October 1, 2009

MADISON WEST

SLI 2010

MADISON WEST ROCKET CLUB

THE EFFECT OF ATMOSPHERIC CONDITIONS AND GROUND FEATURES ON THE INTENSITY OF DIRECT AND REFLECTED SUNLIGHT

Front Row: Tenzin, Jacqueline, Tulika, Henry
Back Row: Zander, David, Jacob, John, Larissa

http://www.westrocketry.com

SLI 2010 Statement of Work

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School Information

Educators and Mentors

Project Title

The Effect of Atmospheric Conditions and Ground Features on the Intensity of Direct and Reflected Sunlight

Administrative Staff Member

West High School Principal Ed Holmes
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Lead Educators

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Pavel Pinkas, Ph.D., Senior Software Engineer for DNASTAR, Inc.
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Other Educators

Professor Dan McCammon
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Rehan Quraishi
Student attending UW-Madison, SLI 2006, 2007 Graduate
Phone: (608) 358-8944
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NAR Mentors

Scott T. Goebel
3423 Pierce Boulevard, Racine, WI, 53405-4515
Phone: (262) 634-3971
Email: zapjolt@wi.rr.com

Brent Lillesand
4809 Jade Lane, Madison, WI 53705
Phone: (608) 241-9282
Email: Blillesand@charter.net

Section 508 Consultant

Ms. Ronda Solberg
DNASTAR, Inc. (senior software designer)
3801 Regent St, Madison, WI, 53705
Email: rondas@dnastar.com

Student Participants

VEHICLE TEAM			
	HENRY *Team Leader* *hwroblewski@westrocketry.com* **Duties:** task delegation, vehicle design, construction and operation supervision, document assembler and editor		JOHN *Vehicle Engineer* *john.schoech@westrocketry.com* **Duties:** vehicle construction, vehicle checklist, electronics hardware specialist
	ZANDER *Integration Specialist* *zstiechen@westrocketry.com* **Duties:** Vehicle-payload integration, integration checklist, vehicle tracking and recovery		
PAYLOAD TEAM			
	DAVID *Webmaster, Electronics Specialist* *daeschlimann@westrocketry.com* **Duties:** website design and construction, graphic design, payload electronics software specialist		JACOB *Experiment Design* *jkelly@westrocketry.com* **Duties:** Scientific research, experimental design, payload design
	JACQUELINE *Payload Engineer* *jgerman@westrocketry.com* **Duties:** payload design and construction, payload tracking and recovery		LARISSA *Outreach and Public Relations* *lbwalder@westrocketry.com* **Duties:** coordinating and leading outreach efforts
	TENZIN *Payload Engineer* *tsonam@westrocketry.com* **Duties:** payload design and construction, payload tracking and recovery		TULIKA *Integration Specialist* *tsingh@westrocketry.com* **Duties:** payload-vehicle integration, integration checklist

Facilities and Equipment

Facilities for Rocket Design and Testing

Planning, discussion, design and documentation writing will occur in the conference rooms of DNASTAR located at 3801 Regent Street, Madison, Wisconsin, 53705, on the weekends.

Construction of the rocket will occur at the construction facilities located at 3555 University Avenue, Madison, Wisconsin, 53705, and various team members' home workshops on the weekends.

Construction of the payload container will also occur at the construction facilities located at 3555 University Avenue, Madison, Wisconsin, 53705, and at various team members' home workshops on the weekends. We have a 24/7 access to this facility.

Preparation and construction of the payload will occur, occur at the construction facilities located at 3555 University Avenue, Madison, Wisconsin, 53705 and at various team members home workshops on the weekends.

Team Organizational Meetings will occur during lunchtime on Mondays at Madison West High School, located at 30 Ash Street, Madison, Wisconsin, 53726.

Launching of low-powered scale model rockets will occur on weekends from November through April, at Reddan Soccer Park located at 6874 Cross Country Road, Verona, Wisconsin, 53593. Large Model Rocket Launch Notification will made to comply with FAA regulations Part 101. NFPA code 1122 and NAR Model Rocket Safety Code will be followed during these launches. Mentors will supervise all rocket launches.

Launching of high-powered rockets will occur at Richard Bong Recreational Area located in Southeast Wisconsin at 26313 Burlington Road, Kansasville, Wisconsin, 53189. We will obtain Power Rocket Altitude waivers from the FAA prior to high power launches. High power launches will coincide with the high power launch of WOOSH, Section #558 of the NAR. Mentors will supervise all rocket launches.

Scheduling and Facilities Risks

Risks	Consequences	Mitigation
Workshop space unavailable	Unable to complete construction of rocket and/or payload	We will insure the availability of our workshop space for the times that we need it. We will also work at team members' homes if necessary.
Design facilities unavailable	Unable to complete project design/description	We will insure the availability of our design facilities and work at team members' homes if needed.
Team members unavailable	Unable to complete project	We will plan meetings in advance and insure that enough team members will be present to allow sufficient progress.

Table 1: Risks associated with scheduling and facilities

Personnel

- Ms. Christine Hager — Main Advisor, Educational Supervisor
- Dr. Pavel Pinkas — NAR Mentor, Scientific Advisor
- Mr. Brent Lillesand — NAR Mentor, Vehicle Construction Supervisor
- Mr. Scott Goebel — NAR Mentor, High Power Rocketry Advisor
- Mr. Russ Read — Scientific Advisor, Payload Design Advisor
- Prof. Dan McCammon — Dept. of Physics, Scientific Advisor
- Prof. Edwin Eloranta — Dept. of Atmospheric Sciences, Scientific Advisor
- Mr. Don Michalski — Space and Astronomy Lab, Electronics Advisor

Equipment and Supplies

EQUIPMENT	POWER TOOLS	SUPPLIES	ROCKET COMPONENTS
Soldering irons	Drill press	Cyanoacrylate glue (superglue)	G10 sheets of fiberglass
Band saws	Dremel tool (with necessary attachments)	Accelerator and de-bonder for superglue	Kevlar and tubular nylon shock cords
Hacksaws	Hand drill	West Epoxy (resin, quick and slow hardener, various fillers)	Nomex Fabric
Hand saw	Hydraulic press	5 Minute Epoxy	Quick links
Scroll saw	Jig saw	Masking tape	Plywood centering rings, sheets, bulkheads
Wire strippers	Table saw	Electric tape	Screws, nuts, T-nuts, washers, etc.
Drill bits	Belt sander	Batteries of varying size and voltage to power electronic components	4-inch fiberglass tubing, 6-inch fiberglass tubing
Box cutters	Table saw	Various minor electronic components (resistors, capacitors, LEDs)	U-Bolts, I-Bolts
X-acto knives	Jig saw	JB Weld Glue	Nose cone
Sandpaper and sanding blocks	Router	Solder, flux	Lock'N'Load motor retention kit
Rulers and yardsticks		Breathing masks (to be used when sanding or cutting fiberglass)	Rail buttons
Ring and C-clamps		Latex gloves, safety goggles	PerfectFlite altimeters
Pliers, clippers		First aid kit	PerfectFlite timers
Phillips/flathead screwdrivers (various sizes)		Ethyl-alcohol Isopropyl-alcohol	Parallax Propeller Chips and development kits
Vices of varying sizes			

Computer Equipment

School Computers

- 500MHz-2GHz, 128MB-1GB RAM
- Windows 98, XP
- Able to use Apple G3-G5

Student Personal Computers' Range

- 1.60 - 3.06 GHz Intel Core 2 Duo Processor
- 4 GB RAM
- 40 GB – 2 TB Hard Drive
- Windows XP, Vista, Windows 7
- Max OS X Tiger, Leopard, Snow Leopard
- High End: iMac and Mac Book Pro, 256 - 512MB Graphic Card, 860-8800 NVIDIA GeForce GS and, 667-800 MHz DDR2 SDRAM – 4GB
- Team members possess ten laptop computers in total.

Web Hosting

Our websites are hosted by HostGator (a commercial hosting company). Our club website can be found at http://westrocketry.com.

Internet Connection

- School Computers - T3 connection for Internet
- DNASTAR - T3 connection and an internal wireless network (801b/g/n)
- Home – DSL 768Kbps-6.0Mbps (download), 256Kbps-1.5Mbps (upload)

Computer Accessible Programs

- Adobe Creative Suite 4 Design Premium Edition
- Adobe After Effects CS4
- Apple Final Cut Express
- Eclipse Java IDE, XCode, Propeller Tool
- Octave 3.2.2
- Apogee RockSim 8
- Firefox, Safari, Chrome and Internet Explorer Browsers
- Google Sketchup 3D Design
- MS Outlook
- Microsoft Office 2003-2008

E-mail capability

The team will be communicating via email. All SLI members have personal email accounts. There is also a group e-mail address that allows addressing the whole team by sending a message to a single e-mail address (sli2010r@westrocketry.com). This format has worked with great efficiency for the last five years.

Presentation Simulation Software

- Microsoft Power Point 2003

Video Teleconferencing (Webcasting)

Our SLI 2010 team will use the UW Extension at the Pyle Center for Video Teleconferencing facilities. We prefer to use VSee teleconferencing software.

Contact Dr. Rosemary Lehman for information about firewall issues.

UW Extension Pyle Center
702 Langdon St.
Madison WI, 53706
Fax: 608-236-4435
Phone: 608-262-7524
lehman@ics.uwex.edu

Section 508 Compliance

Architectural and Transportation Barriers Compliance Board Electronic and Information Technology (EIT) Accessibility Standards (36 CFR Part 1194)
The team will implement required parts of Section 508, namely

- § 1194.21 Software applications and operating systems (all items)
- § 1194.22 Web-based intranet and internet information and applications (all items)
- § 1194.26 Desktop and portable computers (all items)
    - § 1194.23 Telecommunications products (items (k)(1) through (4)) as referenced by § 1194.26

The team carefully reviewed the above listed sections and consulted the same with two senior software engineers at DNASTAR, Inc. (a bioinformatics software company).

Re: § 1194.21: The team is using MS Windows and Mac OS-X based computers. Both Microsoft and Apple are strong supporters of Section 508 and all installation of MS Windows and Mac OS-X are complete including the access assistive features. All third party software used in the SLI project is claimed as Section 508 compliant by the software company producing the software (Microsoft, Apple, and Adobe).

Software and firmware developed by the students during the project will be verified for Section 508 compliance by senior software engineers from DNASTAR Inc. All found violations will be fixed prior software deployment.

Re: § 1194.22: The rocket club website (http://www.westrocketry.com) has been checked for Section 508 compliance using various automated validators (such as http://section508.info). No violations have been found.

The website specific to the proposed project will be periodically subjected to the same selection of tests and the webmaster will remove all found violations in a timely manner.

Re: § 1194.26: All computers used by the team members and educators are Section 508 compliant. No computer has been modified beyond the manufacturer approved upgrades.

Safety

Local NAR Mentors

NAR Mentor: Brent Lillesand
Home Address: 4809 Jade Lane, Madison, WI 53714-2621
Work Phone: (608) 243-3273
Home Phone: (608) 243-3273 (same as work)
Email Address: blillesand@charter.net
HPR Certification: NAR Level 3

Mr. Lillesand has been a mentor of Madison West Rocketry since 2005 and has provided both SLI teams with equipment, expertise and professional advice on rocket-specific tasks. Mr. Lillesand is the vehicle construction and testing supervisor. Mr. Lillesand is the designated individual rocket owner for liability purposes and he will accompany the team to Huntsville.

NAR Mentor: Scott Goebel
Home Address: 3423 Pierce Blvd, Racine, WI 53405-4515
Work Phone: (262) 634-3971
Home Phone: (262) 634-3971
Email Address: zapjolt@wi.rr.com
HPR Certification: NAR Level 3

Mr. Goebel is the lead mentor for all HPR issues and operations. He brought HPR knowledge and techniques to our club in 2005, when he assisted our first SLI team. He has also loaned us many parachutes, shock cords, and motor casings over the years.

NAR Mentor: Dr. Pavel Pinkas
Home Address: 1763 Norman Way, Madison, WI, 53705
Work Phone: (608) 237-3067
Home Phone: (608) 217-5735
Email Address: pavelp@dnastar.com
HPR Certification: NAR Level 1

Dr. Pinkas has been the mentor of the Madison West Rocketry Club since its beginning in 2003. He has played a key role in the success of the team, both with the Team America Rocketry Challenge in 2004-2009 and the Student Launch Initiative program in 2005-2009.

Written Safety Plan

NAR Safety Requirements

a. Certification and Operating Clearances: Mr. Goebel and Mr. Lillesand both hold a Level 3 HPR certification. Dr. Pinkas has a Level 1 HPR certification and plans on having a Level 2 HPR certification by the end of February 2010. Both Mr. Goebel and Mr. Lillesand have Low Explosives User Permits (LEUPs). Mr. Goebel owns a BATFE approved magazine for storage of solid motor grains containing over 62.5 grams of propellant.

All HPR flights will be conducted only at launches covered by an HPR waiver (mostly the WOOSH/NAR Section #558 10,000ft waiver for Richard Bong Recreation Area launch site). All LMR flights will be conducted only at the launches with the FAA notification phoned in at least 24 hours prior to the launch. NAR and NFPA Safety Codes for model rockets and high power rockets will be observed at all launches.

Mr. Lillesand is the designated individual rocket owner for liability purposes and he will accompany the team to Huntsville. Upon his successful L2 certification, Dr. Pinkas will become a backup person for this role.

b. Motors: We will purchase and use in our vehicle only NAR-certified rocket motors and will do so through our NAR mentors. Mentors will handle all motors and ejection charges.

c. Construction of Rocket: In the construction of our vehicle, we will use only proven, reliable materials made by well established manufacturers, under the supervision of our NAR mentors. We will comply with all NAR standards regarding the materials and construction methods. Reliable, verified methods of recovery will be exercised with the retrieval of our vehicle. Motors will be used that fall within the NAR HPR Level 2 power limits as well as the restrictions outlined by the SLI program. Lightweight materials such as fiberglass tubing and carbon fiber will be used in the construction of the rocket to ensure that the vehicle is under the engine's maximum liftoff weight. The computer program RockSim will be utilized to help design and pre-test the stability of our rocket so that no unexpected and potentially dangerous problems with the vehicle occur. A scale model of the rocket will be built and flown to prove the rocket stability.

d. Payload: As our payload does not contain hazardous materials, it does not prove potentially harmful to the environment. However, our NAR mentors will check the payload prior to launch in order to secure and verify that there will be no problems.

e. Launch Conditions: Test launches will be performed at Richard I. Bong Recreation Area with our mentors present to oversee all proceedings. All launches will be carried out in accordance with FAA, NFPA and NAR safety regulations regarding launch angles, and weather conditions. Caution will be exercised by all team members when recovering the vehicle components after flight. No rocket will be launched under conditions of limited visibility, low cloud cover, winds over 20mph, or increased fire hazards (drought).

Hazardous Materials

All hazardous materials will be purchased, handled, used, and stored by our NAR mentors. The use of hazardous chemicals in the construction of the rocket, such as epoxy resin, will be carefully supervised by our NAR mentors. When handling such materials, we will make sure to carefully scrutinize and use all MSDS sheets and necessary protection (gloves, goggles, proper ventilation etc.) will be utilized.

All MSDS sheets applicable to our project are available online at

http://westrocketry.com/sli2010/msds/msds2010r.html

Compliance with Laws and Environmental Regulations

All team members and mentors will conduct themselves responsibly and construct the vehicle and payload with regard to all applicable laws and environmental regulations. We will make sure to minimize the effects of the launch process on the environment. All recoverable waste will be disposed properly. We will spare no efforts when recovering the parts of the rocket that drifted away. Properly inspected, filled and primed fire extinguishers will be on hand at the launch site.

Education, Safety Briefings and Supervision

Mentors and experienced rocketry team members will take time to teach new members the basics of rocket safety. All team members will be taught about the hazards of rocketry and how to respond to them; for example, fires, errant trajectories, and environmental hazards. Students will attend mandatory safety meetings and pay attention to pertinent emails prior participation in any of our launches to ensure their safety. A mandatory safety briefing will be held prior each launch. During the launch, adult supervisors will make sure the launch area is clear and that all students are attentively observing the launch. Our NAR mentors will ensure that any electronics included in the vehicle are disarmed until all essential pre-launch preparations are finished. All hazardous and flammable materials, such as ejection charges and motors, will be constructed and installed by our NAR-certified mentor, complying with NAR regulations. Each launch will be announced and preceded by a countdown (in accordance with NAR safety codes).

Procedures and Documentation

In all working documents, all sections describing the use of dangerous chemicals will be highlighted. Proper working procedure for such substances will be consistently applied, such as using protective goggles and gloves while working with chemicals such as epoxy. MSDS sheets will be on hand at all times to refer to for safety procedures. All work done on the building of the vehicle will be closely supervised by adult mentors, who will make sure that students use proper protection and technique when handling dangerous materials and tools which inherent in the building of rockets.

Hazardous Materials

Propulsion and Deployment	Glues	Construction Supplies
Ammonium Perchlorate	Elmer's White Glue	Fiberglass Cloth
Animal Motor Works Reloadable Motors	Two Ton Epoxy Resin	Fiberglass Resin
Igniters	Bob Smith Cyanoacrylate Glue	Fiberglass Hardener
M-Tek E-matches	Superglue Accelerator	Self-expanding foam
Pyrodex pellets	Superglue Debonder	
Black Powder	West Epoxy Resin and Hardeners	
Soldering	Painting and Finishing	
Flux	Automotive Primer	
Solder	Automotive Spray Paint	
	Clear Coat	

Table 2: Hazardous materials used in our project. The MSDS sheets are available at http://www.westrocketry.com/sli2010/msds/msds2010r.html

Physical Risks

Risks	Consequences	Mitigation
Saws, knives, Dremel tools, band saws	Laceration	All members will follow safety procedures and use protective devices to minimize risk.
Sandpaper, fiberglass	Abrasion	All members will follow safety procedures and use protective devices to minimize risk.
Drill press	Puncture wound	All members will follow safety procedures and use protective devices to minimize risk.
Soldering iron	Burns	All members will follow safety procedures to minimize risk.
Computer, printer	Electric shock	All members will follow safety procedures to minimize risk.
Workshop risks	Personal injury, material damage	All work in the workshop will be supervised by one or more adults. The working area will be well lit and strict discipline will be required.

Table 3: Risks that would cause physical harm to an individual

Toxicity Risks

Risks	Consequences	Mitigation
Superglue, epoxy, enamel paints, primer	Toxic fumes	Area will be well ventilated and there will be minimal use of possibly toxic-fume emitting substances.
Superglue, epoxy, enamel paints, primer	Toxic substance consumption	All members will follow safety procedures to minimize risk. Emergency procedure will be followed in case of accidental digestion.

Table 4: Risks that would cause toxic harm to an individual

Rocket/Payload Risks

Risks	Consequences	Mitigation
Unstable rocket	Errant flight	Rocket stability will be verified by computer and scale model flight.
Improper motor mounting	Damage or destruction of rocket.	Engine system will be integrated into the rocket under proper supervision and used in the accordance with the manufactures' recommendations.
Weak rocket structure	Rocket structural failure	Rocket will be constructed with durable products to minimize risk.
Propellant malfunction	Engine explosion	All members will follow NAR Safety Code for High Powered Rocketry, especially the safe distance requirement. Attention of all launch participants will be required.
Parachute	Parachute failure	Parachute Packaging will be double checked by team members. Deployment of parachutes will be verified during static testing.
Payload	Payload failure/malfunction	Team members will double-check all possible failure points on payload.
Launch rail failure	Errant flight	NAR Safety code will be observed to protect all member and spectators
Separation failure	Parachutes fail to deploy	Separation joints will be properly lubricated and inspected before launch. All other joints will be fastened securely.
Ejection falsely triggered	Unexpected ignition/personal injury/property damage	Proper arming and disarming procedures will be followed. External switches will control all rocket electronics.
Recovery failure	Rocket is lost	The rocket will be equipped with radio and sonic tracking beacons
Transportation damage	Possible aberrations in launch, flight and recovery.	Rocket will be properly packaged for transportation and inspected carefully prior to launch.

Table 5: Risks associated with the rocket launch

Technical Design

Vehicle

We will use a single stage vehicle for our experiment. We are measuring sunlight intensity and atmospheric characteristics using two payload modules. We will utilize a pod design to accommodate the large payload modules while minimizing weight. The rocket will be 116 inches total length, with a payload bay (pod) diameter of 6 inches, and a 4-inch booster section. The vehicle will weigh 36.6lbs at lift-off. The proposed vehicle and propulsion options are discussed in detail below. The propulsion is an L-class motor. The vehicle can launch from a standard eight-foot launch rail.

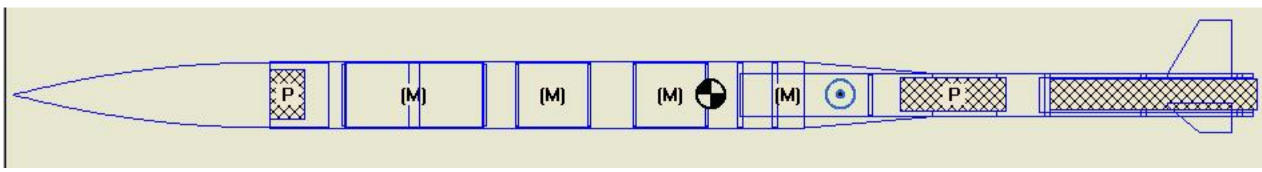


Figure 1: A two dimensional schematic of our vehicle

Vehicle Parameters

Length *[in]*	Liftoff weight *[lbs]*	Diameter *[in]*	Motor Selection	Stability Margin *[calibers]*	Thrust to Weight Ratio
116	36.6	6.155	AMW-L1080BB	3.04	6.5

Table 6: The rocket's dimensions, stability and propulsion

Figure 2: A three dimensional schematic of the entire rocket, showing the payload integration.

Letter	Part	Letter	Part
A	Nosecone	***F***	Booster Drogue Parachute Storage
B	Drogue Parachute	***G***	Transition and Booster Electronics
C	Electronics Bay and Electronics	***H***	Booster Main Parachute Storage
D	Payload Parachute Storage Areas	***I***	Motor Mount
E	Payload Modules	***J***	Fins

Table 7: Rocket Parts and Sections

Integration

The rocket will separate into two sections at the payload deployment altitude. The booster section, with the booster electronics, transition, and fin and motor mount assembly will utilize an independent dual deployment system. The payload modules will easily deploy from the bottom of the payload compartment, propelled by an ejection charge. There will be no connections between the payload compartment and the payload modules. The deployment scheme is described in detail in the *Payload* section.

Motor

Animal Motor Works L1080BB is the first choice motor. It will provide sufficient thrust for the liftoff of the entire vehicle (thrust/weight ratio is 6.5) and will burn out around 3.4 seconds after accelerating our rocket to about 435mph.

Motor	Length *[mm]*	Diameter *[mm]*	Average Thrust *[N]*	Impulse *[Ns]*	Burn Time *[s]*
AMW-L1080BB	497	75	1080	3700	3.4s

Motor Alternatives

Motor	Apogee *[ft]*	Thrust to Weight Ratio
AT-L850W	5949	5.1

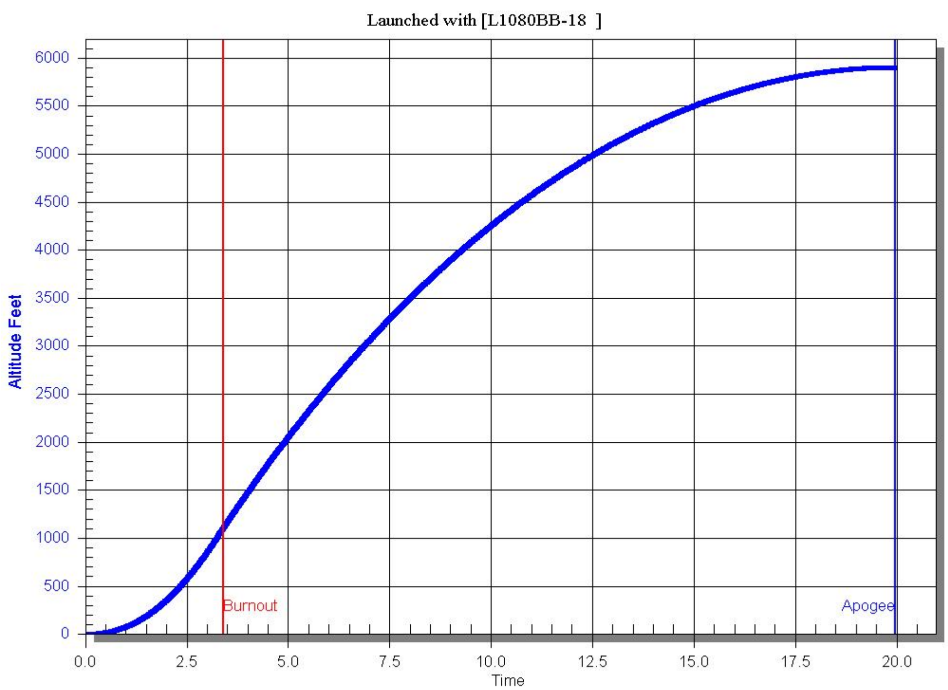


Figure 3: Altitude vs. Time graph. The rocket reaches an apogee of 5900 feet in 20 seconds.

The above graph shows simulated altitude vs. time with the L1080 motor. The predicted altitude of 5900ft, although above the target altitude of 5280ft, is considered acceptable at this stage in the project as RockSim tends to overestimate vehicle altitudes. Based on the results of our test flights we will adjust the ballast to achieve the final apogee of 5280ft.

Wind Speed vs. Altitude

Wind Speed *[mph]*	Altitude *[ft]*	Percentage Change in Altitude
0	5904	0.00
5	5894	0.17
10	5869	0.59
15	5832	1.22
20	5790	1.93

Table 8: Flight apogee vs. wind speed

The effect of the wind speed on the apogee of the entire flight is investigated in the table above. Even though under the worst possible conditions (wind speeds 20mph, the NAR safety limit) the flight apogee will differ by less than 2% from the apogee reached in the windless conditions.

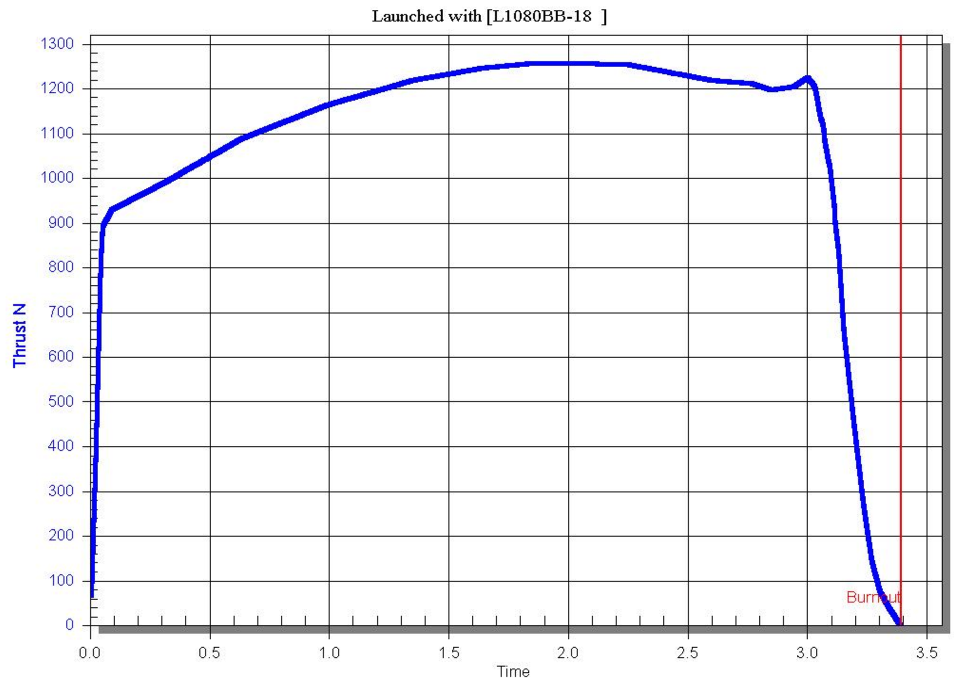


Figure 4: Thrust vs. Time graph. The motor provides a maximum thrust of about 1250 N and burns for 3.4s.

The above graph shows the thrust profile of the L1080 motor. The motor provides sufficient initial thrust to carry the vehicle safely off the launch rail.

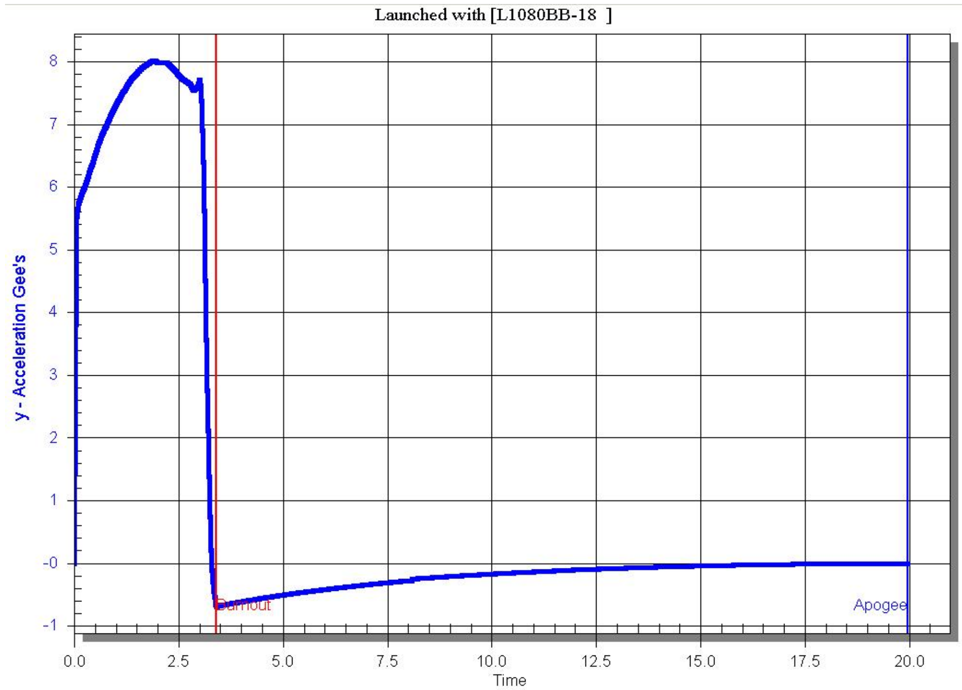


Figure 5: Acceleration vs. Time graph. The rocket experiences just over eight gees of acceleration.

The above graph shows the acceleration profile for the L1080 motor. Our rocket will be constructed in a sufficiently robust way to withstand the 10g+ acceleration.

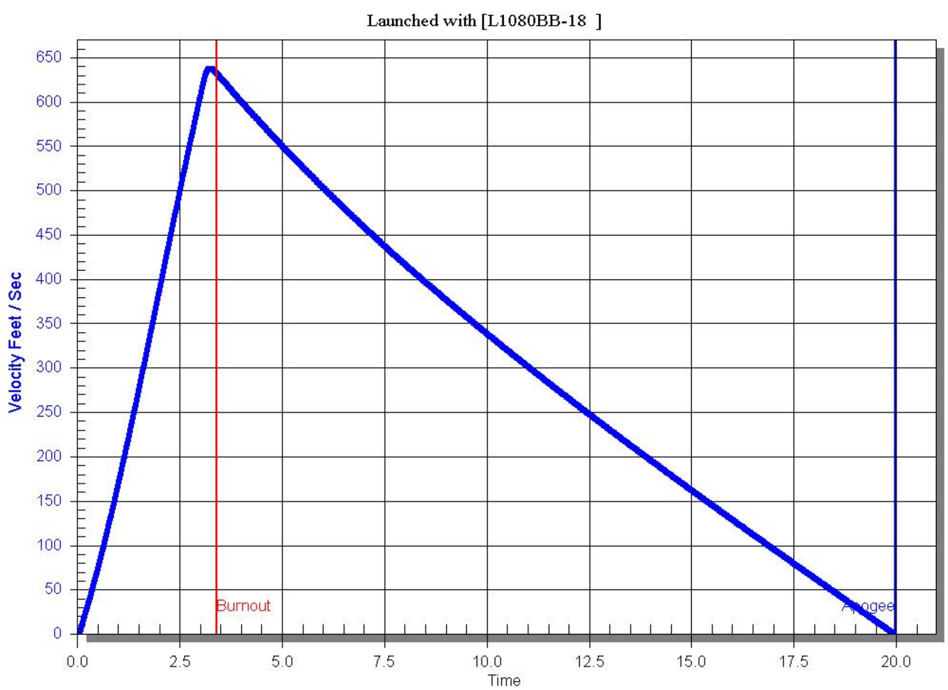


Figure 6: Velocity vs. Time graph. Our rocket will accelerate to about 640 feet per second, about 440 miles per hour. This is less than Mach 1, as required by SLI guidelines.

Payload

Our objective is to determine the effect of the atmospheric conditions/composition and ground features on direct and reflected sunlight above and within the planetary boundary layer. The planetary boundary layer (PBL) is a fairly recent addition to the scientific knowledge of our atmosphere, and the term refers to the lowest level of the atmosphere which is affected by convection and the close proximity of surface features (orography).

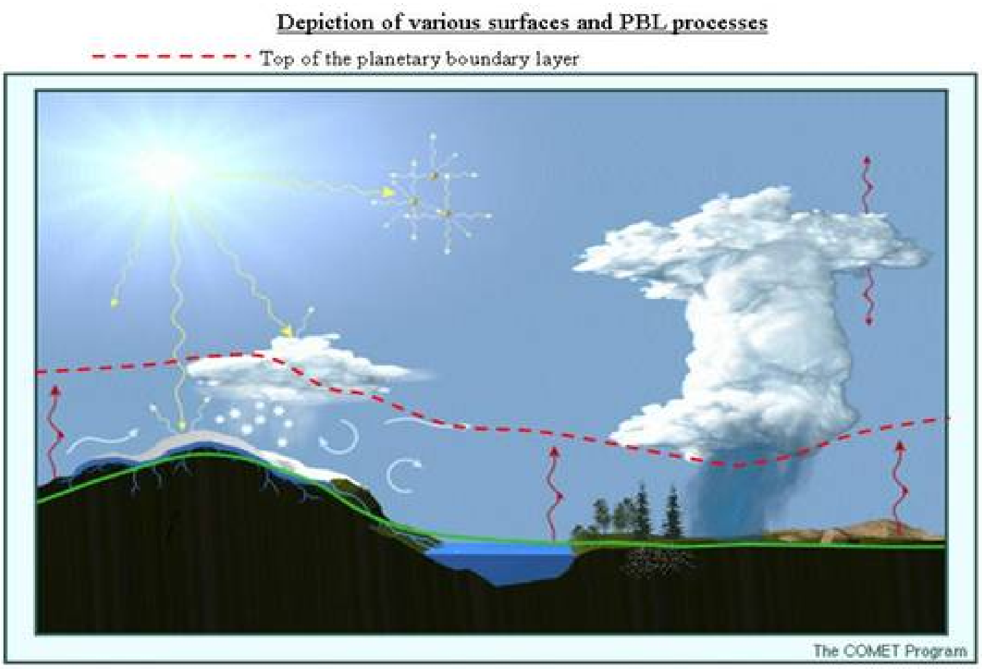


Figure 7: Depiction of sunlight passing through and being reflected in the boundary layer. Atmospheric conditions and composition affect the transmission of the sunlight as well as its reflection. The ground features affect the amount of sunlight reflected back from the ground to the planetary boundary layer. Source: *www.esrl.noaa.gov/.../themes/pbl/img/fig1.jpg*

In theory, perfect mixing occurs within the atmospheric boundary layer; the airborne particles are approximately equally dispersed. The heat from the sun causes the air near the ground to rise to higher altitudes. Air typically ascends at a rate of 2-3 meters per second or slower, if wind is not a factor. The decrease in temperature at higher altitudes cools the air, causing it to sink back to ground level. This constant convection equalizes the relative abundance of particles at different altitudes, creating the boundary layer.

This “perfect mixing” phenomenon sets the boundary layer apart from other atmospheric layers. We predict that the higher density of particles and pollutants within the boundary layer compared to other layers will dramatically affect the amount of sunlight available above versus within the PBL.

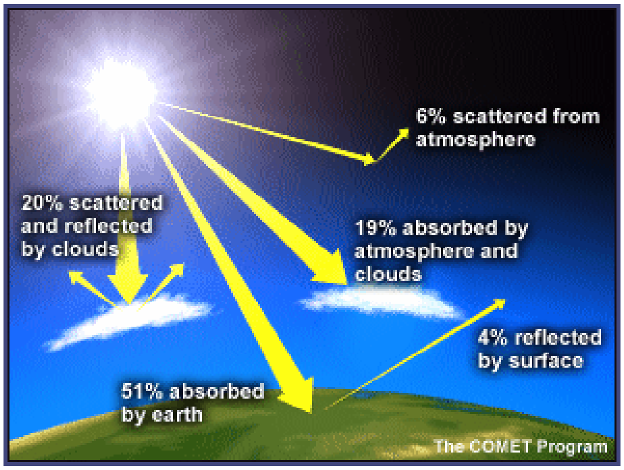


Figure 8: The sunlight entering the atmosphere follows several paths. Approximately 6% is reflected back, 20% is scattered and reflected by the clouds, 19% is absorbed by the clouds, 51% is absorbed by the ground and 4% is reflected by the ground back into the atmosphere. (Credit: The COMET Program)
Source: www.*windows.ucar.edu/tour/link=/earth/climate/greenhouse_effect_gases.html*

The atmosphere has varying compositions based on human activity, landscape, and weather patterns. For example, industrialized areas have a higher density of atmospheric pollution compared to rural and uninhabited regions. Solar radiation interacts differently with these atmospheric variations. Airborne particles and humidity diffuse and reflect sunlight, decreasing the amount of available sunlight. Atmospheric particles also absorb the energy of the photon, converting solar energy to heat.

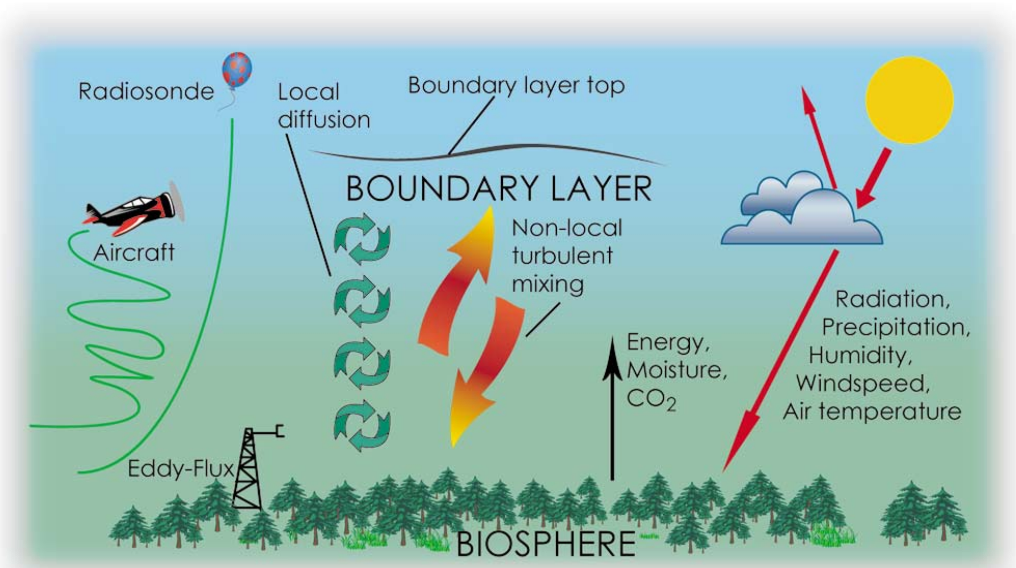


Figure 9: The figure above illustrates the different processes occurring within the boundary layer. It also lists the variables that affect the path of rays within the atmosphere such as precipitation, humidity, wind speed, and air temperature. Source: www.geos.ed.ac.uk/homes/s0349727/pbl.jpg

Our experiment has many practical applications in terms of knowledge of the atmosphere, biosphere, and pollutants. Understanding the behavior of solar radiation is vital, since sunlight is the primary source of energy for all living things on Earth. Plants absorb the energy in the photons to synthesize carbon-based molecules that are not only consumed by humans, but can also be burned to generate heat and mechanical energy.

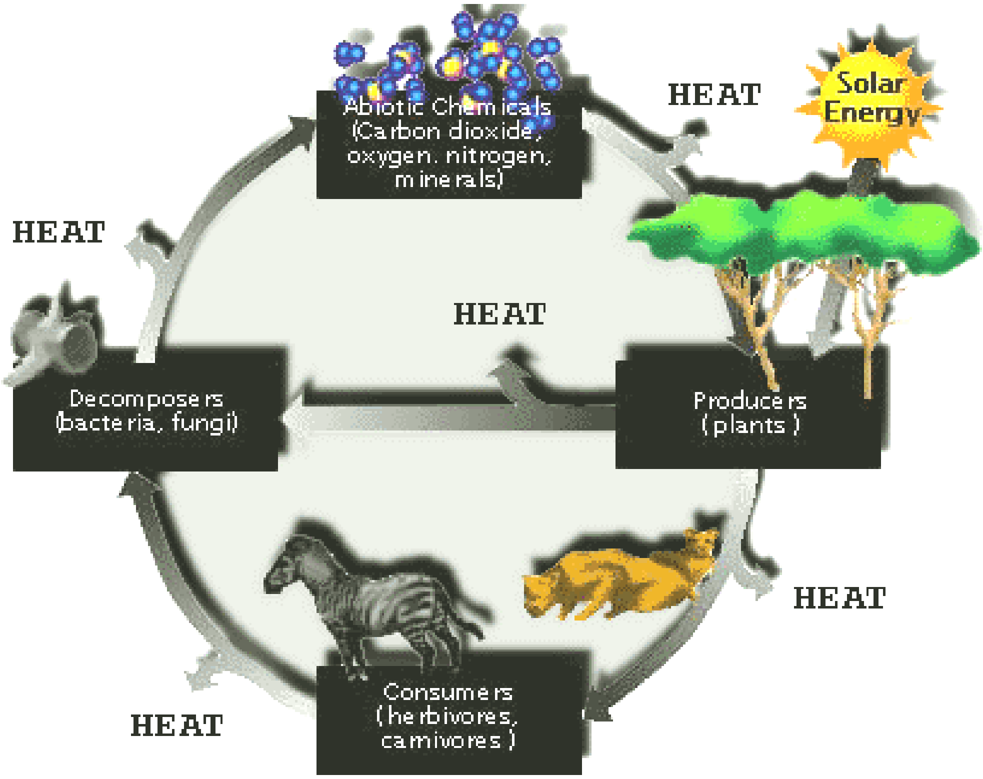
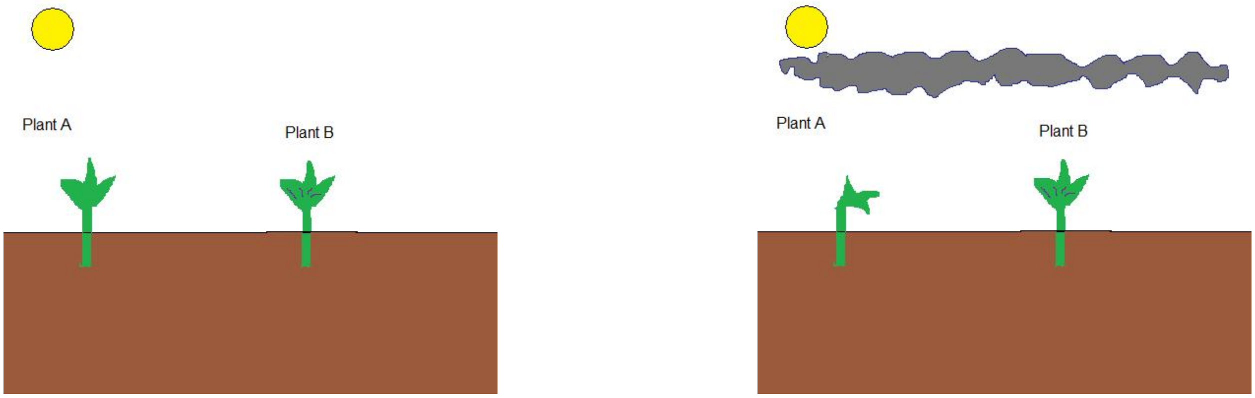


Figure 10: This diagram is a pictorial representation of solar radiation's role as the primary energy source for all life. The arrows show how energy moves through the system. The arrows leading out of the circle display the diffusion of energy as un-useable heat.

Since consumers depend on producers, plants provide the foundation for a stable habitat; therefore the entire ecosystems also predominantly rely on the availability of sunlight. A decreased availability of sunlight due to pollution and air-borne particles may prevent some plants from obtaining the needed amount of light. This gives certain species which are less reliant on direct sunlight a competitive advantage over other plants. Such ecosystem disruptions may then displace local wildlife dependent on the struggling plant. These disruptions not only occur in natural environments, but also in human industries such as farming.



Figures 11 and 12: Plants A and B are equally successful with full sunlight, right, however Plant B is less dependent on the amount of sunlight. When the atmosphere becomes polluted, the highly sunlight dependent Plan A vanishes and the ecosystem balance is changed. The extinction of Plant A can subsequently lead to extinction of species dependent on Plant A.

Our research will also contribute to the understanding of atmospheric pollution. We will measure the concentrations of selected pollutants (based on the sensor availability) at different altitudes and correlate the amount of sunlight that reaches a given altitude with the amount of pollutants in the sunlight path (and thus possibly blocking, absorbing or reflecting some of the sunlight.

Our research also has a practical application for agriculture and industry. Since sunlight is the basis of all natural energy, it is crucial to understand how pollutants and human-caused global climate change may impact available sunlight. During times of low agricultural yield, farmers often resort to excessive use of phosphate and nitrate fertilizers, both of which pollute water sources and end up in the air. In turn, these pollutants may block sunlight and the plants, while being provided with abundance of nutrients, will not receive enough sunlight to be able to utilize the extra nutrients and the yield will continue to drop, seemingly without explanation.

Figure 13: This flowchart illustrates the possible incorrect explanation for crop failure. In the first image, the soil in the area with significant atmospheric pollution is producing minimal agricultural profit. The farmers respond by applying increased phosphate and sulfate fertilizers in the second image. This causes increased pollution and air-borne particles (third image), which diffuses and reflects sunlight, preventing it from reaching the crops.

On-going research consistently proves that atmospheric content alters the intensity of solar radiation. Various studies have shown that sunlight intensity differs 1-2% above and within the planetary boundary layer, and a 10% reduction has been observed under conditions of smog and industrial pollution. Another study suggests that highly populated areas suffer a decline in solar radiation by approximately 0.41 W/m^2/yr (watts per meter squared per year), whereas sparsely populated areas experience a decline rate of merely 0.16 W/m^2/yr. This difference of sunlight intensities can be attributed to quality of the atmosphere in both the areas. Therefore the content of the atmosphere appears to have a direct effect on the availability of solar radiation on ground level.

We hypothesize that the abundance of various atmospheric pollutants will have a direct correlation with the amount of available sunlight. We also predict that these pollution levels will be higher at the upper edge of the boundary layer, and that there will be more available sunlight above the boundary layer.

Sensor Probes

To collect data, we will design and construct two identical sensor probes (Argus-1 and Argus-2). The probes will be constructed inside two plastic hemispheres, and will house light sensors on the surface of the hemispheres, as well as two electronics boards and batteries to power the electronics.

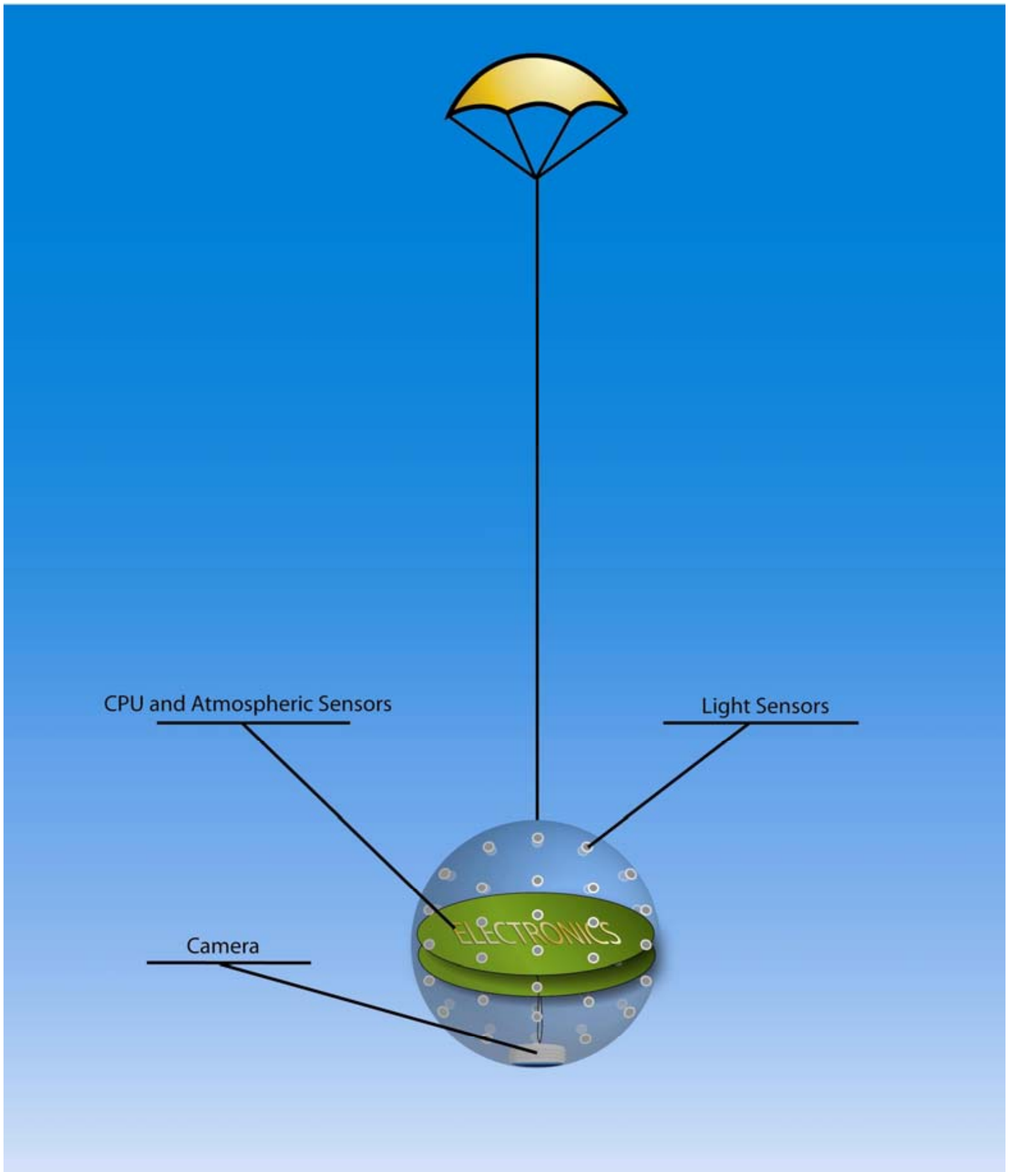


Figure 14: The rocket will carry and deploy two identical sensor modules. Each sensor module has numerous light sensors measuring light intensity from different directions. Electronic 2-axis compass will monitor the attitude of each module. Additionally, each module collect atmospheric data: pressure, temperature, humidity and concentrations of selected pollutants. A camera at the bottom of each sensor module will take pictures of the ground to correlate the ground features with the amount of light reflected by the ground. A GPS chip will allow us to trace the path traversed by each module. The shock cords connecting each sensor package to its parachute will be long, reducing the angular obstruction of sunlight caused by the parachute.

Our payload will require complex electronics to obtain, synchronize, and store data from the numerous sensors demanded by our experiment. We have had success in producing custom electronics to fit the needs of our past investigations, and that experience will be invaluable in the face of the challenges presented by this project.

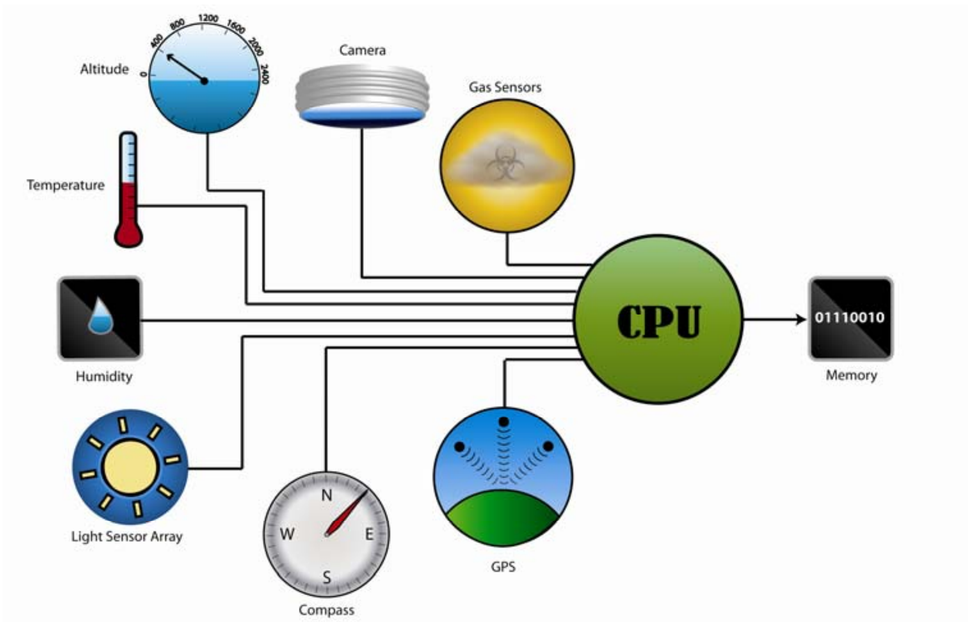


Figure 15: Pressure (altitude), temperature, humidity, attitude (2-axis compass), and GPS readings, along with data from the light sensor array, camera, and gas (pollutant) sensors will be passed into the central processor to be stored in non-volatile memory.

Each sensor probe will contain two identical circuit boards, one serving the sky-facing sensors and the other serving the ground-facing light sensors and the camera. Both will collect and record altitude, temperature, humidity, direction, location, and gas data with the light readings in a non-volatile memory. We will ensure that each sensor package has enough battery life to be activated on the pad before launch for more than an hour before the launch, and that data will still be collected for the entire descent.

Experiment Sequence

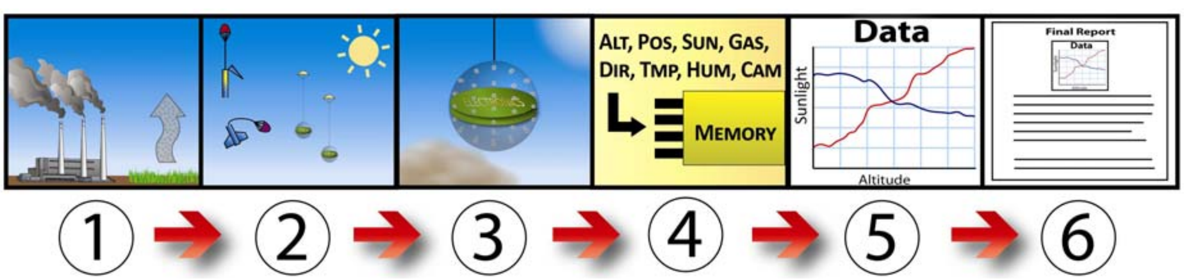


Figure 16: This picture shows our experiment sequence. Pollutants have been released into the air, via industrial and agricultural processes (1). We will launch our rocket, and deploy the sensor packages (2). The sensor packages will descend through the atmosphere, collecting data on the intensity of sunlight, the atmospheric content/conditions, and ground features (3). The altitude, position, sunlight intensity, atmospheric composition, sensor orientation, temperature and humidity data, as well as pictures from the onboard camera, will all be stored in non-volatile memory (5). After flight, the data will be analyzed (5) and placed in our final report (6).

Flight Sequence

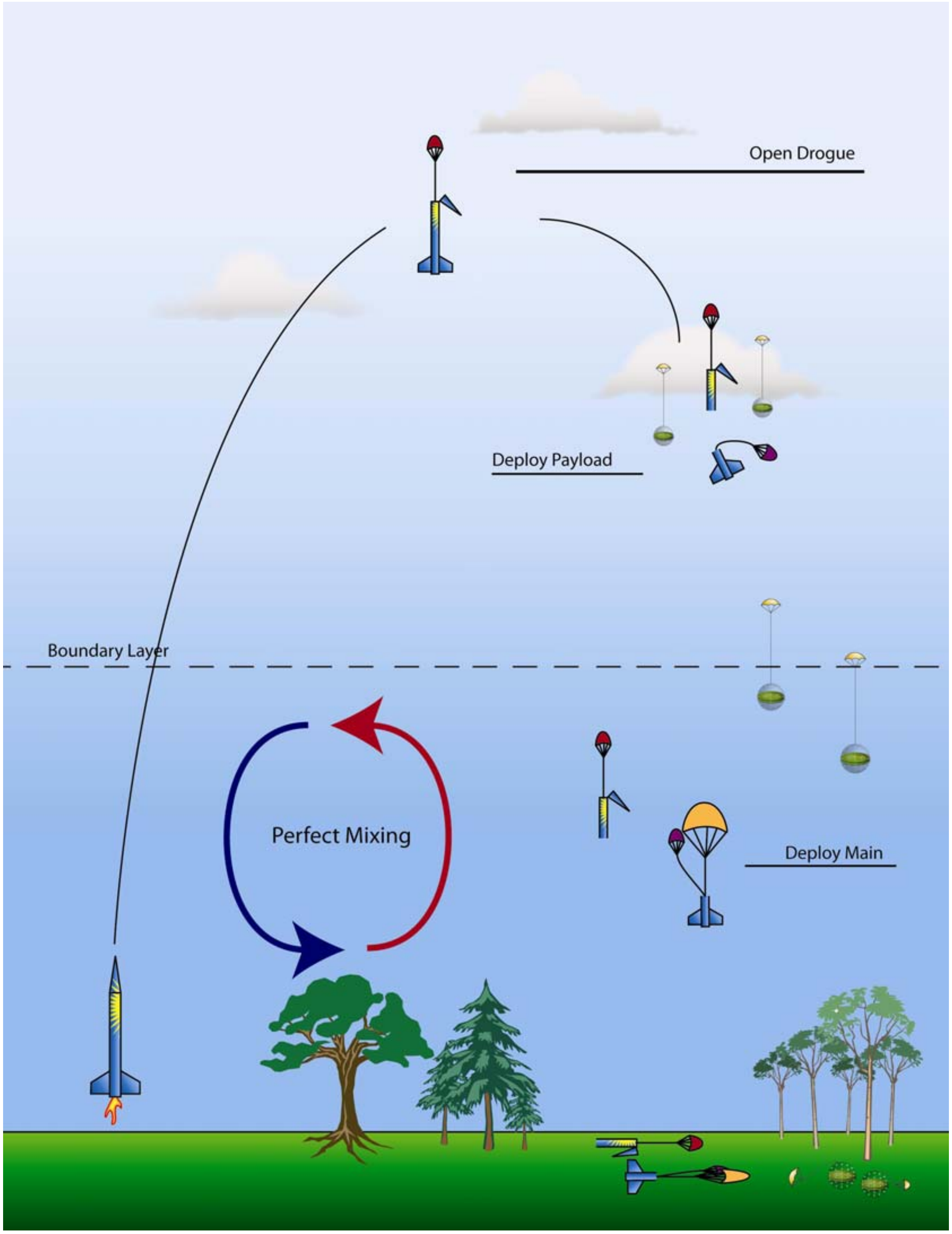


Figure 17: The flight sequence of the payload and vehicle. The drogue parachute for the entire vehicle (including the payload section) is deployed at apogee. The rocket then descends to the payload deployment altitude where the payload and booster sections separate from each other and sensor modules Argus-1 and Argus-2 are deployed from the payload section. The booster section deploys the booster drogue parachute and quickly descends to 700ft where the booster main parachute is deployed to slow the booster section to a safe landing speed. The payload section is now light enough to land safely under the vehicle drogue. The sensor modules descends through the atmosphere, collecting data until their landing.

The flight sequence is shown on the previous page, Figure 17. The sampling will be continuous from the payload deployment until the landing of each payload module.

A modified dual recovery scheme is utilized. At apogee, the rocket will deploy a drogue parachute from the payload compartment large enough for the entire rocket. The entire rocket will descend under this drogue parachute to the payload deployment altitude. At this altitude, the rocket will separate into two sections, the payload compartment and the booster section, deploying the payload modules in the process. The payload modules will descend under their own parachutes. The payload compartment will continue to descend under the original drogue parachute, however as the mass has been reduced this parachute will be large enough to slow the payload compartment to a safe landing speed. At payload deployment, the booster section will deploy its own drogue parachute, and at an altitude of 700 feet deploy the main parachute. This will insure the safe and easy recovery of the most valuable, complex, and massive portion of the rocket, including the transition, motor mount, motor casing, and fin assembly.

If weather conditions do not allow for high altitude payload deployment, the flight sequence can be easily modified by reprogramming the flight computer for a lower payload deployment altitude. A compromise on exact sampling range and the danger of the rocket drifting away will be considered and balanced prior to launch. We plan more than one launch during the project duration to maximize our opportunities to collect data.

Data and Correlations

Independent Variables

H	Relative Humidity
B	Location of planetary boundary layer
C	Atmospheric content (selected pollutants)
A	Altitude
G	Underlying ground features
X	Position
T	Temperature
P	Atmospheric pressure

Dependent Variables

L_v	Intensity of visible light (Red, Blue, Green)
L_I	Intensity of infrared radiation
L_u	Intensity of ultraviolet radiation

Primary Correlations

$L = F(H)$ Light intensities in relation to relative humidity
$L = F(B)$ Light intensities in relation to location planetary boundary layer
$L = F(C)$ Light intensities in relation to atmospheric content

Other Possible Correlations

$\boldsymbol{L} = F(\boldsymbol{G})$ Light intensities in relation to underlying land features
$\boldsymbol{L} = F(\boldsymbol{A})$ Light intensities in relation to altitude
$\boldsymbol{L} = F(\boldsymbol{X})$ Light intensities in relation to position

Primary Requirements and Objectives

1. **Payload:** The main purpose of our rocket is to carry a scientific payload to the target altitude of one mile. During flight, our payload will collect data concerning relative humidity, temperature, altitude, pollutant concentrations, and available sunlight for us to show the correlation between atmospheric factors, ground features and sunlight. The payload is not time critical and is reusable.

2. **Target Altitude:** Rocket needs to reach an altitude of 1 mile (simulations show that our rocket should reach 5900ft using L1080BB motor.)

3. **Launch Guidance:** The rocket can launch from a standard launch rail and it needs less than 8 feet of launch guidance to achieve the stable flight velocity.

4. **Motor:** The L1080BB, our primary motor choice, has a total impulse of 3700 Ns, not exceeding the 4000 Ns total impulse limit for returning teams. It uses solid ammonium perchlorate composite propellant.

5. **Reusability:** Both rocket and payload must withstand acceleration up to 15g (rocket will be constructed from fiberglass tubing, G10 sheets (for fins) using industrial strength epoxy glue (West Epoxy) with fillers. The fins will be mounted through the wall to improve robustness.

6. **Deployment and Recovery:** The rocket will deploy a drogue parachute at apogee, and the payload deployment altitude will be reprogrammable based on launch conditions. The deployment of the payload modules will be set so neither the payload or payload compartment leave the recovery field. We will use shear pins to prevent the rocket from separating prematurely, and test all ejection charges to insure that they are sufficient to cleanly separate all sections of the rocket. All sections of the rocket will have Walston tracking beacons and acoustic beacons (140dB screamers) to aid in recovery.

7. **Preparation:** the vehicle and payload will not take more than 4 hours to prepare for the flight.

8. **Time Constraints:** The payload modules will have sufficient battery life to run for several hours. The payload modules will draw only minimum current until the liftoff is detected and full scale data collection begins.

9. **Launch Sequence:** Our rocket will follow standard launch procedures and will use a standard firing system. Our rocket does not need additional circuitry or special ground support equipment to initiate the flight or complicate the standard 10 seconds countdown.

10. **Data:** Data will be collected during the flight and analyzed after the vehicle (including the payload modules) is recovered. We will use appropriate scientific methods when analyzing the data collected by the payload modules.

11. **Test Flight:** We will launch our rocket with the final motor before the FRR. A L2 certified NAR/TRA member will fill out a flight certification form.

12. **Prohibited Items:** We are not using flashbulbs, forward canards, forward firing motors, or rear ejection schemes on our vehicle. The vehicle does not exceed Mach 1.

13. **Stability:** The rocket has stability of 3.0 calibers. The stability of the rocket will be verified during test flights of a scale model and a full scale vehicle.

14. **Payload Deployment:** Payload must be ejected from payload bay (redundant deployment will be used; deployment scheme and ejection charge sizes will be determined and verified during static tests). Payload deployment altitude will be programmed so that neither payload nor vehicle drifts outside the launch site. If necessary, we will launch additional flights in our state to collect data from higher altitudes.

Major Challenges and Solutions

Vehicle Challenges and Solutions

1. **Rocket Design:** Designing and constructing a rocket of sufficient size to carry two payload modules (atmospheric sensor packages) and fly to an altitude of one mile: a pod rocket design will be utilized; the payload bay will be of larger size to accommodate the sensor packages while the booster section will be of smaller size to reduce vehicle weight. This design will be verified using computer simulation and scale model testing.

2. **Payload Deployment:** Ejecting both payload modules (sensor packages) at a specified altitude: the payload bay will be designed with ample room to eject the modules using ejection charges. Deployment scheme and ejection charge sizes will be verified using static testing. All deployment triggers (altimeters) will have backups to ensure that all necessary ejection charges are fired.

Payload Challenges and Solutions

1. **Unobstructed View of the Sky:** The parachute, necessary for safe recovery of the sensor package, could obstruct sunlight from some directions. In order to minimize the angular shading, we will use a long shock cord to remove the parachute as far as practical from the sensor package.

2. **Sensor Orientation:** As the sensor probes descend, they will most likely be rotating through the atmosphere. To account for this, we will include a dual-axis compass to determine the attitude (orientation) of each payload module.

3. **Sensor Resolution:** The sunlight intensity above and below the boundary layer only varies 1-2% on a clear day, and only 10% on a very smoggy day. We will use high resolution sensors to precisely detect these small changes.

4. **Payload Computational Requirements:** our payload modules will collect large amount of data and each payload module will utilize a multitude of sensors. To meet the computational and data storage requirements we will use 32-bit Parallax Propeller chips with eight cores, each core running at 80MHz. We will also use FLASH RAM non-volatile memory to store all the data collected during the flight (the FLASH RAM chips far surpass EEPROM chips in capacity).

5. **Payload Modules Tracking and Recovery:** since we plan to take measurements above and within the planetary boundary layer, the payload modules will be deployed at high altitudes and may drift far. Both radio and sonic beacons will be used to track and locate the payload. However, for our flight in Huntsville we will reprogram the payload deployment altitude based on local conditions to ensure that neither the vehicle nor the payload drifts outside the launch site.

6. **Payload Electronics:** our data-acquisition printed circuit boards will measure both digital and analog signals. Mixed signals boards always present a challenge as careful noise management must be incorporated in the board design. Additionally, the soldering work needs to be of high quality to eliminate problems caused by imperfect solder joints. We will work together with experts from UW Space and Astronomy Lab to ensure that our printed circuit boards meet the requirements of our experiment.

Educational Engagement

Community Support

Our school's Rocket Club receives extensive support from the community. For our experimental payload this year, we have already made contacts with several professors and professionals in our area who are eager to assist with our project. For example, we have met with Professor Eloranta of the University of Wisconsin's Atmospheric Sciences Department, who has greatly contributed to the design of our payload.

The local business DNASTAR Inc. allows us to use the meeting rooms to research and design our rocket. The state of art projection technology in DNASTAR conference room allows us to conduct our meeting effectively with all members actively participating in all discussions.

Hazelbaker & Associates law firm located and rented a space for our workshop. After six years of our existence we are finally moving into a dedicated workshop and we expect that this change will be reflected in higher effectiveness of our manual work.

To fundraise for our club and gain community awareness, we rake leaves each fall. This money sustains our TARC program and provides extra resources for our SLI programs as well. Since our TARC team won first place last year, many local newspapers have featured our Rocket Club, increasing our community's support.

Our TARC teams benefit from the local launch site at Reddan Soccer Park, courtesy of Madison Area Youth Soccer Association. In exchange for MAYSA's generosity we have built a new timber fence around Reddan Soccer Park.

We continue building our relationship with Parallax, Inc., an electronics/robotics company, well known for their Basic STAMP microcontroller. All our electronics is build around Parallax's current flagship microcontroller, P8X32A chip (marketing name: Propeller Mk I). Parallax Inc. already donated dozens of Propeller chips to our efforts. Printed circuit boards for all our electronics are manufactured by Advanced Circuits, Inc. and we are receiving at least 50% discount on all our orders.

We also contribute to our local community through local volunteering efforts for Wisconsin Public Television and radio stations. This volunteering increases the city's awareness and interest in our club.

Educational Outreach

This year, we plan to help out at Allied Outreach Center, an afterschool and weekend program for economically disadvantaged kids. We will give them a presentation on basic rocketry on one day, then build A-class rockets with them on another day. We will ask a rocket manufacture company (Quest Aerospace or Estes) to donate the small rockets, to increase our community's support for rocketry. This program will include around 30 children aged 5-10.

Similar to the previous outreach project, we will offer our assistance in organizing and running a Make-It-Take-It session for UW Space Place, a UW outreach center. The session will include rocket building and then launch at our TARC practice launch site, Reddan Soccer Park in Verona. The estimated participation at the activity is about 50 kids, ages 6-10.

We also plan to do rocketry presentations and/or workshops and demonstrations with local schools and after-school programs. Our school's club, Science for Kids, visits local elementary schools giving science talks and demonstrations to interest children in science. When we participate in this program, we will seek community monetary support or manufacturers donation to obtain rocketry kits. We will present to around 50 children each time.

Project Plan

Timeline

August 2009	
14	Request for Proposal (RFP) goes out to all teams
October 2009	
1	One electronic version of the completed proposal due to NASA
22	Awards Granted. Schools notified of selection
23	SLI teams teleconference
November 2009	
1	PDR work begins
5	Web presence established for each team, NASA media announces new teams
December 2009	
4	Preliminary Design Review (PDR) report due
7	Begin work on scale model
14	Acquire parts and supplies for scale model
21-Jan 3	Winter break
January 2010	
4	Scale Model Completed
5	Purchase parts and supplies for full scale vehicle
13	Scale model test flight
20	Critical Design Review (CDR) due
24	CDR Presentation practice
28-Feb. 5	Critical Design Review presentations (tentative)
February 2010	
8	Payload design finalized, payload construction starts
15	Full scale vehicle completed
22	First test flight of the full scale vehicle
March 2010	
17	Flight Readiness Review presentation slides and CDR report due
15	Second test flight, payload complete
22	Payload test flight
25-Apr. 2	FRR presentations (tentative)
April 2010	
12	Rocket Ready for Launch in Huntsville
14	Travel to Huntsville
15/16	Rocket Fair/hardware and safety check
17-18	Launch weekend
19	Return Home
May 2010	
21	Post-Launch Assessment Review (PLAR) due

Budget

Full Scale Vehicle

Nosecone	$20.00
Body	$300.00
Parachutes	$0*
Fins	$50.00
Other Parts	$100.00
Preliminary Flight Motors	$250.00
Final Flight Motors	$0.00**

Scale Model

Parts of Scale Model	$70.00
Scale Model Motors	$60.00

Payload

Altimeters	$0*
Sensors	$0***
Custom Electronics	$350.00

Tracking

Tracking System (beacon only)	$0*

Miscellaneous

Tools, glues, screws, etc.	$150.00

Project Expenses Total = $1350.00

* Already in possession, **Provided by NASA, SLI Program, *** Donated by Parallax

Travel and Lodging Expenses

Number of travelers: 11 (9 team members, 1 teacher, 1 mentor)

Traveling by plane	11 x $400 (estimated)	$4,400
Ground support vehicle	$400 (gasoline) + $400 (rental)	$800.00
Lodging	5 rooms x 4 nights x $119.00 (estimated)	$2,380.00

Travel/ Lodging Total =$7,580.00

The total estimated travel/lodging expenses for a team of 9 members, a teacher and a mentor are $7,580.00. NASA contributes $1,200.00 and the team will pay the remaining amount of $6,380.00. Therefore each member's personal contributions would be $709.00 ($6,380.00 divided to 9 members).We will explore various possibilities of acquiring the needed funds, either through sponsors, or fundraising.

Educational Standards

Wisconsin's Model Academic Standards

English/Language Arts

Reading and Literature

A.12.4 Students will read to acquire information

- Analyze and synthesize the concepts and details encountered in informational texts such as reports, technical manuals, historical papers, and government documents
- Draw on and integrate information from multiple sources when acquiring knowledge and developing a position on a topic of interest

Writing

B.12.1 Create or produce writing to communicate with different audiences for a variety of purposes

- Prepare and publish technical writing such as memos, applications, letters, reports and resumes for various audiences, attending to details of layout and format as appropriate to purpose

B.12.2 Plan, revise, edit and publish clear and effective writing.

Oral Language

C.12.1 Prepare and deliver formal oral presentations appropriate to specific purposes and audiences

Language

D.12.1 Develop their vocabulary and ability to use words, phrases, idioms, and various grammatical structures as a means of improving communication

Media and Technology

E.04.3 Create products appropriate to audience and purpose

- Write news articles appropriate for familiar media

E.12.1 Use computers to acquire, organize, analyze, and communicate Information

Research and Inquiry

F.12.1 Conduct research and inquiry on self-selected or assigned topics, issues, or problems and use an appropriate form to communicate their findings.

- Formulate questions addressing issues or problems that can be answered through a well defined and focused investigation
- Use research tools found in school and college libraries, take notes collect and classify sources, and develop strategies for finding and recording information
- Conduct interviews, taking notes or recording and transcribing oral information, then summarizing the results

- Develop research strategies appropriate to the investigation, considering methods such as questionnaires, experiments and field studies
- Organize research materials and data, maintaining a note-taking system that includes summary, paraphrase, and quoted material
- Evaluate the usefulness and credibility of data and sources by applying tests of evidence including bias, position, expertise, adequacy, validity, reliability, and date
- Analyze, synthesize, and integrate data, drafting a reasoned report that supports and appropriately illustrates inferences and conclusions drawn from research
- Present findings in oral and written reports, correctly citing sources

Mathematics

Mathematical Processes

A.12.4 Develop effective oral and written presentations employing correct mathematical terminology, notation, symbols, and conventions for mathematical arguments and display of data

A.12.5 Organize work and present mathematical procedures and results clearly, systematically, succinctly, and correctly

Number Operations and Relationships

B.12.6 Routinely assess the acceptable limits of error when

- evaluating strategies
- testing the reasonableness of results
- using technology to carry out computations

Geometry

C.12.1 Identify, describe, and analyze properties of figures, relationships among figures, and relationships among their parts by constructing physical models

C.12.2 Use geometric models to solve mathematical and real-world problems

C.12.5 Identify and demonstrate an understanding of the three ratios used in right triangle trigonometry

Measurement

D.12.1 Identify, describe, and use derived attributes (e.g., density, speed acceleration, pressure) to represent and solve problem situations

D.12.2 Select and use tools with appropriate degree of precision to determine measurements directly within specifies degrees of accuracy and error

Statistics and Probability

E.12.1 Work with data in the context of real-world situations by

- Formulating hypotheses that lead to collection and analysis of one and two variable data
- Designing a data collection plan that considers random sampling, control groups, the role of assumptions, etc.

- Conducting an investigation based on that plan
- Using technology to generate displays, summary statistics, and Presentations

Algebraic Relationships

F.12.2 Use mathematical functions (e.g., linear, exponential, quadratic, power) in a variety of ways, including

- using appropriate technology to interpret properties of their graphical representations (e.g., intercepts, slopes, rates of change, changes in rates of change, maximum, minimum)

F.12.4 Model and solve a variety of mathematical and real-world problems by using algebraic expressions, equations, and inequalities

Science

Science Connections

A.12.3 Give examples that show how partial systems, models and explanations are used to give quick and reasonable solutions that are accurate enough for basic needs

A.12.5 Show how the ideas and themes of science can be used to make real-life decisions about careers, work places, life-styles, and use of resources

Science Inquiry

C.12.2 Identify issues from an area of science study, write questions that could by investigated, review previous research on these questions, and design and conduct responsible and safe investigations to help answer the questions

C.12.6 Present the results of investigations to groups concerned with the issues, explaining the meaning and implications of the results, and answering questions in terms the audience can understand

Motions and Forces

D.12.7 Qualitatively and quantitatively analyze changes in the motion of objects and the forces that act on them and represent analytical data both algebraically and graphically

Science Applications

G.12.1 Identify personal interests in science and technology, implications that these interests might have for future education, and decisions to be considered

G.12.2 Design, build, evaluate, and revise models and explanations related to the earth and space, life and environmental, and physical sciences

National Science Educational Standards

Science and Technology (9-12)

Content Standard E

Students should develop

- Abilities of technological design
- Understanding about science and technology

Science as Inquiry (9-12)

Content Standard A

Students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Sustainability

Rocket Program Sustainability

The rocketry program at Madison West High School is now in its seventh year, and it provides a strong, compelling incentive for students to research unique science concepts and enhance their problem-solving skills.

Incoming students are enrolled in the TARC program, where they attend classroom sessions taught by the mentors in order to learn the basic rocketry knowledge and methodologies essential to the contest.

Returning members are encouraged to participate in either 10K or NASA's SLI program, in addition to TARC. In all three of these programs, members are challenged to apply rocketry concepts in order to design and build a rocket/payload that achieves a specific goal (flight objective). Additionally, the veteran members assist in tutoring new members, aiding them in rocket design, building, and flight preparation. Through such a system, older members assume leadership roles, and contribute to the sustainability of the club.

The 10K program is a program for the veteran students with interest in high power rocketry. A year of experience in TARC is required for 10K enrollment. The program begins with a series of lectures explaining the concepts of high power rocketry in detail. After the lectures, participants work toward their L1 certification (within the NAR Jr. program) and eventually progress to a 10,000ft target altitude project with hybrid propulsion.

Madison West Rocketry actively recruits new members in the fall season: the Freshman Club Carnival, West Fest, Homecoming parade, and daily announcements, all showcase our club's achievements, appealing to interested individuals.

We collaborate extensively with experts at the University of Wisconsin (UW). During our meetings we are able to have analytical discussions with professionals regarding the feasibility and limitations of various potential experimental payloads. We have developed such relationships with eight different departments; this variety provides us with experiences perspectives on our design and objectives.

Our many meetings for project planning, document writing, practice presentations, and design drafts, occur at the conference rooms of DNASTAR. These well equipped rooms provide multiple workspaces and high-speed network capabilities. The facilities at DNASTAR are crucial to our research meetings and brainstorming sessions. We hope to continue and maintain this vital partnership.

We now have five committed mentors who aid our group throughout all the stages of our well-established rocketry program. They patiently teach us and guide us in the planning, processing, writing, building, organization, and launching of our project. Our mentors dedicate much time and effort throughout the year- we greatly value their compassion and support.

An increasing number of parents are taking interest in supporting our club's meetings, fundraisers, outreach projects, and launches. They provide us with food and transportation during the cold winter events and launches, and are a great source of encouragement.

Second Year Project Complexity

Our club has now been established for seven consecutive years. With each passing year, our technologies improve and we continue to add to our vast base of scientific knowledge. Due to such a strong foundation, we are able to demand greater quality in our work and seek deeper challenges in our scientific research.

Our project this year is much more complex and involved, both from a rocketry standpoint and a science standpoint. An L-class high power rocket will be utilized to carry the payload to one mile. The payload will be secured in our rocket and be deployed during descent at a determined altitude. We must successfully deploy our payload from the vehicle and the payload must function as designed while descending in order to acquire reliable data from our sensors. We have three rocketry mentors who all have experience with high power rocket flights and will be able to guide us through this process. With hard work and concentration, we will be able to safely and successfully fly our rocket and deploy our payload.

Our experiment is also more complex, involving several stages of data collection and analysis. Our payload modules will be constructed within two clear hemispheres. The hemispheres will contain atmospheric sampling sensors, and sensors for sampling sunlight intensity across a broad spectrum will be spread on the surface of each hemisphere. Then we will fly our rocket and collect solar intensity, location, air composition, pressure, and temperature data, as well as photographs of ground features, while the payload is descending. Finally, we must compare the data received from the solar intensity instruments to the specific atmospheric conditions.

Significant amount of custom electronics (including mixed digital-analog signals boards) will be involved in our payload. We are building on three years of experience in data-acquisition electronics design and will work with the support of Parallax, Inc. and Advanced Circuits, Inc. to achieve our goals.

The project will present many challenges, however we will be able and dedicated to find solutions to all of them. Our prior experience in TARC and SLI will give us a starting point for this year, and our rocketry mentors and our additional contacts will be able to guide us through the construction and implementation.

Appendix A: Resume for David

3514 Topping Rd
Madison, WI 53705
daeschlimann@westrocketry.com

Academic Experience:

EAGLE School (1998-2007)
Madison West High School (2007- Present (11th Grade)) 4.0 GPA

Languages:

English
French (Intermediate)

Volunteer Work:

Wisconsin Public Television Volunteer (2007 – Present)
Religious Congregation Volunteer for Food Pantry etc. (1999 - 2005)
Volunteer for School Library (2005 - 2007)

Academic Interests:

Science – Biology and Physics
Computer Science
Mathematics
History – Post-Modern Era
English

Other Interests:

Rocketry, Design Graphics, Video Editing, Computer Programming, Rock Climbing, Skiing, Camping, Sailing, Windsurfing, Travel, Photography, Theater

Music:

Piano (1998-2007)

Extra Curricular Activities:

Madison West Rocket Club (2007 - Present)
West Theater Sound Crew (2007 - Present)
Science Olympiad (2005 - 2007)
National Young Leaders Conference (2007)
Washington Workshops (2007)

Achievements, Honors and Awards:

TARC 2008 – 18th Place
SLI 2009
EAGLE Wings Award for Creativity
EAGLE Wings Award for Citizenship
Midwest Academic Talent Search Recognition Award

National Knowledge Master Open – Fourth Place Team (2007)
State Science Olympiad - 3rd Place Category Winner
Madison West High Honor Roll (2007- Present)
Wisconsin National History Day State Champion – Documentary (2008)
National History Day National Finalist – Documentary (2008)

Honors Classes:

English 10 Honors
Shakespeare Honors
Trends in 20th Century Literature Honors
Advanced Writing Workshop Honors
Western Civilization Honors
Theater II Honors
Biology Accelerated
Accelerated Math Physics
Algebra 2 Trigonometry Honors
Pre-Calculus Honors
AP Calculus AB
AP Computer Science AB
AP Psychology
AP French Language

Appendix B: Resume for Jacqueline

4406 Herrick Lane
Madison, Wisconsin 53711
jgerman@westrocketry.com
(608)-338-5987

Objective:
To gain knowledge in engineering, aerospace, and the research process and application

Related Experience:
US Space and Rocket Center: Space Academy; Huntsville Alabama (summer of 2004)
Mission Work; REF: Sonja Parr
- Refurbishing housing
- Supervising
- Teaching

Team America Rocketry Challenge; REF. Christine Hager (2008)

Education:
Completed:
- Elementary: Midvale (1997-2000)
  - Lincoln (200-2003)
- Middle School: Hamilton (2003-2006)
  - Honor roll all four years

Currently enrolled:
- High School: Madison West High School (2006-present)
  - Classes completed relating:
    - Biology Honors
    - Math Physics (Honors)
    - Geometry-Pre Calculus
  - Classes enrolled relating:
    - Biology II
    - Advanced Physics
    - Astrophysics (enrolled in the winter-spring)

Skills:
Completed Spanish 2003-2008
Completed German 2008-present
- Summer Immersion Program (Summer of 2009)

Achievements/Awards:
Certificate of Recognition
- From Steve Cook, Ares Project Manager: NASA/Marshall Space Flight Center

Resolution of Recognition

From Supervisor Scott McDonell, Chair Dane Country Board of Supervisors
Member of National Honor Society (2009-present)
Honor roll 2006-present
Champions of Team America Rocketry Challenge of 2009

Extra-Curricular Activities:

Varsity Swimming (2006-present)
High Junior Varsity Soccer (2006-present)
Leo Club [community service club] (2006-present)
Rocket club (2008-present)
Team America Rocketry Challenge participant (2009)
Finalist (first place)
NASA's Student Launch Initiative program participant (2009-present)

Appendix C: Resume for Jacob

454 Toepfer Ave.
Madison, WI 53711
jkelly@westrocketry.com

Education:
Home schooled for elementary and middle school
West High School – currently junior year

Academic Interests:
Madison West Rocket Club - 2007 TARC 19th Place
SLI Participant 2008-2009
Madison West Cross Country Team
Trees for Tomorrow
Experience with AutoCAD, Inventor, and Solidworks software programs
Carleton Summer Science Institution – 2009
Project Lead the Way

Other Interests:
Youth in Government, including Conference on National Affairs in North Carolina
Suzuki violin for 6 years
Guitar for 2 years
Young Shakespeare Players – 20+ productions of Shakespeare and Shaw

Voluntary and Work Experience:
Brat Fest
Friends of Troy Gardens – Farm and Field Program
Continuing volunteer work with Baha'i Community

Languages: English, Intermediate Spanish

Honor Classes:
Biology
Geometry
Algebra II/Trigonometry
English 10
Western Civilization
Chemistry

Appendix D: Resume for John

2130 Chadbourne Avenue
Madison, WI 53726
john.schoech@westrocketry.com

Academic Experience:
Franklin Elementary School (1998-2000)
Randall Elementary School (2000-2003)
Velma Hamilton Middle School (2003-2006)
Madison West High School (class of ’10) GPA 4.0

Interests:
Computers and Technology, Photography, Music, Running, Biking, Rocketry

Achievements, Awards and Honors:
Future Problem Solving State Qualification (Junior Level) (2002)
Future Problem Solving State Qualification (Junior Level) (2004)
Velma Hamilton Middle School Honor Roll (2003-2006)
Madison West High School Honor Roll (2006-)
Solo and Ensemble Festival (Alto Saxophone, Class C, Score 1) (2006)
Solo and Ensemble Festival (Alto Saxophone, Class B, Score 1) (2007)
Solo and Ensemble Festival (Alto Saxophone, Class A, Score 1) (2008)
Solo and Ensemble Festival (Alto Saxophone, Class A, Score 1*, invite to state competition) (2009)
Team America Rocketry Challenge Finals (2nd Place) (2007)
Team America Rocketry Challenge Finals (1st Place) (2009)
Spanish Honor Society Member (2008-)
National Honor Society Member (2009-)

Extracurricular Activities:
West High Rocket Club (2006-)
  2nd and 1st Place in Team America Rocketry Challenge Finals
  NASA Student Launch Initiative Team Member (2007-)
Student Support Foundation West (2007-) (Secretary 2009)
Cross Country (2006-)
Track (2006)
Madison West Jazz Too (2006-)
Madison West Pep Band (2006-)
Madison West Freshman Band (2006-2007)
Madison West Concert Band (2007-2008)
Madison West Honor Band (2008-)
Alto Saxophone Lessons (2003-)
Guitar Lessons (2002-2007)

Volunteer Work:

Luther Memorial Church (Sound Board Operator) (2006-)
Brat Fest (2007, 2008)
Wisconsin Public Television (Office Assistant) (Summer 2007)
Atwood Community Center (Food Pantry Worker) (Summer 2008)
Blackhawk Girl Scout Council Rocket Launch (2008)

Work Experience:
Laurits R. Christensen Assoc.
Office Assistant (Summer 2008)

University of Wisconsin Radio Frequency Identification Lab
Research Intern (Summer 2009)

Appendix E: Resume for Tulika

1249 Dayflower Drive
Madison, WI 53719
tsingh@westrocketry.com

Academic Experience:

Elementary School

PS183 RL Stevenson School, New York City, USA (1996-1998)
Bhartiya Vidhya Bhavan, Pune, India (1998-2000)
Dalton School, Utrecht, Netherlands (2000-2001)
Violen International School, Hilversum, Netherlands (2001-2003)

Velma Hamilton Middle School, Madison, USA (2003-2006)
Madison West High School, Madison, USA (2006-present, 12th grade)

Languages: English, Hindi, Dutch, and French

Interests: Sailing, Water Sports, Hiking, Camping, Beach Volleyball, Rocketry, and Traveling

Achievements, Honors, and Awards:

Velma Hamilton Middle School Honor Roll (2003-2006)
Hamilton Pride Award (2003-2006)
Solo Ensemble Festival, District Level (2005)
Distinguished Service Award by Kiwanis Club (2005)
Earth Science Student-of-the-year award (2008)
Madison West High School Honor Roll (2006-)
French Honors Society (2008-)
National Honors Society (2009-)

Extra Curricular Activities:

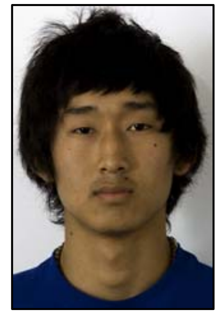
Avondvierdaagse (2001-2002)
Hamilton Yearbook Club (2003-2006)
Science Saturdays and Biology for Kids at UW Madison (Summer of 2004)
Community Karate (Winter of 2004)
Hamilton Battle of the Books (2005)
Hamilton Art club (2004-2006)
Hamilton Pottery club (2004-2006)
Hamilton Badminton club (2004-2006)
Hamilton Student Council (2005-2006)
Hamilton Volleyball Club (2005-2006)
Hamilton 8th Grade Video Graduation Team (2006)
Medicinal Workshop at UW Health Sciences (2006)
West Freshman Girls Volleyball Team (2006)
West Biology Honors Club (2006-2007)
Latin Dance Club (2006-2007)

Trees for Tomorrow (2006-2007)
West Student Council (2006-2008)
SLC Commissions (2007-2008)
Student Support Foundation (2007-2008)
West Forensics (2007-2008)
West Rocket Club, TARC (2008)
Department of Natural Resources Workshop at Kemp (Summer of 2008)
Hoofer Sailing Youth Instructor (Summer of 2008)
Student Launch Initiative (2008-2009)
West Gold Girl's Soccer Team (2009)
Research Apprentice Program, Dept. of Neurology (Summer of 2009)
Natural Supports, Peer Partners (2007-)

Volunteer Experience:

Help-Your-Teacher Project (2005)
Waisman Center Babysitting (2007)
Brat Fest with West Forensics (2007)
Wisconsin Public Television Phone Bank (2007-2008)
Hoofer's Sailing Instruction (Summer of 2008)

Appendix F: Resume for Tenzin



5721 Rosslare Ln.
Fitchburg, Wisconsin 53711
608-274-1309
atutsang@gmail.com

Academic Experience:
- Glenn Stephens Elementary School (1998-2003)
- Cherokee Heights Middle School (2003-2006)
- Madison West High School (Class of '10)
- Tibetan Cultural School (1999-)

Languages:
- Fluent in Tibetan and English
- Learning Spanish

Achievements, Awards, and Honors:
- Madison West High School Honor Roll (2006-)
- West Science Department Daniel Conley Award (2009)
- Team America Rocketry Challenge Finalist (2007, 2009)
  - 1st Place (2009)
- Mini Business World Participant (2008)
  - 1st Place (2009)
- Member of Sociedad Honoraria Hispánica (2008-)
- Member of National Honor Society West Chapter (2009-)
- Performed in the presence of H. H. the 14th Dalai Lama (2007, 2008)

Extra-Curricular Activities
- Asian Club (9th and 10th grade)
- Culinary Club (9th grade)
- DECA (11th and 12th grade)
  - Mini Business World participant
    - 1st Place (11th grade)
  - DECA Regional Competition participant
- Rocket Club (9th - 12th grade)
  - Team America Rocketry Challenge participant (9th and 11th grade)
    - 1st place (11th grade)
  - NASA's Student Launch Initiative program participant (10th, 11th, and 12th grade)
- National Honor Society (11th and 12th grade)
  - President (12th grade)
- Sociedad Honoraria Hispánica (10th, 11th, and 12th grade)
- Health Occupation Students of America (11th and 12th grade)
  - Co-President (12th grade)

    - Treasurer (11th grade)
- Student Council (10th, 11th, and 12th grade)
    - Vice President

Volunteer Experience:

- St. Mary's Hospital (2008-2009)
- Wisconsin Public Television phone bank operator (2008)
- Girl Scout Launch (2008)

Appendix G: Resume for Zander

3634 Spring Trl.
Madison, WI 53711
zsteichen@westrocketry.com

Education:

EAGLE School of Madison (1997-2006)
Madison West High School, currently in twelfth grade

Languages: Fluent in English, studied French for 12 years, near fluent, Spanish for 2 years

Interests and Activities:

Biking: Road and Mountain (Racing)
Kayaking
Sailboat Racing
Skiing (Downhill & Cross country)
Shorewood Squids Soccer Team 2000-2004
Tennis
Camping
Horseback Riding
Interlaken JCC Summer Camp 2005-Present
Madison West High School Auditorium Lighting Crew Head
Math Olympiad 2005, 2006
Travel Experience:
- 31 US States
- Panama
- Brazil
- Mexico
- Canada
- Czech Republic
- Germany
- Austria

Brazil Biology Research Trip 2007
Rocketry Experience:
- TARC Finals 2008 11th Place
- TARC Finals 2009
- SLI 2009
- Small scale personal fleet (A-D motors)

Instruments played:

Piano 1998-2006
Bass Clarinet 2002-2006

Volunteer Experience:

Madison West Regent Drama Club 2006-Present

Brat Fest 2007
Locks Of Love
ACT6 AIDS Support
Salvation Army
2^{nd} Harvest Food Bank
Public Park Cleanup

Work Experience:
Hohlstein Construction Company- Part Time Assistant Contractor 2007-Present

Appendix H: Resume for Larissa

Age 17

Education:
Shorewood Elementary School, Madison, Wisconsin (Grades K through 5)
EAGLE School of Madison, Fitchburg, Wisconsin (Grades 6 through 8)
West High School, Madison, Wisconsin, currently enrolled in 12th grade

Languages:
11 years of French
4 years of Japanese
1 year of Latin

Academic Experience Outside of School:
2-week drama course through Wisconsin Center for Academically Talented Youth (WCATY)
3-week intensive writing through WCATY
3-week intensive Japanese language and culture course through WCATY
Mentorship under UW-Madison's Psychology Department Chair, Dr. Seth Pollak
2-Day Biology research expedition at Trees for Tomorrow in Northern Wisconsin
2-week biology research trip to Brazil
6-week exchange student trip to Japan (included attending school)
2-month online Japanese culture course through Stanford Continuing Studies Program
11-week internship with UW-Madison researcher Dr. Leslie Seltzer

Volunteer Experience:
3 consecutive years participating in National Youth Service Day
2 years as a leader organizing our school's food drive
Collecting neighborhood food donations
Biology research in Brazil's wetland, the Pantanal
Raising money for local organizations and clubs by working at Madison's Brat Fest
Helping with Middleton Outreach Ministry's School Supply Drive
Student government at school
Bell-ringing for the Salvation Army
70 hours volunteering at Hoofer Sailing Camp for kids

Achievements:
Superior solo ratings in Federation Piano Competition for 6 consecutive years
Superior duet ratings in Federation Piano Competition for 6 consecutive years
State Finalist for Forensics (public speaking and presentation)
My poem selected to be read at Madison's Cultural Awareness Event
Membership in French Honor Society
Membership in National Honor Society
Honor roll ever semester at West High
Recipient of Sony Scholarship for a 6-week exchange trip to Japan

Recipient of Stanford Scholarship for 2-month online course

Extra Curricular Activities:
Piano
Forensics (public speaking and presentation)
Peer Partners (involving students with disabilities in our school)
Student Government (served as Freshman representative and Chair)
Rocket Club
Japanese Club

Rocket Experience:
1 year at Team America Rocketry Challenge
1 year in SLI

Appendix I: Resume for Henry

2229 Eton Ridge
Madison, WI 53726
hwroblewski@westrocketry.com

Education:

Franklin Elementary School, finished 2000
Randall Elementary School, finished 2003
Velma Hamilton Middle School, finished 2006
Madison West High School, currently in 12th grade

Languages: Fluent in English, studied French for four years

Interests and Activities:

<u>Dance:</u>

Studios:
- Madison School of Ballet 1996-1999
- A Step Above 1999-2000
- Ballet Madison 2000-2002
- Storybook Ballet 2002-2003
- Madison Professional Dance Center 2003-Present
- Monona Academy of Dance 2007-Present

Performances:
- Madison School of Ballet's Sleeping Beauty 1997

Madison School of Ballet's La Boutique Fantasque 1999
Madison Ballet's The Nutcracker 2000-2005
- Madison Dance Production's Cinderella 2001
- Madison Ballet's Cinderella 2005
- Dance Wisconsin's Nutcracker Fantasy 2006-2008
- Dance Wisconsin's New Works Concert 2007, 2008
- Dance Wisconsin's Peter Rabbit's Ballet 2007
- Dance Wisconsin's La Fille Mal Gardée 2009

<u>Math Competitions:</u>

Hamilton Middle School Math Team 2005-2006
- Mathcounts Middle School Math State Competition 2006
- MATC Middle School Math Competition
- American Mathematics Council-8 Test
- Purple Comet Online Math Competition

Madison West High School Math Team 2006-Present
- LaFollette Math Meet, October 11, 2006
- Mandelbrot Competition, October 2006
- Memorial Math Meet, December 13, 2006
- Wisconsin Mathematics League Contest 3 January 9, 2007
- Wisconsin Mathematics League Contest 4 February 6, 2007
- Wisconsin Mathematics League Contest 5 March 6, 2007

West Math Meet, February 7, 2007
Purple Comet Online Math Competition
Other Clubs and Activities
Regent Soccer Club 1998-2004
Future Problem Solving 2001-2003
Battle of the Books 2004-2007
Madison West Cross Country 2006
TARC Finals 2007, 2008
Brazil Research Trip 2007
SLI participant 2008, 2009

Instruments played:
Piano 1998-2001
Cello 2001-2003
Oboe 2003-Present

Volunteer Experience:
Appalachian Service Project 2006, 2008
Brat Fest 2007
WPTV phone bank operator 2007

Appendix J: 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 K: High Power Rocket Safety Code

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.

1. **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.

2. **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.

3. **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.

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 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.

6. **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.

7. **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.

8. **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.

9. **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.

10. **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.

11. **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.

12. **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.

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

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

Appendix L: Section 508

§ 1194.21 Software applications and operating systems.

(a) When software is designed to run on a system that has a keyboard, product functions shall be executable from a keyboard where the function itself or the result of performing a function can be discerned textually.

(b) Applications shall not disrupt or disable activated features of other products that are identified as accessibility features, where those features are developed and documented according to industry standards. Applications also shall not disrupt or disable activated features of any operating system that are identified as accessibility features where the application programming interface for those accessibility features has been documented by the manufacturer of the operating system and is available to the product developer.

(c) A well-defined on-screen indication of the current focus shall be provided that moves among interactive interface elements as the input focus changes. The focus shall be programmatically exposed so that assistive technology can track focus and focus changes.

(d) Sufficient information about a user interface element including the identity, operation and state of the element shall be available to assistive technology. When an image represents a program element, the information conveyed by the image must also be available in text.

(e) When bitmap images are used to identify controls, status indicators, or other programmatic elements, the meaning assigned to those images shall be consistent throughout an application's performance.

(f) Textual information shall be provided through operating system functions for displaying text. The minimum information that shall be made available is text content, text input caret location, and text attributes.

(g) Applications shall not override user selected contrast and color selections and other individual display attributes.

(h) When animation is displayed, the information shall be displayable in at least one non-animated presentation mode at the option of the user.

(i) Color coding shall not be used as the only means of conveying information, indicating an action, prompting a response, or distinguishing a visual element.

(j) When a product permits a user to adjust color and contrast settings, a variety of color selections capable of producing a range of contrast levels shall be provided.

(k) Software shall not use flashing or blinking text, objects, or other elements having a flash or blink frequency greater than 2 Hz and lower than 55 Hz.

(l) When electronic forms are used, the form shall allow people using assistive technology to access the information, field elements, and functionality required for completion and submission of the form, including all directions and cues.

§ 1194.22 Web-based intranet and internet information and applications.

(a) A text equivalent for every non-text element shall be provided (e.g., via "alt", "longdesc", or in element content).

(b) Equivalent alternatives for any multimedia presentation shall be synchronized with the presentation.

(c) Web pages shall be designed so that all information conveyed with color is also available without color, for example from context or markup.

(d) Documents shall be organized so they are readable without requiring an associated style sheet.

(e) Redundant text links shall be provided for each active region of a server-side image map.

(f) Client-side image maps shall be provided instead of server-side image maps except where the regions cannot be defined with an available geometric shape.

(g) Row and column headers shall be identified for data tables.

(h) Markup shall be used to associate data cells and header cells for data tables that have two or more logical levels of row or column headers.

(i) Frames shall be titled with text that facilitates frame identification and navigation.

(j) Pages shall be designed to avoid causing the screen to flicker with a frequency greater than 2 Hz and lower than 55 Hz.

(k) A text-only page, with equivalent information or functionality, shall be provided to make a web site comply with the provisions of this part, when compliance cannot be accomplished in any other way. The content of the text-only page shall be updated whenever the primary page changes.

(l) When pages utilize scripting languages to display content, or to create interface elements, the information provided by the script shall be identified with functional text that can be read by assistive technology.

(m) When a web page requires that an applet, plug-in or other application be present on the client system to interpret page content, the page must provide a link to a plug-in or applet that complies with §1194.21(a) through (l).

(n) When electronic forms are designed to be completed on-line, the form shall allow people using assistive technology to access the information, field elements, and functionality required for completion and submission of the form, including all directions and cues.

(o) A method shall be provided that permits users to skip repetitive navigation links.

(p) When a timed response is required, the user shall be alerted and given sufficient time to indicate more time is required.

Note to §1194.22:

1. The Board interprets paragraphs (a) through (k) of this section as consistent with the following priority 1 Checkpoints of the Web Content Accessibility Guidelines 1.0 (WCAG 1.0) (May 5, 1999) published by the Web Accessibility Initiative of the World Wide Web Consortium:

Section 1194.22 Paragraph	WCAG 1.0 Checkpoint
(a)	1.1
(b)	1.4
(c)	2.1
(d)	6.1
(e)	1.2
(f)	9.1
(g)	5.1
(h)	5.2
(i)	12.1
(j)	7.1
(k)	11.4

2. Paragraphs (l), (m), (n), (o), and (p) of this section are different from WCAG 1.0. Web pages that conform to WCAG 1.0, level A (i.e., all priority 1 checkpoints) must also meet paragraphs (l), (m), (n), (o), and (p) of this section to comply with this section. WCAG 1.0 is available at http://www.w3.org/TR/1999/WAI-WEBCONTENT-19990505.

§ 1194.23 Telecommunications products.

(a) Telecommunications products or systems which provide a function allowing voice communication and which do not themselves provide a TTY functionality shall provide a standard non-acoustic connection point for TTYs. Microphones shall be capable of being turned on and off to allow the user to intermix speech with TTY use.

(b) Telecommunications products which include voice communication functionality shall support all commonly used cross-manufacturer non-proprietary standard TTY signal protocols.

(c) Voice mail, auto-attendant, and interactive voice response telecommunications systems shall be usable by TTY users with their TTYs.

(d) Voice mail, messaging, auto-attendant, and interactive voice response telecommunications systems that require a response from a user within a time interval, shall give an alert when the time interval is about to run out, and shall provide sufficient time for the user to indicate more time is required.

(e) Where provided, caller identification and similar telecommunications functions shall also be available for users of TTYs, and for users who cannot see displays.

(f) For transmitted voice signals, telecommunications products shall provide a gain adjustable up to a minimum of 20 dB. For incremental volume control, at least one intermediate step of 12 dB of gain shall be provided.

(g) If the telecommunications product allows a user to adjust the receive volume, a function shall be provided to automatically reset the volume to the default level after every use.

(h) Where a telecommunications product delivers output by an audio transducer which is normally held up to the ear, a means for effective magnetic wireless coupling to hearing technologies shall be provided.

(i) Interference to hearing technologies (including hearing aids, cochlear implants, and assistive listening devices) shall be reduced to the lowest possible level that allows a user of hearing technologies to utilize the telecommunications product.

(j) Products that transmit or conduct information or communication, shall pass through cross-manufacturer, non-proprietary, industry-standard codes, translation protocols, formats or other information necessary to provide the information or communication in a usable format. Technologies which use encoding, signal compression, format transformation, or similar techniques shall not remove information needed for access or shall restore it upon delivery.

(k) Products which have mechanically operated controls or keys, shall comply with the following:

(1) Controls and keys shall be tactilely discernible without activating the controls or keys.

(2) Controls and keys shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate controls and keys shall be 5 lbs. (22.2 N) maximum.

(3) If key repeat is supported, the delay before repeat shall be adjustable to at least 2 seconds. Key repeat rate shall be adjustable to 2 seconds per character.

(4) The status of all locking or toggle controls or keys shall be visually discernible, and discernible either through touch or sound.

§ 1194.26 Desktop and portable computers.

(a) All mechanically operated controls and keys shall comply with §1194.23 (k) (1) through (4).

(b) If a product utilizes touch screens or touch-operated controls, an input method shall be provided that complies with §1194.23 (k) (1) through (4).

(c) When biometric forms of user identification or control are used, an alternative form of identification or activation, which does not require the user to possess particular biological characteristics, shall also be provided.

(d) Where provided, at least one of each type of expansion slots, ports and connectors shall comply with publicly available industry standards.

Appendix M: Material Safety Data Sheets

Material Safety Data Sheets

All MSDS sheets are available on our website

http://www.westrocketry.com/sli2010/msds/msds2010r.html

Propulsion and Deployment
Ammonium Perchlorate
Animal Motor Works Reloadable Motors
Igniters
M-Tek E-matches
Pyrodex Pellets
Black Powder
Nomex (thermal protector)

Glues
Elmer's White Glue
Two Ton Epoxy Resin
Two Ton Epoxy Hardener
Bob Smith Cyanoacrylate Glue
Superglue Accelerator (kicker)
Superglue Debonder

Soldering
Flux
Solder

Construction Supplies
Carbon Fiber
Kevlar
Fiberglass Cloth
Fiberglass Resin
Fiberglass Hardener
Self-expanding Foam

Painting and Finishing
Automotive Primer
Automotive Spray Paint
Clear Coat