - Reading

Here are the educational standards for reading in the state of Wisconsin. We will be reading when we research for our experiment.

> At the beginning of the year, tenth-grade students performing at the Proficient level appropriately use a range of word-identification strategies and on grade-level reading vocabulary to understand text. They use context clues to determine the meaning of unfamiliar words, or which meaning of a multiple-meaning word is used, as well as interpret the meaning of words and phrases used figuratively, including in poetry. Additionally, students use affixes to determine the meaning of unfamiliar words and use a dictionary or thesaurus entry and context clues to determine the meaning of an unfamiliar or multiple-meaning word.
>
> When reading literary texts, students at this level can identify an implied theme or central message and identify details that support or reveal the theme. They analyze a text to identify one or more conflicts that are central to a text and analyze implied cause and effect relationships or the impact of events on the narrator or characters. When reading informational texts, students identify stated or implied main ideas, identify supporting details and distinguish between fact and opinion or between important and unimportant details. Students also sequence stated events or steps in a process and use a graphic organizer to recall and sequence events. They use text features such as tables, charts, or diagrams to locate and identify a main idea or supporting details.
>
> When reading either literary or informational texts, students at this level are able to identify an author's general style or the tone conveyed in a portion of text. In addition, they can analyze an author's style by inferring a purpose for making specific word choices or for including certain ideas or images in a text, including poetry. They identify phrases or sentences that reveal a specific purpose or create a given effect. Students are able to draw conclusions, summarize important ideas and events and provide some relevant, text-based information to support the summary. They identify stated or implied cause and effect relationships or comparisons and contrasts as well as implied bias and propaganda. Students are able to connect or extend concepts in an informational text to a new situation, themselves, or real-world experiences. In general, students at the Proficient level sufficiently comprehend a variety of grade-level texts at literal, inferential, and evaluative levels. They easily recognize and thoroughly analyze important ideas and make connections among ideas to demonstrate comprehension.

Appendix A Wind Turbine Theory

Generator Background

In the 1830s Michael Faraday discovered that if you present a changing magnetic field around a coil of insulated wire the coil will produce current. This concept is the basis of most electricity generators.

Generators are now at the center of renewable energy sources. They are found in dams, wind turbines, and power plants.

There are many different types of generators. Induction generators feed electricity into a grid without brushes or other complications. These types of generators are used most commonly in producing electricity from the wind. However, the permanent magnet AC generator is simpler in a situation like this because it can be self-excited. This means it can start operating without an initial external power source. They are usually used in smaller wind turbines due to cost considerations.

Our team has researched generators and we concluded that the best choice for our experiment is the permanent magnet AC generator.

This experiment is not meant to find new ways of using generators nor as a practical modification to any rocket. Instead, our goals are to gain knowledge of clean energy sources and to learn the basics of electricity generation. The knowledge gained may have very practical applications later in our lifetime. We will gain insights into the technological and engineering challenges that will need to be overcome in order to make the production of electricity from clean, renewable energy sources a reality.

Wind Turbine Physics

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:

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

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:

$$\textbf{Mass/sec = Velocity * Area * Air Density} \qquad \text{(Eq. 2)}$$

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:

$$\textbf{Power = 0.5 * Swept Area * Air Density * Velocity}^3 \qquad \text{(Eq. 3)}$$

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

Swept area is pi*r2 (r == radius of the swept area, or the 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, however. 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:

$$\textbf{Effective Power} = \textbf{Cp} * \textbf{0.5} * \textbf{Swept Area} * \textbf{Air Density} * \textbf{Velocity}^3 \qquad \text{(Eq. 4)}$$

Where Cp is the power efficiency.

Figures A, B, and C show predicted power generation for various blade sizes and efficiencies.

Predicted Power at 50 m/s Wind Velocity					
			Power Efficiency (Cp)		
Blade Length (mm)	**Swept Area (mm^2)**	**Maximum Betz Power (W)**	**10%(W)**	**20%(W)**	**30%(W)**
15	706.8583	32.2560664	5.434	10.86795	16.30192
30	2827.433	129.024266	21.736	43.47179	65.20768
45	6361.725	290.304598	48.906	97.81152	146.7173

Figure A. Predicted Power at 50 m/s Wind Velocity

Predicted Power at 100 m/s Wind Velocity					
			Power Efficiency (Cp)		
Blade Length (mm)	**Swept Area (mm^2)**	**Maximum Betz Power (W)**	**10%(W)**	**20%(W)**	**30%(W)**
15	706.8583	258.048531	43.472	86.94358	130.4154
30	2827.433	1032.19412	173.89	347.7743	521.6615
45	6361.725	2322.43678	391.25	782.4922	1173.738

Figure B. Predicted Power at 100 m/s Wind Velocity

Predicted Power at 200 m/s Wind Velocity					
			Power Efficiency (Cp)		
Blade Length (mm)	Swept Area (mm^2)	Maximum Betz Power (W)	10%(W)	20%(W)	30%(W)
15	706.8583	2064.38825	347.77	695.5486	1043.323
30	2827.433	8257.553	1391.1	2782.194	4173.292
45	6361.725	18579.4942	3130	6259.937	9389.906

Figure C. Predicted Power at 200 m/s Wind Velocity

Appendix B Model Rocket Safety Code

1. **Materials.** I will use only lightweight, non-metal parts for the nose, body, and fins of my rocket.

2. **Motors.** I will use only certified, commercially-made model rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer.

3. **Ignition System.** I will launch my rockets with an electrical launch system and electrical motor igniters. My launch system will have a safety interlock in series with the launch switch, and will use a launch switch that returns to the "off" position when released.

4. **Misfires.** If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher's safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.

5. **Launch Safety.** I will use a countdown before launch, and will ensure that everyone is paying attention and is a safe distance of at least 15 feet away when I launch rockets with D motors or smaller, and 30 feet when I launch larger rockets. If I am uncertain about the safety or stability of an untested rocket, I will check the stability before flight and will fly it only after warning spectators and clearing them away to a safe distance.

6. **Launcher.** I will launch my rocket from a launch rod, tower, or rail that is pointed to within 30 degrees of the vertical to ensure that the rocket flies nearly straight up, and I will use a blast deflector to prevent the motor's exhaust from hitting the ground. To prevent accidental eye injury, I will place launchers so that the end of the launch rod is above eye level or will cap the end of the rod when it is not in use.

7. **Size.** My model rocket will not weigh more than 1,500 grams (53 ounces) at liftoff and will not contain more than 125 grams (4.4 ounces) of propellant or 320 N-sec (71.9 pound-seconds) of total impulse. If my model rocket weighs more than one pound (453 grams) at liftoff or has more than four ounces (113 grams) of propellant, I will check and comply with Federal Aviation Administration regulations before flying.

8. **Flight Safety.** I will not launch my rocket at targets, into clouds, or near airplanes, and will not put any flammable or explosive payload in my rocket.

9. **Launch Site.** I will launch my rocket outdoors, in an open area at least as large as shown in the accompanying table, and in safe weather conditions with wind speeds no greater than 20 miles per hour. I will ensure that there is no dry grass close to the launch pad, and that the launch site does not present risk of grass fires.

10. **Recovery System.** I will use a recovery system such as a streamer or parachute in my rocket so that it returns safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

11. **Recovery Safety.** I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places.

LAUNCH SITE DIMENSIONS		
Installed Total Impulse (N-sec)	**Equivalent Motor Type**	**Minimum Site Dimensions (ft.)**
0.00--1.25	1/4A, 1/2A	50
1.26--2.50	A	100
2.51--5.00	B	200
5.01--10.00	C	400
10.01--20.00	D	500
20.01--40.00	E	1,000
40.01--80.00	F	1,000
80.01--160.00	G	1,000
160.01--320.00	Two Gs	1,500

Revision of February, 2001

Appendix C High Power Rocket Safety Code

1. **Certification.** I will only fly high power rockets or possess high power rocket motors that are within the scope of my user certification and required licensing.

2. **Materials.** I will use only lightweight materials such as paper, wood, rubber, plastic, fiberglass, or when necessary ductile metal, for the construction of my rocket.

3. **Motors.** I will use only certified, commercially made rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer. I will not allow smoking, open flames, nor heat sources within 25 feet of these motors.

4. **Ignition System.** I will launch my rockets with an electrical launch system, and with electrical motor igniters that are installed in the motor only after my rocket is at the launch pad or in a designated prepping area. My launch system will have a safety interlock that is in series with the launch switch that is not installed until my rocket is ready for launch, and will use a launch switch that returns to the "off" position when released. If my rocket has onboard ignition systems for motors or recovery devices, these will have safety interlocks that interrupt the current path until the rocket is at the launch pad.

5. **Misfires.** If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher's safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.

6. **Launch Safety.** I will use a 5-second countdown before launch. I will ensure that no person is closer to the launch pad than allowed by the accompanying Minimum Distance Table, and that a means is available to warn participants and spectators in the event of a problem. I will check the stability of my rocket before flight and will not fly it if it cannot be determined to be stable.

7. **Launcher.** I will launch my rocket from a stable device that provides rigid guidance until the rocket has attained a speed that ensures a stable flight, and that is pointed to within 20 degrees of vertical. If the wind speed exceeds 5 miles per hour I will use a launcher length that permits the rocket to attain a safe velocity before separation from the launcher. I will use a blast deflector to prevent the motor's exhaust from hitting the ground. I will ensure that dry grass is cleared around each launch pad in accordance with the accompanying Minimum Distance table, and will increase this distance by a factor of 1.5 if the rocket motor being launched uses titanium sponge in the propellant.

8. **Size.** My rocket will not contain any combination of motors that total more than 40,960 N-sec (9208 pound-seconds) of total impulse. My rocket will not weigh more at liftoff than one-third of the certified average thrust of the high power rocket motor(s) intended to be ignited at launch.

9. **Flight Safety.** I will not launch my rocket at targets, into clouds, near airplanes, nor on trajectories that take it directly over the heads of spectators or beyond the boundaries of the launch site, and will not put any flammable or explosive payload in my rocket. I will not launch my rockets if wind speeds exceed 20 miles per hour. I will comply with Federal Aviation Administration airspace regulations when flying, and will ensure that my rocket will not exceed any applicable altitude limit in effect at that launch site.

10. **Launch Site.** I will launch my rocket outdoors, in an open area where trees, power lines, buildings, and persons not involved in the launch do not present a hazard, and that is at least as large on its smallest dimension as one-half of the maximum altitude to which rockets are allowed to be flown at that site or 1500 feet, whichever is greater.

11. **Launcher Location.** My launcher will be at least one half the minimum launch site dimension, or 1500 feet (whichever is greater) from any inhabited building, or from any public highway on which traffic flow exceeds 10 vehicles per hour, not including traffic flow related to the launch. It will also be no closer than the appropriate Minimum Personnel Distance from the accompanying table from any boundary of the launch site.

12. **Recovery System.** I will use a recovery system such as a parachute in my rocket so that all parts of my rocket return safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

13. **Recovery Safety.** I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places, fly it under conditions where it is likely to recover in spectator areas or outside the launch site, nor attempt to catch it as it approaches the ground.

Note: A Complex rocket is one that is multi-staged or that is propelled by two or more rocket motors

MINIMUM DISTANCE TABLE

Installed Total Impulse (Newton-Seconds)	Equivalent High Power Motor Type	Minimum Diameter of Cleared Area (ft.)	Minimum Personnel Distance (ft.)	Minimum Personnel Distance (Complex Rocket) (ft.)
0 -- 320.00	H or smaller	50	100	200
320.01 -- 640.00	I	50	100	200
640.01 -- 1,280.00	J	50	100	200
1,280.01 -- 2,560.00	K	75	200	300
2,560.01 -- 5,120.00	L	100	300	500
5,120.01 -- 10,240.00	M	125	500	1000
10,240.01 -- 20,480.00	N	125	1000	1500
20,480.01 -- 40,960.00	O	125	1500	2000

Revision of July 2006