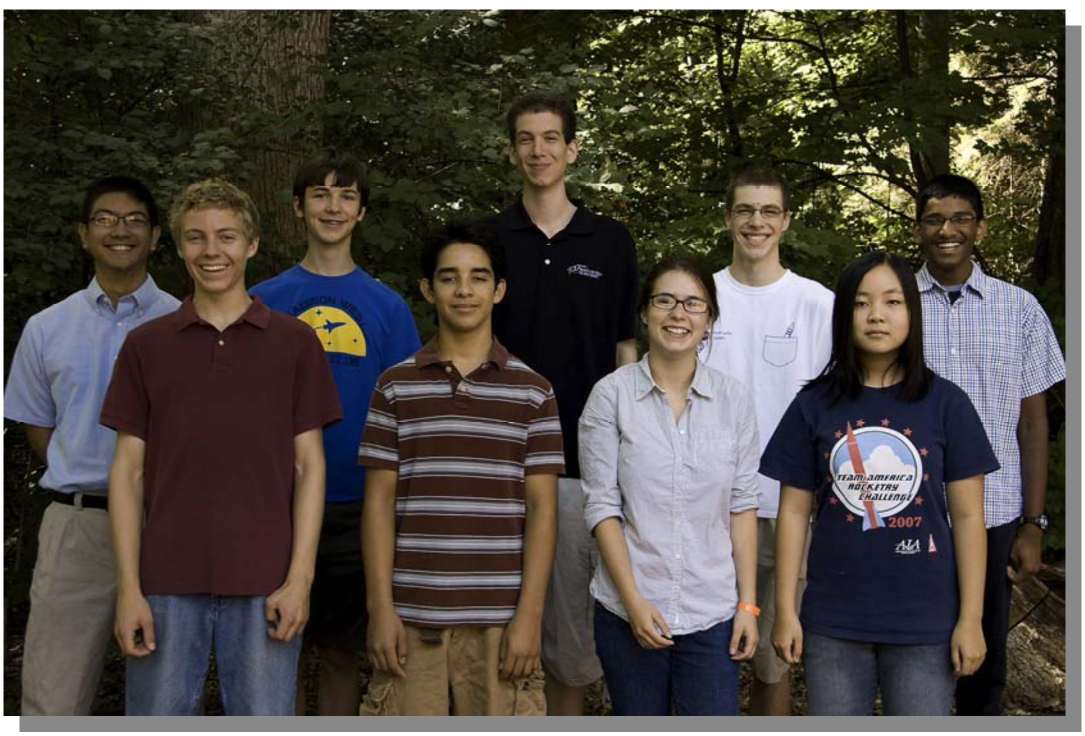
October 1, 2009

The Effect of Acceleration on the Crystallization of Sodium Acetate

Madison West High School

MADISON WEST

SLI 2010



First Row: John, Enrique, Zoe, Rose
Second Row: Yifan, Duncan, Ben, Jacob, Suhas

SLI 2010 Statement of Work

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School Information

School Name
Madison West High School

Title of Project
The Effect of Acceleration on the Crystallization of Sodium Acetate

Educators and Mentors

Administrative Staff Member
West High School Principal Ed Holmes
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Educators and Mentors:
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Pavel Pinkas, Ph.D., Senior Software Engineer for DNASTAR, Inc.
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Section 508 Consultant:
Ms. Ronda Solberg
DNASTAR, Inc. (senior software designer)
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Student Participants

Vehicle Team

Ben
Team Leader
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Recovery deployment
Electronics
Launch procedures

Zoë
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Master checklist
Vehicle design

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Post-Flight data processor

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Construction coordination
Task delegation

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Vehicle-payload integration

Payload Team

Enrique
Payload Team Leader
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Payload deployment, tracking and recovery
Payload checklist
Task Delegation

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Payload designer
Payload graphics artist

Suhas
Electronics/Software
skodali@westrocketry.com

Payload electronics
Electronics functionality test and checklist

Yifan
Safety Officer
yli@westrocketry.com

Payload and vehicle safety

Facilities and Equipment

Facilities

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

2. Construction of the rocket will occur at a workshop at 3555 University Ave, Madison, Wisconsin, 53705, on the weekends or as necessary. We have a 24/7 access to this facility.

3. Construction of the payload container will also occur at a workshop at 3555 University Ave, Madison, Wisconsin, 53705, on the weekends.

4. Preparation of the payload contents will occur at a workshop at 3555 University Ave, Madison, Wisconsin, 53705, on the weekends.

5. Additional manufacturing of the payload and/or result analysis will occur at biology laboratories at Madison West High School, 30 Ash Street, Madison, Wisconsin, 53726, on weekdays, after school.

6. Team organizational meetings will occur during lunchtime every Monday in Room 365 of Madison West High School, 30 Ash Street, Madison, Wisconsin, 53726.

7. 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 be 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 launches.

8. 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 launches.

Personnel

Name	Role or Area of Expertise
Ms. Christine Hager	School Advisor, Educational Supervisor
Dr. Pavel Pinkas	NAR Mentor, Scientific Advisor, NAR L-1 Certified
Mr. Brent Lillesand	NAR Mentor, Vehicle Construction/Operation Supervisor, NAR L-3 Certified, Designated Rocket Owner
Mr. Roland Russ Read	Payload Construction/Operation Supervisor

Table 1: Key advisors in Rocketry

Equipment and Supplies

The following equipment, tools and supplies are available to all team members and supervisors at our workshop (3555 University Avenue, Madison, WI).

Equipment

- Band saws
- Box cutters
- Drill bits
- Hacksaws
- Hand saws
- Philips/flathead screwdrivers
- Pliers, clippers
- Ring and C-clamps
- Rulers and yardsticks
- Sandpaper and sanding blocks
- Scroll saws
- Soldering and hot air rework station
- Various sizes of vices
- Various soldering stations (3 total)
- Wire strippers
- X-acto knives

Power Tools

- Belt sander
- Cordless drill
- Dremel tool and attachments (4 Dremel tools total)
- Drill press (2 total)
- Hand drill

- Hydraulic press
- Jig saw
- Table saw

Supplies

- Accelerator and de-bonder for superglue
- Batteries varying in size and voltage, to power electronics
- Breathing masks, used when cutting fiberglass
- Electric tape
- First aid kit
- Latex gloves, safety goggles
- Masking tape
- Solder, flux
- JB Weld glue
- Cyano-acrylate glue (superglue)
- West Epoxy (resin, fast and slow hardeners, assorted fillers)
- Ethyl-alcohol (for epoxy thinning and cleanup)
- Various minor electronic components (resistors, capacitors, LEDs)

Payload Specific Tools and Supplies

- Fan component
- 1-centimeter polycarbonate tubing
- Low-gauge hypodermic needles
- Sodium Acetate solution
- Sodium Acetate seed crystals
- Thermocouples

Rocket Components

- ARRD parachute deployment device
- Fiberglass fabric
- 4-inch fiberglass tubing
- G10 Sheets of fiberglass
- Kevlar cords and ribbons
- Lock’N’Load motor retention kits
- Nose cone
- Parallax Propeller chips and development boards
- PerfectFlite™ altimeters
- PerfectFlite™ timers
- Plywood centering rings, sheets and bulkheads
- Quick links
- Rail buttons
- Screws, nuts, T-nuts, washers, spring washers, etc.
- U-Bolts, I-Bolts

Computer Equipment

A. **Hardware/Software**
   a. School Computer Capabilities:
      i. 500MHz – 2GHz
      ii. 128MB – 2GB RAM
      iii. Windows 98, XP
      iv. Able to use MAC G3-G5
   b. Student Personal Computer Capabilities:
      i. 500mhz – 3.2ghz
      ii. 1GB – 4GB RAM
      iii. Windows XP, Vista, Vista-64
      iv. These computers include 8 laptops, enabling almost all of our members to be working at the same time.

B. **Internet**
   a. School – Every computer has access the Internet via a T3 connection
   b. DNASTAR – T3 connection, internal wireless network (801b/g/n)
   c. Home – ADSL/cable, 768Kbps-6Mbps (download), 256Kbps-1.5Mbps (upload)

C. **Team Communication**
   a. The team will communicate via e-mail, instant messaging, website postings
   b. Personal contact, group meetings and phone. These channels have been successfully used for the last five years.

D. **Currently Accessible Applications**
   a. Adobe Illustrator
   b. Adobe Photoshop
   c. Apogee – RockSim 6.92, 8.2
   d. Mozilla Thunderbird/Eudora/ MS Outlook/MS Express mail clients
   e. Mozilla Firefox/Safari/Internet Explorer web browsers
   f. Microsoft Office Suite 2003, 2008

E. **Web Site**
   a. Madison West Rocketry's website can be accessed through the URL http://www.westrocketry.com. This site pertains to all of Madison West Rocketry. A specific SLI 2009-2010 project web page will be created upon acceptance of SLI grant proposal.

F. **Video Teleconferencing (Webcasting)**
   a. We will be making use of the video conferencing facilities available through the UW Extension at the Pyle Center. Contact Dr. Rosemary Lehman for information regarding 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

Written Safety Plan

I. NAR Safety Requirements

a. Certification and Operating Clearances: Mr. Lillesand holds 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. Mr. Lillesand has Low Explosives User Permit (LEUP). If necessary, the team can store propellant with Mr. Goebel, who owns a BATFE approved magazine for storage of solid motor grains containing over 62.5 grams of propellant.

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.

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. Mentors will be present at all launches to supervise the proceedings.

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 during 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. 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 present danger to the environment. However, our NAR mentors will check the payload prior to launch in order to 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 model and HPR rocket safety, 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).

II. 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.).

All MSDS sheets applicable to our project are available online at

http://westrocketry.com/sli2010/msds/msds2010n.html

III. 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.

IV. 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 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 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 assembled 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).

V. 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 and emergency 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 necessary for rocket construction.

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 2: Risks that would cause physical harm to an individual

Toxicity Risks

Risks	Consequences	Mitigation
Epoxy, enamel paints, primer, superglue	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 3: Risks that would cause toxic harm to an individual

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	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 4: Risks associated with scheduling and facilities

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. Mentors will assemble the motors in accordance with manufacturer's instructions.
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. Launch rail will be inspected prior each launch.
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 or premature 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.
Hypodermic Needle	Possibility of puncture wound	All members will follow safety procedures and use protective devices to minimize risk.
Sodium Acetate	Burns and skin irritation	Sodium Acetate will be handled using proper safety equipment. MSDS sheet is available.
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

Specific Two Stage Vehicle Risks

Risks	Consequences	Mitigation
Stages fail to separate	Stage 2 motor burns while still attached to booster	Make sure coupler fit is exact, and use a previously tested method for use in two-stage rockets of this size. The size of separation charge will be verified in static testing.
Second stage motor fails to ignite	No second stage separation, rocket too heavy for safe descent rate	Recommended staging igniters will be used and the staging electronics will thoroughly tested before each flight. Recovery of all stages is triggered by altimeters and all recovery devices will deploy even if the second stage fails to ignite.
Second stage motor fires late	Horizontal second stage flight	Our members will check that the timer is accurately set, a reliable igniter will be used, and we will supply new batteries for each flight.
Motor failure (chaff or CATO)	Second stage mistakenly detects launch and ignites	We will use reliable motors and electronics. The timers require 2g+ acceleration for 0.5s before they trigger the timer countdown.

Table 6: Risks associated with a two stage rocket launch

Technical Design

We will use a two stage vehicle for our experiment. We will be observing the effects of gravitational forces on the crystallization of sodium acetate, and a two stage rocket will provide us with two distinct acceleration profiles during flight.

To have a successful mission we need to reach one mile AGL and have successful crystallization in all reactor tubes in the payload. The rocket will be 119.75 inches long, with a 4 inch diameter for both the booster and the sustainer. It has estimated liftoff weight of 20.6 pounds (sustainer itself is 13.7 pounds). The proposed vehicle and propulsion options are discussed in detail below. The propulsion is a K-class motor in the booster and a J-class motor in the sustainer and total impulse is 2421 Ns. The vehicle can launch from a standard launch rail.

Both stages will use dual deployment to minimize the drift.

The entire payload is located in the sustainer.

Vehicle Dimensions

Entire Vehicle

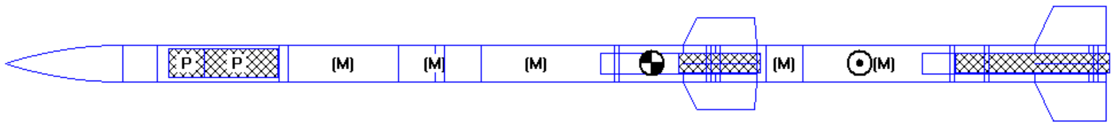


Figure 1: A two dimensional schematic of the entire rocket

Vehicle Parameters

Length *[in]*	Weight *[lbs]*	Diameter *[in]*	Motor Selection	Stability Margin *[calibers]*	Thrust to weight ratio
119.75	20.6	4	AT-K1100T	5.73	9.73

Table 7: The rocket's dimensions, stability and propulsion

The figure below shows all compartments and section of our rocket. The entire payload is located in the sustainer. We will use ARRD dual deployment device in both stages.

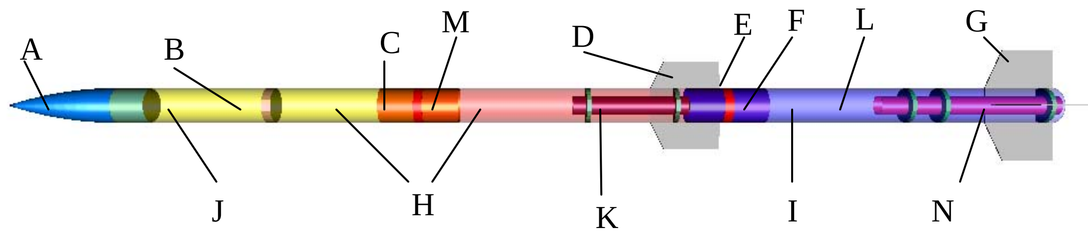


Figure 2: A three dimensional schematic of the entire rocket

Letter	Part	Letter	Part
A	Nosecone	***H***	Payload Bay
B	Main Sustainer Parachute	***I***	Booster Drogue Parachute
C	Sustainer E-Bay	***J***	Drogue Sustainer Parachute
D	Sustainer Fins	***K***	Sustainer Motor Mount
E	Interstage coupler	***L***	Booster Main Parachute
F	Booster E-Bay	***M***	Payload Electronics
G	Booster Fins	***N***	Booster Motor Mount

Table 8: Rocket sections and parts

Sustainer

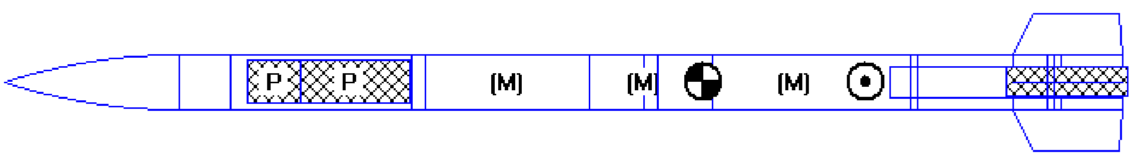


Figure 3: A two dimensional schematic of the sustainer part of the rocket

Sustainer Parameters

Length *[in]*	Weight *[lbs]*	Diameter *[in]*	Motor Selection	Stability Margin *[calibers]*	Thrust to weight ratio
81.75	13.9	4	AT-J1299N	2.95	20.31

Table 9: The dimensions of the sustainer, stability margin and propulsion

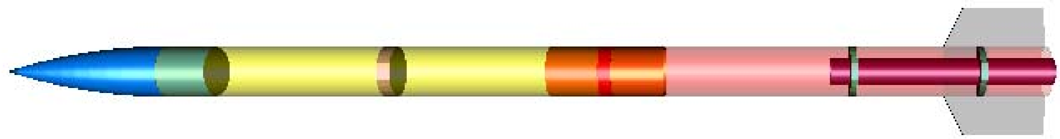


Figure 4: A three dimensional schematic of the sustainer

Motors

Booster Motor

Aerotech K1100-T is suggested as the first choice for the booster. It will provide sufficient thrust for the liftoff of the entire vehicle (thrust/weight ratio is 7.64) and will burn out at around 650 ft after accelerating the rocket to about 350 mph. The booster is expected to coast to 3,000ft and dual deployment will be used for booster recovery.

Motor	Length *[mm]*	Diameter *[mm]*	Average Impulse *[N]*	Total Impulse *[Ns]*	Burn Time *[s]*
AT-K1100T	398	54	910	1586	1.74

Table 10: The information of our primary booster motor

Sustainer Motor

After the separation from the booster, the J1299 motor will deliver the sustainer to the target altitude. The maximum estimated speed is 600 mph and the motor will burn for 0.7s.

Motor	Length *[mm]*	Diameter *[mm]*	Average Impulse *[N]*	Total Impulse *[Ns]*	Burn Time *[s]*
AT-J1299T	230	54	1253	850	0.68

Table 11: The information of our primary sustainer motor

Motor Alternatives

Two sets of suitable alternative motors are listed in the table below.

Motor	Diameter *[mm]*	Total Impulse *[Ns]*	Burn Time *[s]*	Stability Margin *[calibers]*	Thrust to weight ratio
Alternative 1					
AMW-K700BB	430	1608	2.24	5.86	7.64
AT-J460T	241	813	1.90	2.93	6.98
Alternative 2					
AT-K695R	54	1493	2.3	5.63	6.62
AMW-J357	54	999	2.95	2.64	5.2

Table 12: Motor alternatives

The graph below shows the simulated flight profile for K1100/J1299 motor combination. A significant increase in slope is visible shortly after the first stage burnout (1.74s) and the sustainer reaches the apogee of 7,500ft twenty-one seconds after the ignition. At this stage of the project we consider 7,500ft “close enough” to one mile target altitude, especially considering that RockSim tends to overestimate apogees and the rocket tends to “gain weight” as the project progresses.

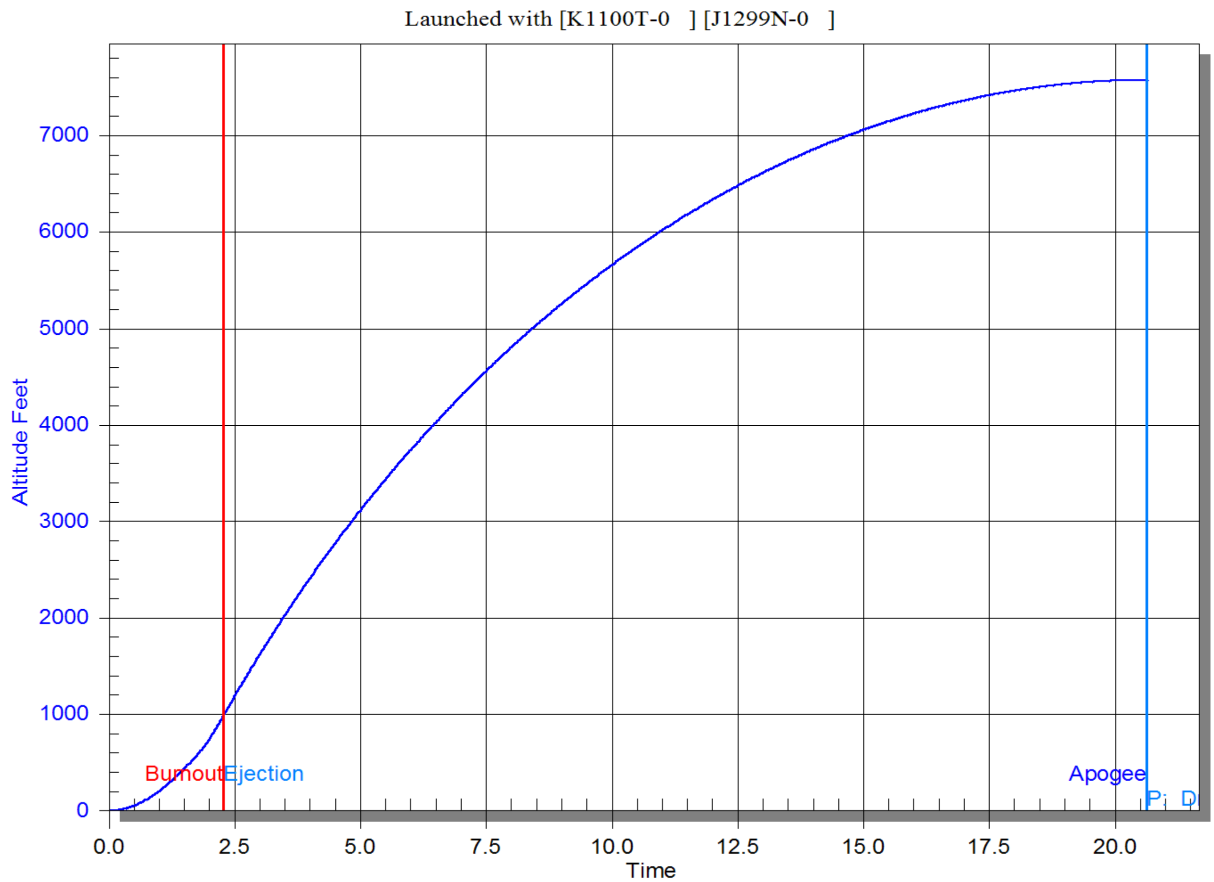


Figure 5: Altitude vs. time graph for K1100/J1299 motor combination. The rocket reaches 7500ft at 21s after ignition.

Wind Speed vs. Altitude

The effect of the wind speed on the apogee of the entire flight is investigated in the table below. Even under the worst possible conditions (wind speeds 20mph, the NAR limit) the flight apogee will differ by less than 4% from the apogee reached in windless conditions.

Wind Speed *[mph]*	Altitude *[ft]*	Percent Change in Altitude
0	7574	0.00%
5	7497	0.10%
10	7454	1.61%
15	7386	2.55%
20	7298	3.78%

Table 13: Flight apogee vs. wind speed

Thrust Profile

The graph below shows the thrust profile for K1100/J1299 motor combination. The two distinct burns are clearly visible. The K1100 motor has a 1500N initial spike which will provide a sufficient speedup of the whole vehicle as it leaves the launch rail (the rocket needs approximately 6 ft to reach a safe flight velocity).

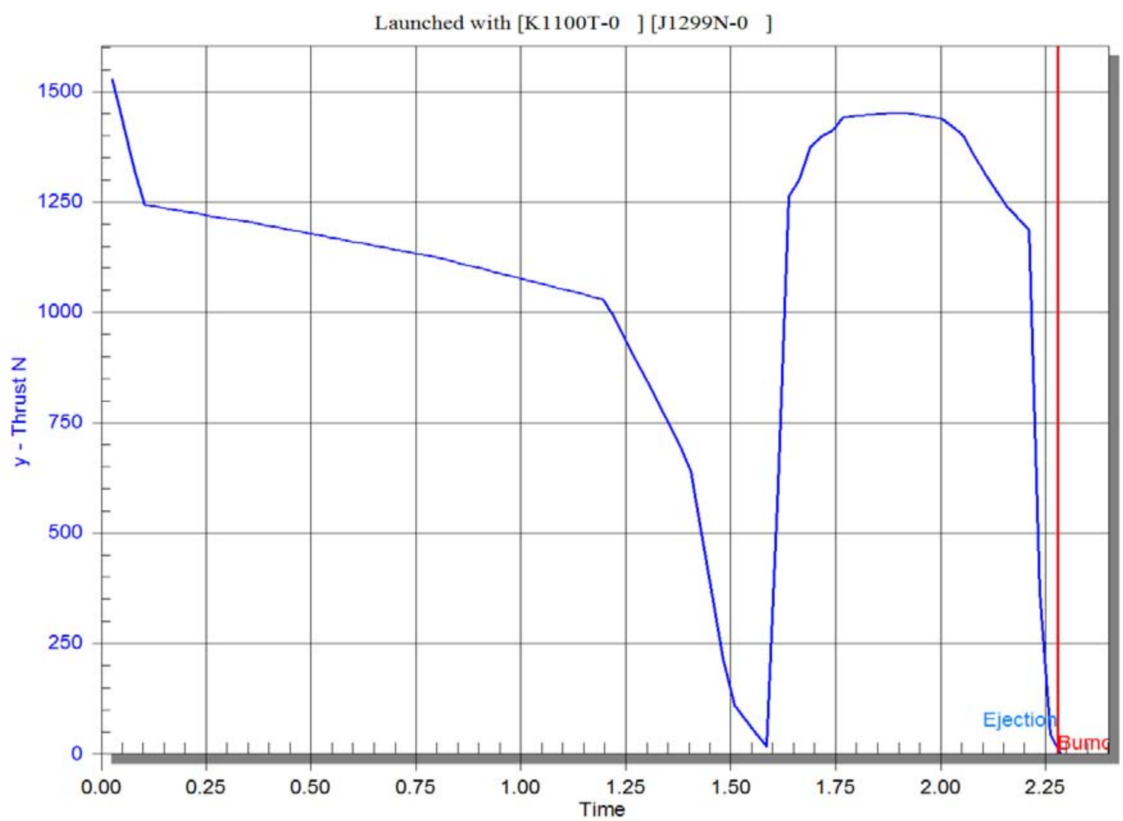


Figure 6: Thrust vs. time graph. The rocket has a maximum thrust of just over 1500 N.

From the velocity profile below we can read that the first stage will accelerate to 350mph+ before the thrust tapers off, at which point a momentary negative acceleration can occur. The second stage will then take over, accelerating the sustainer to 600mph+ and delivering the sustainer to the flight apogee.

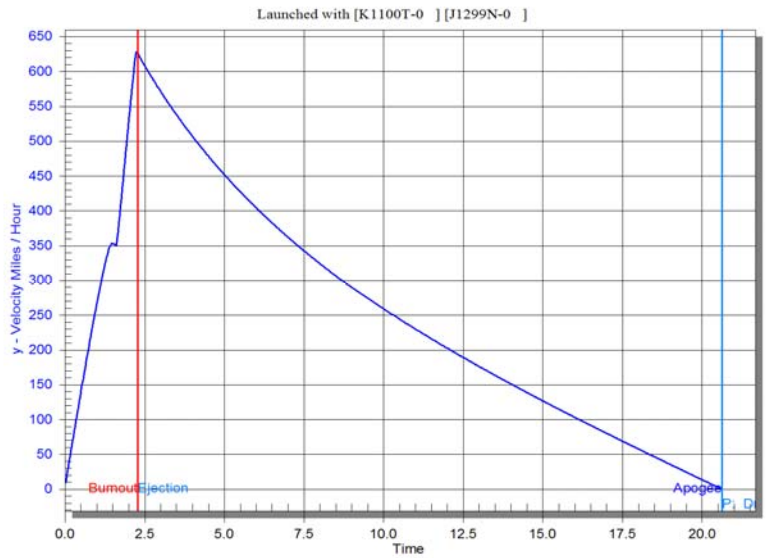


Figure 7: Velocity vs. time graph. The booster motor burns out at 1.74s and the sustainer motor burns out at about 2.3 seconds. After burnout the rocket slows down gradually until it reaches apogee.

Acceleration Profile

The graph below depicts the estimated acceleration profile. Two separate peaks correspond to the two burns. Our rocket will be robust enough to endure the 25g+ acceleration shocks.

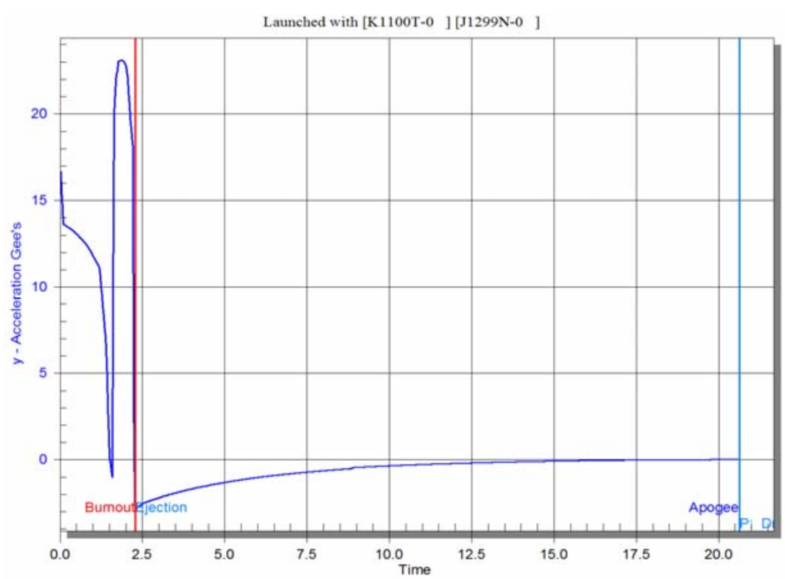


Figure 8: Acceleration vs. time graph. The rocket has a maximum acceleration of approximately 16 gee's for the booster and a maximum of just over 22 gee's for the sustainer's burn.

Payload

Experimental Overview

In our experiment, we will investigate the effect of acceleration on the crystallization from the supersaturated sodium acetate ($C_2H_3NaO_2$) solution. We will be testing pure supersaturated sodium acetate solutions, along with supersaturated sodium acetate solutions containing trace amounts of selected impurities (dopes). The changes in crystallization rate and overall crystal formations (size, structure) will be investigated.

Several literature sources have indicated that both increase and decrease in the intensity of gravitational forces will change the crystal structure and sizes. The published articled describing the possible effects of the gravitational forces on the crystal structure are listed in our *Bibliography* section[1,2,3,4].

The crystallization of sodium acetate is a fast exothermic reaction and has been suggested as an energy storage medium. Commercially, sodium acetate is used to make economical and reusable heating pads. It is supersaturated in boiling water, and can be cooled to form a solution which crystallizes upon the introduction of a seed crystal. The crystallization reaction is exothermic, and will maintain a temperature of 54 °C until the reaction is complete. The crystals are generally dissolved by reheating the solution above 54 °C.

Figure 9: The crystallization of a sodium acetate hand warmer. The first picture shows the hand warmer in a liquid state, pre-activation. The second one is two seconds into the crystallization (the bulk of crystals is forming in the bottom right corner). The third picture is nine seconds into crystallization, and the pack is almost fully crystallized. The last picture shows the hand warmer completely crystallized.

[1] Cheng, ZD
[2] Zhu, JX
[3] Vergara, A
[4] DeLucas, LJ

In one scenario, this reaction could be used to balance the temperature of the exterior of a spacecraft. On the side of the vehicle facing away from the sun, the heat from a sodium acetate crystallization would provide a continuous heat source. On the side of the vehicle facing the sun, solar energy will heat the crystallized (depleted) heatpacks and reverse the crystallization reaction; energy which would be stored until the recharged packs rotate back to the side facing away from the sun. Sodium acetate has several advantages over other temperature regulation methods in that it is relatively non-toxic, does not present a fire hazard, does not reach dangerous temperatures, and can be stored indefinitely in liquid form.

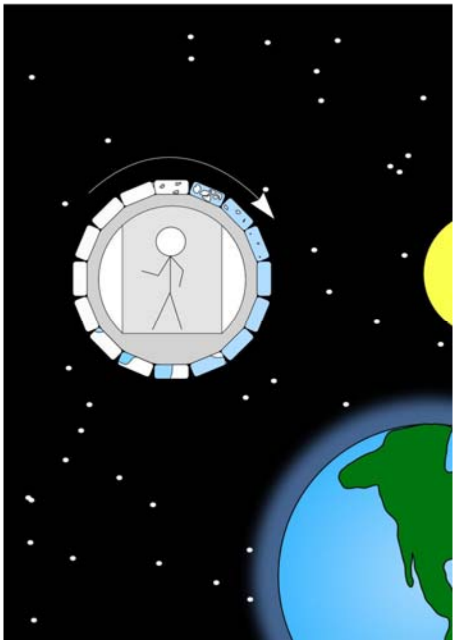


Figure 10: As the spacecraft rotates, the sodium acetate facing the is re-dissolved and ready to provide heat via exothermic crystallization when it reaches the "dark side" again.

Sodium acetate's large capacity for heat absorption and the possible applications in the field of rocketry led us to ask: how does extreme acceleration affect the temperature and crystal structure of the sodium acetate reaction? Another field we will be researching is the possible effect of impurities on the sodium acetate reaction. We expect the different impurities will change the crystallization and heat storage capabilities. We will be doing further research to determine which impurities we will use.

Madison West Rocket Club has long sought a suitable chemical/physical process for research of the effect of both low and high gravitational force on the process. Crystallization from a supersaturated solution of sodium acetate seems to be a perfect candidate for such research: it is fast, strongly exothermic (so the reaction front can be easily observed) and the previous research indicates that the intensity of gravitational forces has a measurable effect on the observed process.

Experimental Design

To investigate the effect of gravitational forces on the crystallization of sodium acetate, we are going to launch eight reactor vessels made of acrylic tubing, each 1 cm in diameter and 20 cm long. Four reactor vessels, located above the e-bay, will have the crystallization initiated from the bottom. The other four reactors will be below our e-bay and will have the crystallization initiated from the top. Another group of reactors will be kept on the ground (the baseline group).

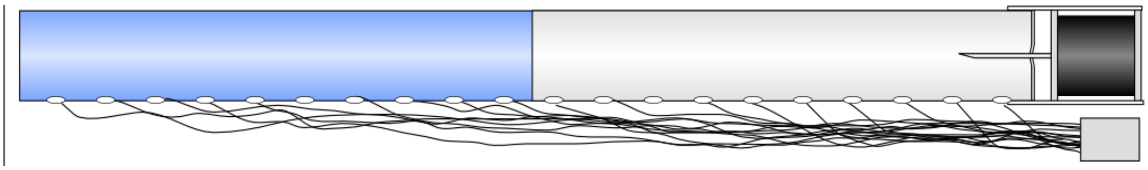


Figure 11: A close up of a single reactor vessel. The hypodermic needle on the right hand side is filled with the seed crystals and is used to initiation the crystallization. An array of thermistors along the tubular reactor will monitor to movement of the reaction front (the crystallization is highly exothermic).The white zone represents the portion that is already crystallized and the blue zone represent the supersaturated solution.

One tube of the four in each payload will contain a pure sodium acetate solution, therefore being our "control" tube. The three remaining tubes will contain trace amounts of different impurities. The crystallization will start immediately after ignition and will continue until its completion, approximately 40 seconds (through apogee and part of descent).

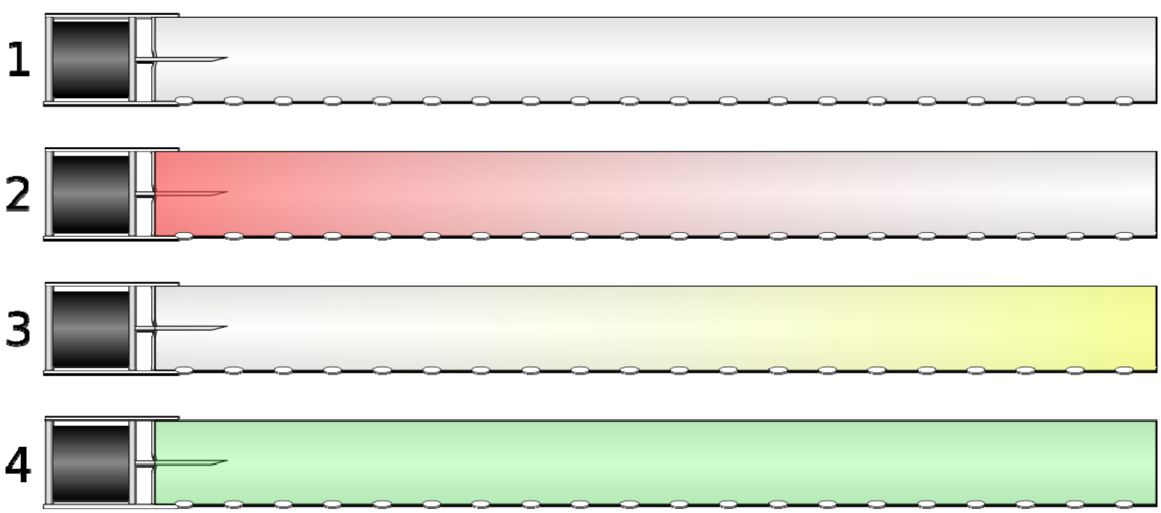


Figure 12: Four reaction vessels: Tube 1 is filled with pure sodium acetate. Tube 2 is filled with a heavier dope. Tube 3 is filled with a lighter dope. Tube 4 is filled with a dope with approximately the same density as the sodium acetate.

The crystallization will be triggered by a hypodermic needle filled with seed crystals. When the vehicle movement is detected (by a G-switch), the needle punctures through a membrane and enters the supersaturated solution. The solution reaches the seed crystals and the crystallization starts.

Spaced evenly along each reactor vessel are 20 thermistors which will collect temperature data. After the flight, we will use these data to form an accurate picture of the moving reaction front. As the solution crystallizes, the temperature readings from the thermistors nearest to the reaction front will sharply increase, showing us the rate and intensity of the crystallization.

Monitoring the temperature on thermistors will also provide with a warning in case the crystallization starts unexpectedly as the vehicle is being prepared for launch. If any of the thermistors register a sudden increase in temperature while the rocket is stationary, an alarm will sound notifying us that the crystallization reactors need to be inspected and possibly replaced (we will have a large number of spare reactors ready).

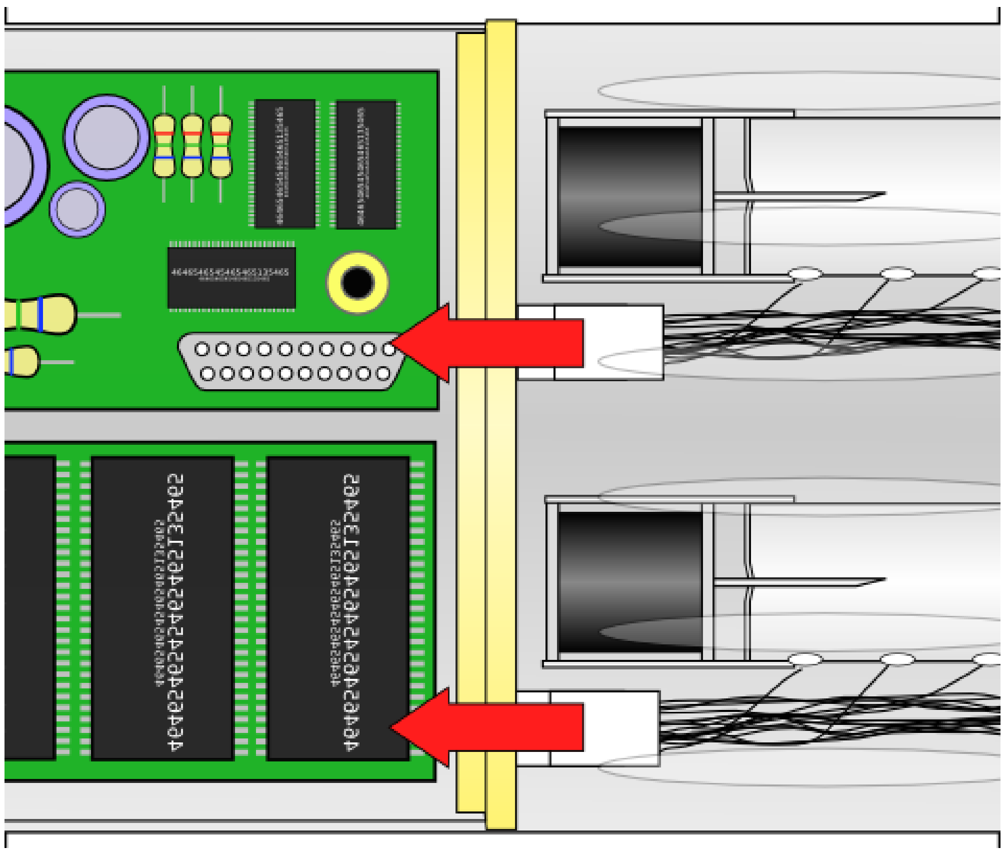


Figure 13: Close up of the thermistors connected to the master flight computer via 40-pin D-SUB connector.

A fan will be placed at the top or bottom of the reaction chamber, to keep the chamber at a constant temperature (the exothermic reaction will be slowed down if the temperature significantly increases). This fan will be controlled by the computer which is connected a single thermistor placed in the center of the payload chamber on a bulkhead. It will take the temperature of the reaction chamber throughout flight. When the temperature rises in the reaction chamber, the fan will speed up, cooling it down. And when the temperature falls in the reaction chamber, the fan will slow down, allowing the temperature to equilibrate.

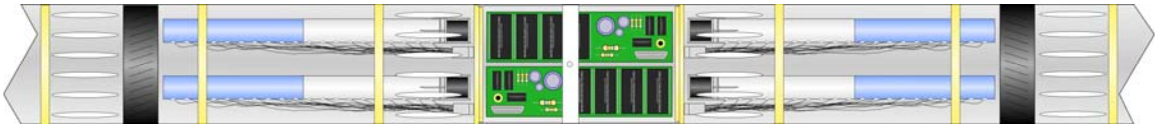


Figure 14: Payload-vehicle integration and an overview of our payload section of our rocket, each reactor chamber contains four reactor vessels. Two reactor vessels per chamber are visible in this diagram. The master flight computer which collects the temperature and flight data and controls the cooling fans is positioned in the middle. The cooling fans and air vents are on the sides.

After the flight we will remove the reactor vessels from the rocket, observe the solid crystals post flight and examine for different structural patterns in our lab. An accelerometer in the E-bay will collect acceleration versus time data. This data will then be compared against temperature data and our crystal structure. This will determine the acceleration at which the crystals formed and the effect of the acceleration on the crystal structures.

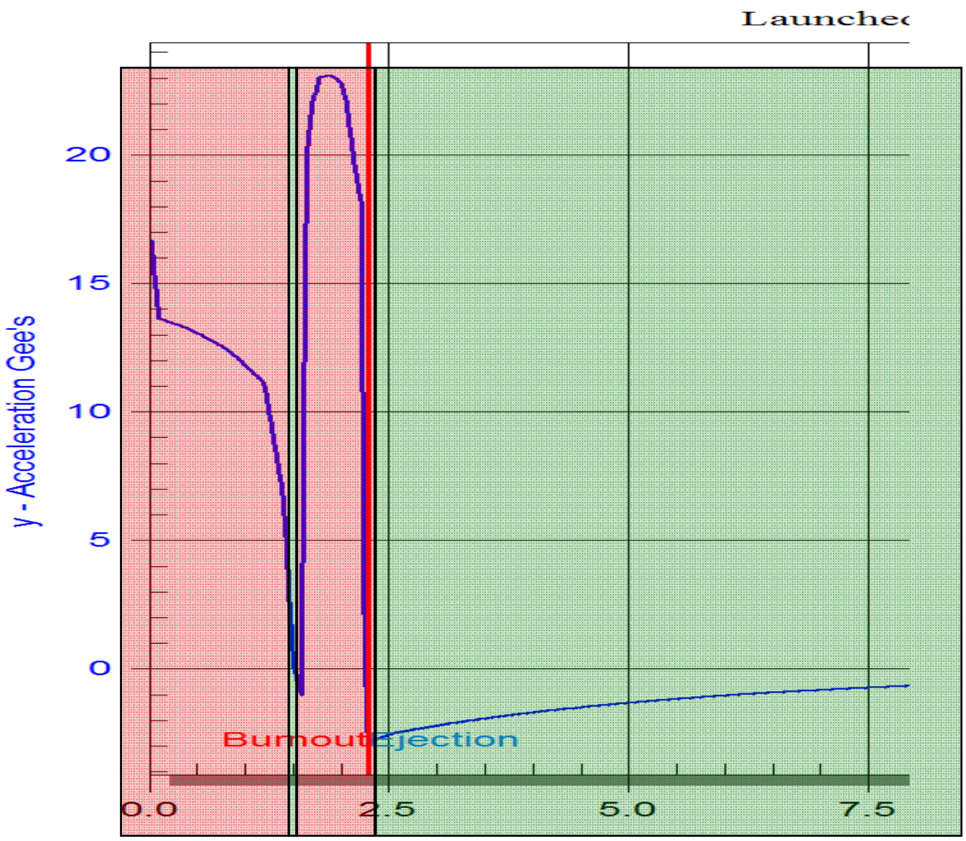


Figure 15: The estimated acceleration of our rocket through flight. The red zones highlight the high gravitational force zones. The green zones highlight the low gravitational forces zones.

Overall Payload Schematic

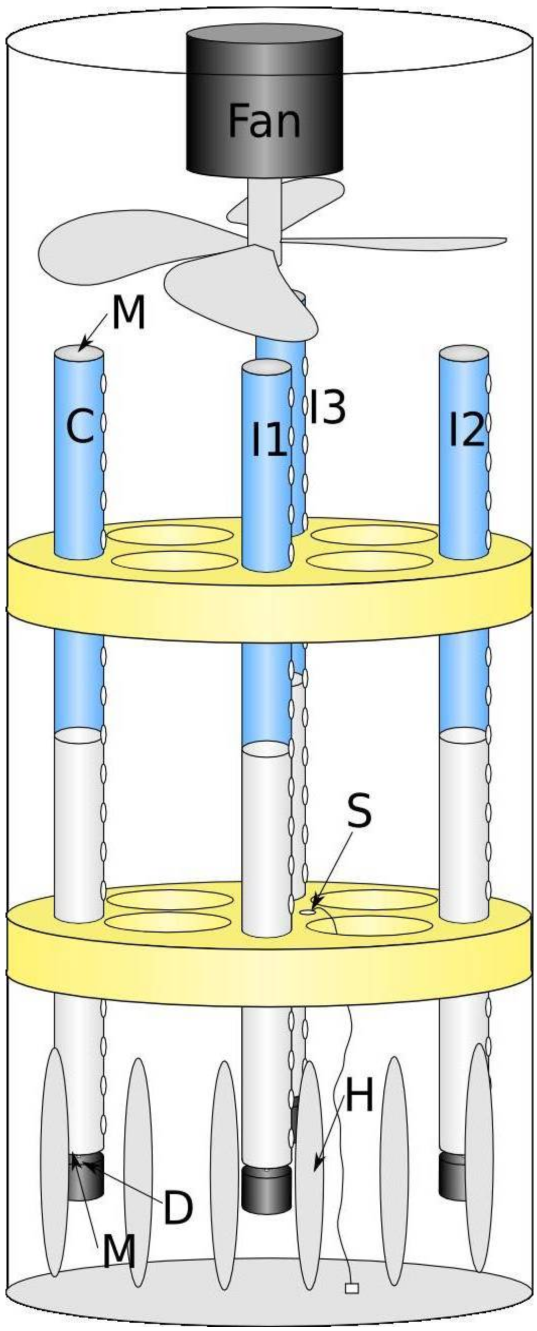
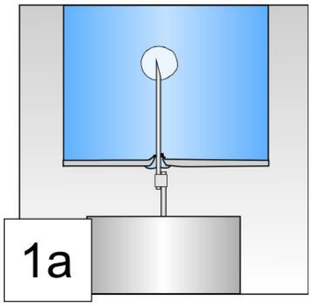


Figure 16: Payload schematics

This is one of the two reactor chambers that are found in the payload section of our rocket. There are three major components in the cylindrical body. **C** is the reaction vessel, containing a pure sodium acetate solution. **I1**, **I2**, and **I3** are three different reaction vessels, each containing different impurities. The array of thermistors on side of each of the reaction vessels will record the temperature to pinpoint the reaction front. **D** is one of the hypodermic needles that will start the crystallization process (either from the top, or the bottom, depending if the reactor chamber is above or below the E-bay). The fan at the top and holes at the bottom, **H**, will allow air flowing through the rocket, keeping the reactor chamber at a constant temperature. A single thermistor, **S**, will be placed in the center of the reaction chamber and will monitor the temperature. That single thermistor will control the fan at the top, increasing the speed when it gets too hot, decreasing the speed when it is unnecessary. The hypodermic needle will puncture the membrane, **M**, covering the top or bottom of the reaction vessel as the rocket takes off. The seed crystal inside the needle will start the crystallization process.

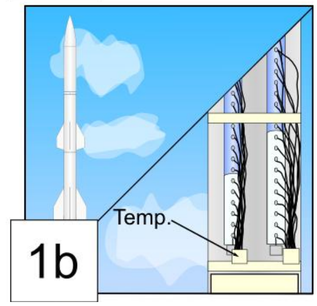
For clarity, the wires leading from the thermistors to the E-bay are not shown on this drawing.

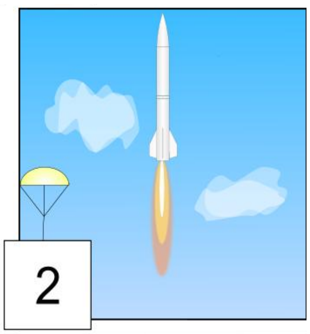
Experimental Flowchart



1a. The hypodermic needle punctures a thin membrane at one end of each reactor vessel, starting the crystallization of our solution as we ignite the motor.

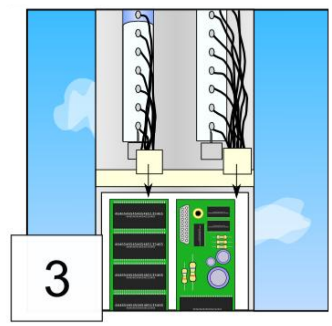
1b. The two stage rocket launches. Our payload collects temperature vs. time and acceleration vs. time data.

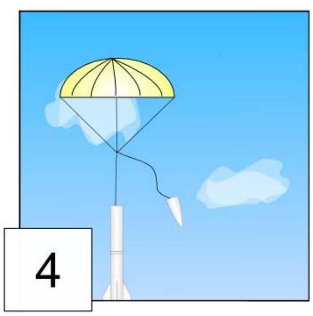




2. The second stage ignites and the same data are collected except now the rocket experiences a different acceleration profile.

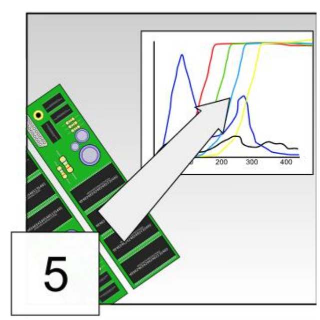
3. All the collected data are immediately saved into non-volatile memory.

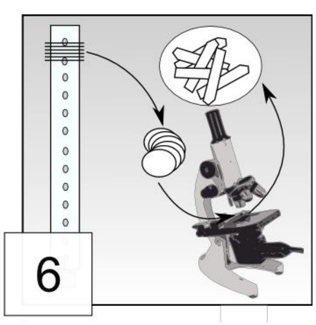




4. The rocket reaches apogee, deploys the drogue and main parachutes and lands safely.

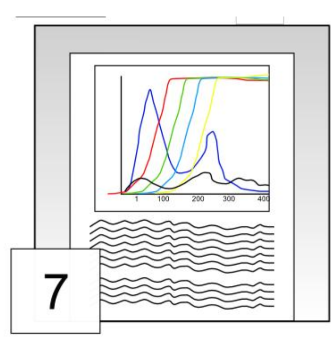
5. Temperature and acceleration data are retrieved from the flight computer and analyzed.





6. We take samples of the crystals into the lab for examination.

7. The final report is written.



Flight Sequence

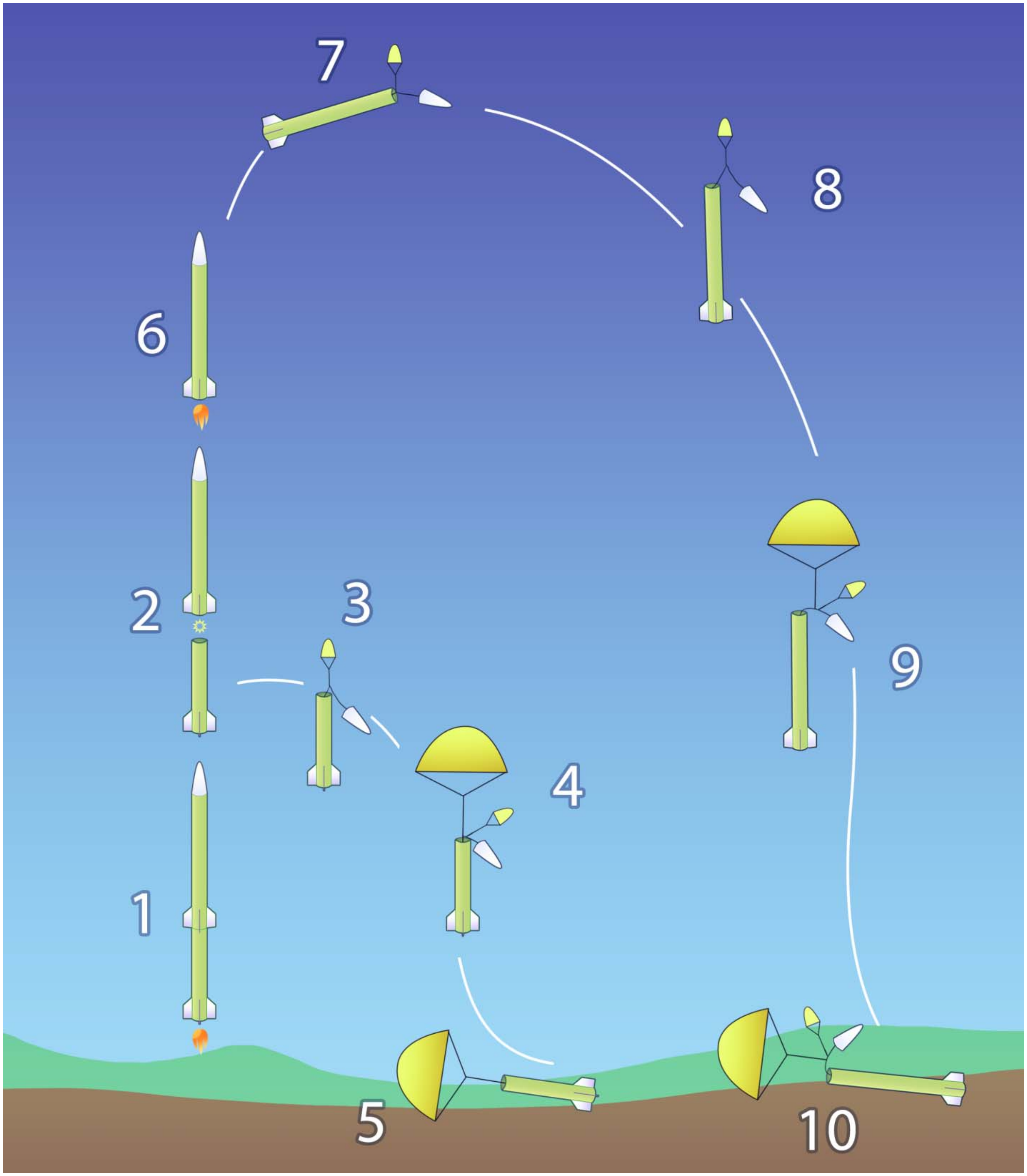


Figure 17: Flight sequence of the rocket from liftoff to touchdown 1. First stage burn, reaction starts 2. Stage separation 3. Booster coasts to its apogee and deploys drogue parachute 4. Booster deploys main parachute 5. Booster lands safely 6. Second stage motor burn 7. Sustainer reaches apogee, deploys drogue parachute 8. Descent under drogue 9. Main parachute deploys, slowing rocket to safe landing speed. 10. Sustainer lands safely.

Electronics

For our experiment to be successful, we will need a significant amount of electronics. With the knowledge acquired from previous years, we have the ability to design and build the electronics for this experiment.

In our payload, we will have multiple thermistors recording the temperatures at a various points on the crystallization vessels at a rate of 20 times per second. We will also have a temperature sensor around the payload to tell the main flight computer (MFC) the current temperature of the payload. Accelerometer will be recording the acceleration profile of the booster and the sustainer. A G-switch will be used to sense the movement of the vehicle, at which point the MFC will initiate the crystallization inside the vessels. All readings will be stored in the onboard non-volatile memory (flash memory).

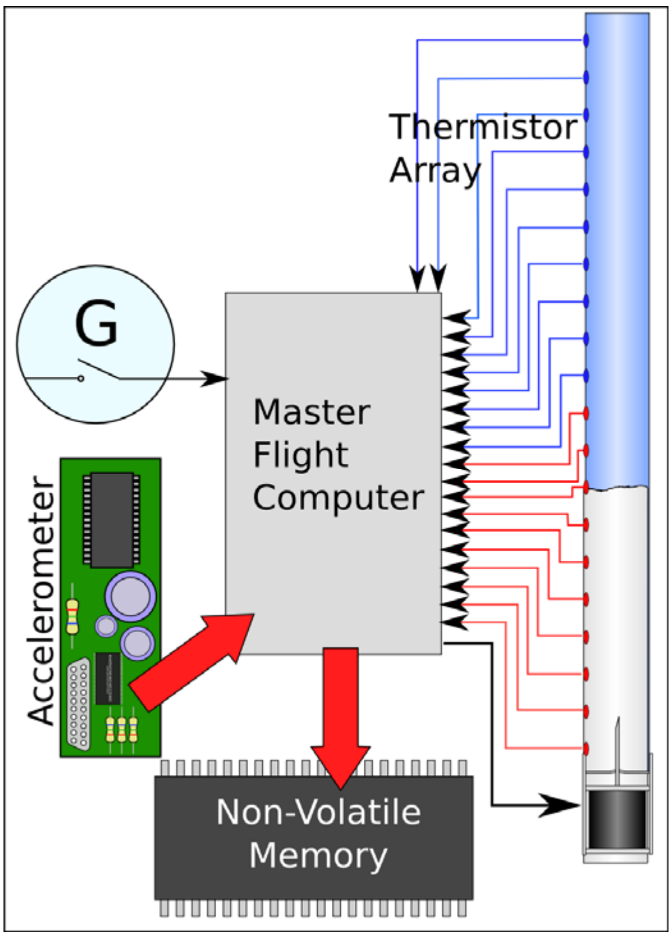


Figure 18: Our data flowchart, the thermistors collected temperature data, which feeds into the master computer. The accelerometer collects the acceleration profile, and sends that, along with the temperature data into non-volatile memory. A G-switch is used to detect the movement of the rocket.

The aforementioned thermistors will be connected to the main flight computer. When the MFC receives a signal to initiate the crystallization (a G-switch closes due to the liftoff), it will send out signals to the push-type solenoids to initiate the reactions and the computer will start recording the data from the thermistors. The MFC will also output signals to speed up the fans to cool the temperature inside the rocket or slow down the fans to let the interior of the rocket heat up, so a constant temperature will be maintained.

A Parallax Propeller chip will be the central processing unit for our data collection board. The Propeller chip has 8 cores, each core running at 80MHz and is capable of achieving the collection frequency desired. A flash memory will be used to store data, while the firmware will be placed in the EEPROM to allow for easy reprogramming.

All the major electronics controlling the payload will be placed in the sustainer.

Independent Variables

C Pure sodium acetate solution (no impurities)
I_1 Presence of impurity number 1
I_2 Presences of impurity number 2
I_3 Presence of impurity number 3
A Acceleration
D Direction of Initiation

Dependent Variables

R Reaction Rate
S Crystal Structure Deformities
T Temperature of Reaction

Correlations

$R = f(I)$ Reaction rate in relation to impurities
$R = f(A)$ Reaction rate in relation to acceleration
$R = f(D)$ Reaction rate in relation to direction of initiation

$S = f(I)$ Crystal deformities in relation to impurities
$S = f(A)$ Crystal deformities in relation to acceleration
$S = f(D)$ Crystal deformities in relation to direction of initiation

$T = f(I)$ Temperature profile of reaction in relation to impurities
$T = f(A)$ Temperature profile of reaction in relation to acceleration
$T = f(D)$ Temperature profile of reaction in relation to direction of initiation

Constants

- Temperature inside rocket
- Amount of solution
- Thermistors used
- Initiation method

By exploring these correlations, we hope to better understand the effects of acceleration on the crystallization of sodium acetate. We will have a control experiment similar to the experiment on board and compare the results.

Post-Flight Procedure

After the rocket flight, we will compare thermistor data from the in-flight reactions and the baseline group on the ground to identify differences in reaction rates. We will also analyze the structure of sodium acetate crystals formed during the flight as well as in the baseline (non-flying) group. The crystals will be removed from their tubes post-flight and will be observed microscopically at the UW. Specifically, we will look for: first, any irregularities in the crystal structure of pure sodium acetate; second, interruptions in the crystal structure caused by impurities; third, the distribution of these impurities throughout the crystals. We will look for differences between in-flight reactions and the baseline group.

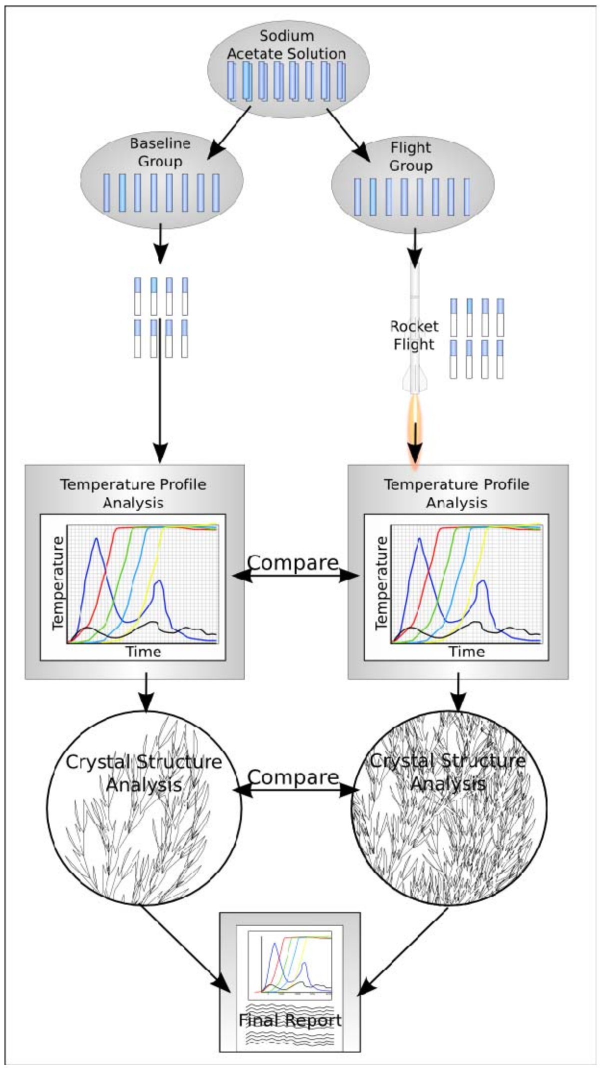


Figure 19: Experiment schematics showing the pathways of sodium acetate. The flight group is crystallized during rocket flight, while the baseline group is crystallized at the same moment, however on the ground. The temperature profiles recorded by thermistor arrays and the crystal structure from both the flight and the baseline group are compared in the final report (PLAR).

Primary Vehicle and Payload Requirements and Objectives

1. **Payload:** the rocket carries a scientific payload to measure crystallization under different gravitational forces.

2. **Target Altitude:** Rocket must reach altitude of 1 mile — (simulations show that our rocket will reach 7,400ft using Aerotech K1100T motor (booster) and Aerotech J1299N (sustainer)). At this stage of the project we are leaving ourselves a sufficient altitude margin to cover for possible rocket design changes and vehicle weight increase.

3. **Launch:** The rocket can launch from a standard launch rail and it needs less than 10ft of launch guidance to support the rocket and achieve the stable flight velocity. The rocket is designed to be launched using a standard 12V ignition system.

4. **Propulsion:** The total impulse of the vehicle is less than 2560Ns. Both motors contain solid ammonium perchlorate based propellant.

5. **Safe Recovery:** Booster and sustainer (including the payload) must land undamaged and suitable for re-flight — We will utilize ARRD (Advanced Rocket Recovery Device) deployment scheme with redundant charges and ejection triggers to ensure the ejection and will determine and verify the sizes of parachutes and ejection charges during static tests. Because of the booster's high apogee (3,000ft) the booster will also use dual deployment via an ARRD. Ejection charges will be triggered by commercially available e-matches. Both the vehicle and the payload are reusable.

6. **Separation:** Only drogue parachute will be deployed at apogee allowing the rocket to descend to 700 ft where the main parachute will deploy. Booster is expected to coast to 3000 ft where it will deploy drogue parachute with the main chute deploying at 700 ft. This recovery scheme is designed to minimize drift while still allowing the rocket to recover safely.

7. **Preparation:** the vehicle will not take more than 4 hours to prepare for the flight. The payload is not time critical.

8. **Recovery:** we are using an ARRD scheme and we expect that both stages will land relatively close to the launch pad and within the designated launch site.

9. **Countdown:** After the rocket is prepared for launch, only the standard 10 second countdown is required prior to ignition.

10. **Data:** data will be produced and recorded during flight and analyzed after the vehicle (including the flight computers) is recovered. We will use proper scientific methods during data analysis.

11. **Tracking:** The radio beacons and acoustic beacons will be used to aid us in the vehicle tracking and recovery, should the excessive drift occur.

12. **Preparedness:** The full scale vehicle will be launched at least once prior to the flight readiness review (FRR). A Level 2 NAR observer will observe the flight and fill out the required form.

13. **Robustness:** Both booster and sustainer must withstand acceleration up to 25*g* — (we will construct rocket from fiberglass tubing, G10 sheets (for fins) using industrial strength epoxy glue (West Epoxy) with fillers. We will mount the fins using through the wall construction in order to improve robustness).

14. **Stability and thrust to weight ratio:** Rocket must have a stability margin of at least 2.0 calibers — (our entire rocket has a stability margin of 5.7 calibers and our sustainer has a stability margin of 3.0 calibers). Both stages are propelled by motors providing at least 5:1 thrust to weight ratio.

15. **Prohibited items:** we are not using flashbulbs, rear ejection, forward firing motors or forward canards on our vehicle. The vehicle does not exceed Mach 1.

Major Challenges and Solutions

Major Challenges and Solutions for a Two Stage Rocket

1. **Staging:** Flying a two stage rocket is a major challenge requiring careful design, construction and operation of the vehicle. We will use two redundant timers to separate the stages and ignite the second stage motor. A low current igniter will be used to ignite the second stage and the staging electronics will be thoroughly tested prior each launch. New batteries will be installed for each flight to ensure sufficient electrical current for the second stage igniter.

2. **Recovery:** The sustainer will utilize the dual deployment Advanced Rocketry Recovery Device (ARRD) technique to minimize the drift and risk of vehicle loss. The ARRD is a proven device which allows us to store two parachutes in the same compartment and still deploy the drogue at apogee and the main at 900 ft. without risk of entanglement. The booster will also use ARRD dual deployment, as it coasts to an altitude of 3,000 ft. We will also make sure that if the rocket fails to stage, the rocket will be able to land safely with normal parachute deployment.

3. **A large complex rocket**: We will make sure that our stability margins and thrust to weight ratio are within acceptable standards and we will repeatedly test all electronic components to ensure a safe flight and recovery.

Major Payload Challenges and Solutions

1. **Staging:** Flying a two stage rocket is a major challenge requiring careful design, construction and operation of the vehicle. We will use two redundant timers to separate the rocket and ignite the second stage motor. A low current igniter will be used to ignite the second stage and the staging electronics will be thoroughly tested prior to each launch. We will install new batteries for each flight to ensure sufficient electrical current for the second stage igniter.

2. **Liquid Payload:** A liquid payload presents multiple problems. Air bubbles in the reaction chambers could lead to sloshing, which could interfere with reaction initiation. Air bubbles could also adversely affect crystal structure. To avoid these problems, we will take adequate measures to fill the tubes completely. Additionally, the expansion of the crystallized solution in an already full chamber could cause leaks or cracks in our reaction vessels. To avoid this problem, the vessels will

be covered by flexible diaphragms which will expand as necessary. Furthermore, the payload will experience acceleration of 20g+ thus the selection of material for crystallization vessels will be of crucial importance. We plan on using polycarbonate tubes, which are practically indestructible, yet the polycarbonate is easy to work it.

3. **Starting the Reaction:** In order for the sodium acetate to crystallize there needs to be a seed crystal to start the reaction. However, a foolproof way to initiate the crystallization was difficult to develop. We decided to use a hypodermic needle filled with seed crystals and introduce it into the vessels by puncturing the needle through a membrane at the top or bottom of the tubes.

4. **Pre-mature Reaction:** We do not want the reaction to start before ignition. The array of thermistors will continuously monitor the temperature of the crystallization vessels and sound an alarm if the crystallization is detected before the liftoff.

5. **Impurities:** Through our preliminary research we found evidence of impurities affecting crystallization and the amount of heat produced by the reaction. We will incorporate impurities into the experiment and analyze the data collected from the flights to find the effect of these impurities on the reaction.

6. **Keeping the Chambers at a Constant Temperature:** The reaction vessels generate a significant amount of heat. The excess heat can significantly affect the reaction rate of the exothermic reaction. This presents many challenges for dissipating the heat and keeping the reaction vessels at a constant temperature. To address this problem we will be using computer controlled fans and outside air as a cooling media to maintain the constant temperature in the reaction chamber.

7. **Data Collection and Storage:** Significant amount of data will be collected and stored during the flight. The data collected include the flight profile (altitude vs. time), acceleration profile, movement of the reaction front (temperature in along the crystallization vessels vs. location vs. time) and operational records of the thermostat and cooling system. Both analog and digital signals will be processed and recorded, thus necessitating 4-6 layer custom printed circuit boards. Fast microcontroller with high data throughput will be used (Parallax Propeller octa-core chips, P8X32A) together with high capacity memory chips (FLASH RAM). Our club undertook electronic projects of similar complexity before and by combining the past experience with hard and diligent work, we will be able to design, assemble, program and operate the custom electronic boards.

Educational Engagement

Community Support

After seven years of the club's existence, we are well known at various departments of the UW and many researchers are eager to work with us. During our six years of participation in SLI we have met with a number of people from various departments within the University of Wisconsin-Madison, including Professor McCammon from the department of Physics, Professor Eloranta from the department of Atmospheric Sciences, Professor Pawley from the department of Zoology, and Professors Anderson and Bonazza from the department of Mechanical Engineering. These contacts have been incredibly helpful in designing and refining our original experimental ideas and creating an experiment that will return meaningful data.

DNASTAR Inc. has allowed us to use their building during the weekends. We hold our research meetings at DNASTAR conference rooms which are equipped with state-of-art projection technology.

Every year we raise funds by raking leaves during autumn in local neighborhoods. We find this is an excellent way to earn the support of the community and increase our visibility. Madison West Rocket Club has received a significant amount of publicity as a result of our first place ranking in the 2009 TARC contest. Many local newspapers and news channels carried the story. The Madison Metropolitan School District Media produced a short film detailing our achievements, which helped spread our accomplishments.

The club also provides a steady stream of volunteers for public television and public radio fundraising drives. While this is not a direct display of our work or interests, it gives us the opportunity to provide public service in the name of our club.

This year many club members gave back to the community by helping a local soccer park, and our primary TARC launch site by constructing a new fence surrounding the perimeter.

Outreach Programs

Last year we participated in an event to build and launch rockets with Girl Scouts. We launched roughly 100 rockets for approximately 1000 girl scouts. This received a very positive response, and we are hoping to do similar things in the future.

This year our team has many educational engagement opportunities. We will be going to the Allied Drive Community Center to teach young children about the science and fun of rocketry twice in October. This program will serve approximately 100 people. We also hope to work with the UW Space Place to provide a similar event for the children they serve. The rockets would be built from kits made by major suppliers (such as Estes or Quest) and launched at a local park or municipal space. We will also be participating in our “Raking for Rockets” program, where we rake community lawns in order to simultaneously bring about an increased awareness in rocketry, and raise the funds necessary for our TARC, SLI, and 10K programs. Besides these programs, we also recruited new members for our club at Madison West High School (our current membership is above 50 students mark). The new members will participate in TARC, along with a few returning members from our SLI teams. TARC club meetings have already started for this school year, with interested new members learning about the basics of rocket design, building and operation.

Along with these other engagements, we have moved our workspace from the UW Space place to an unused room in a local law office on University Avenue. This new workspace’s location not only provides us with a much improved work environment, but also creates additional opportunities to interact with local businesses and the community.

Project Plan

Schedule

Timeline For SLI Project	
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	Sustainer (upper stage) test flight
March 2010	
17	Flight Readiness Review presentation slides and CDR report due
15	Two stage 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

Table 14: Schedule for the 2009-10 SLI

Budget

Project Budget		
Vehicle		
Tubing		$ 600.00
Fin Material		$ 100.00
PerfectFlite MAWD Altimeter (x4)*		$ -
PerfectFlite miniTimer3 (x2)*		$ -
Parachutes, recovery gear*		$ -
Waltson/Tracking System		$ 175.00
Miscellaneous supplies (tools, glues)		$ 100.00
Scale Model		
Tubing		$ 150.00
Fin Material		$ 40.00
Motors		
Scale Model Motors		$ 100.00
Preliminary Flight Motors		$ 600.00
Final Flight Motors		$ 150.00
Payload		
1cm diameter Acrylic Tubes * 2m		$ 5.25
Fans		$ 200.00
Sodium Acetate		$ 16.00
Thermistors		$ 257.00
Mini Push-type Solenoids		$ 8.60
Total		**$ 2,501.85**

Table 15 : Budget for 2009-10 SLI Program (* - already in possession)

Travel Budget		
Flight		
$270/Person * 11 People		$ 2,970.00
Rooms		
$119/Room * 5Rooms * 5 Nights		$ 2,975.00
Car Rental		
$269 rental+ $228 gas		$ 497.00
Total		$ 6,442.00
NASA Support ($1,200)		$(1,200.00)
Member cost		$ 5,242.00
Cost per Team Member		**$ 582.44**

Table 16: Budget for the travel to Huntsville, AL

Educational Standards

A) 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

B) National Science Education 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

Rocket Club Sustainability

Students

Madison West High School Rocket Club is now in its seventh year and it continues to strive to provide challenges, engagement, and opportunities to the interested student population.

All new members participate in the Team America Rocketry Challenge (TARC), which provides them with a foundation of basic rocketry knowledge and skills and gives them the opportunity to earn an invitation into the NASA SLI program. After a successful participation in the TARC competition, the students are given the opportunity to earn a NAR High Power Level-1 Certification. The very first student to complete this program, Jacinth Sohi, earned her L1 certification on August 11, 2007. Ben Winokur, the second student to earn his L1 certification from our club, earned his qualification in June of 2008. Several other students expressed their interest in pursuing the same goal and Level 1 certification is now a part of our new 10K program.

Our 10K program is available to any Rocket Club member who has completed at least 1 year of TARC. The program's principal goal is to launch a sounding rocket to 10,000ft. The students pursue a NAR Level 1 HPR Jr. Certification early in the year. Upon successful completion of this goal, the students form a team to design and build a sounding rocket experiment with a 10,000 foot altitude goal. Many members of the 10K program also participate in TARC because they enjoyed the experience very much in previous years.

Madison West Rocketry recruits new members during the fall season. There are several ways in which we do this. One is during organized recruitment events such as the Freshman Carnival and daily announcements. We have also presented to all incoming freshman through Freshman Advisory. A third way is by individual recruitment. If a rocket club member knows someone outside of the club who they think might enjoy the club, they will notify them of our meetings and encourage them to join.

Partnerships

We are extensively involved in collaborations with experts at the University of Wisconsin Madison. At UW facilities, 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 at least seven different departments, providing us with a variety of experienced perspectives on our design and objectives, as well as exposing us to possible scientific careers.

The extensive meetings for planning, preparation, writing, and analysis are held in the well equipped conference rooms at DNASTAR Inc. (our mentor's work place). The conference rooms are extremely useful, providing multiple workspaces and high-speed network capabilities. The facilities at DNASTAR Inc. are crucial to our success in research meetings and brainstorming sessions.

Mentors

We now have five dedicated mentors who work with the students on all levels of our rocketry program. We are continuously seeking new mentors; however the time demands and the necessity of a long-term commitment are often the major prohibitive factors for many working professionals. Also many of our former members come back and become "junior mentors" to share their expertise.

Parents

An increasing number of parents are taking interest in supporting our club's meetings, fundraisers, membership recruitment, outreach projects, and launches. They provide food, transportation, and expertise from their fields. Our parents are truly a great source of encouragement. Parents with scientific backgrounds often help us while proposing experiments or finding contacts at UW.

Outreach and Visibility

In order to maintain constant development of our club, each year we concentrate on mastering or improving our skills in specific areas. As an example, in 2005/2006 we had established our permanent web presence, in 2006/2007 we learned the basics of micro-controller technology, and in 2008/2009 we focused on public outreach and increasing the visibility of our club. We worked with countless news organizations to further this goal. In 2009/2010 we are focusing on recruiting new members.

Complexity of New Team Project

Our project is complex both from a rocket standpoint and a science standpoint. We are proposing a two-stage rocket in order to get two different acceleration profiles for our experiment, allowing for more variations in the rate, heat production, and the crystal formations of sodium acetate.

The challenges of high-power two-stage rocket flight are manifold. We must successfully separate the sustainer from the booster, ignite the sustainer motor, and then recover the booster and sustainer separately. We have three rocketry mentors who all have experience with multistage rocket flights and will be able to guide us through this process. With their advice and our hard work, we will be successful.

Our payload adds to the complexity of the project involving multiple flight and data analysis. The rocket will carry eight liquid filled tubes and will experience acceleration of 20g or more. Flight stresses can cause the leakage from the tube and the liquid could possibly cause short circuits if it reaches the electronics. We will have to carefully compartmentalize the rocket to prevent this.

Complex electronics including accelerometer, barometric altimeter and array of thermocouples will be needed to collect the payload and flight data. Additionally the reaction chambers need to be isothermal and thus a thermostat driven cooling will have to build into our payload.

A mechanical moving arm will have to be constructed for the initiation of crystallization inside the reaction vessels. An alarm system monitoring the inadvertent initiation of the crystallization process prior liftoff will be needed to ensure that the rocket does not take off with the payload already depleted.

Although the challenges are many, our experiences with TARC and SLI have given us the capacity to deal with such complicated projects as this. Our mentors are also a source of advice and their support will be crucial for the project success.

Appendices

Appendix A : Resume for Ben

Ben
2511 Chamberlain Avenue
53705 Madison, WI
bwinokur@westrocketry.com

Education:

- Franklin Elementary School
- Randall Elementary School
- Copenhagen International School
- Blessed Sacrament
- West High School - current senior

Activities and Interests:

- 2009 TARC 1st Place
- 2007 TARC 2nd Place
- SLI (07-08)
- SLI (08-09)
- Boy Scouts
    - Current Eagle Scout
    - Backpacked in Philmont
    - SCUBA dived in Sea Base
    - Participated in Brownsea
    - Traveled to the Boundary Waters
    - Went Backpacking in Rocky Mountains
- Volleyball
- NAR junior level 1 certified
- PADI certified SCUBA diver
- Basketball
- Reading
- Science

Volunteer Experience:

- Interfaith Hospitality Network
- Peer tutoring
- Brat Fest Volunteer
- Sharing With Appalachian People
- Nurse’s Run
- Volunteer Camp
- Girl Scout Launch
- WPT phone bank operator

Appendix B : Resume for Duncan

Duncan
3621 Spring Tr.
Madison, WI 53711
dun.ed.adams@gmail.com

Academic Experience:

- 2 years at Woodland Montessori Preschool
- 1 year at Casco Bay Montessori Preschool
- Kindergarden-2nd Grade at New Century School
- 3-8th Grade at St. James School
- Currently a Sophomore at Madison West High School
  - Honor Roll since Middle School

Languages:

- Fluent in English, Beginner in Latin and Spanish

Honors and Elective Classes:

- Biology Accelerated
- Geometry 1 Honors
- Latin I
- Latin II
- Introduction to Engineering
- Principles of Engineering
- English 10 Honors
- Western Civilization Honors
- Digital Illustration 1

Extracurricular Activities and Interests:

- *Rocketry:*
  - Qualified for TARC finals
  - 1st place - TARC presentation competition
  - Designed rocket used by TARC 1st place team
  - 2 years at Future Astronaut Training program - Hutchinson, KS
- *School:*
  - First place in School Geography Bee – 2005
  - 4th Place Regional NHD Competition
  - Experience with AutoCAD Inventor, Solidworks and Microsoft Office
- *Other:*
  - Built a functional ramjet out of coffee mugs (3 years ago)
  - Restored a classic Fender guitar

Music: Private Guitar Lessons – 3 years

Appendix C: Resume for Enrique

Enrique
605 Memphis Ave
Madison, WI 53713

Academic Experience:
- Hawthorne Elementary School (1st and 4th grade)
- Lowell Elementary School (1st-3rd grade)
- Lincoln Elementary School (5th grade)
- James C. Wright Middle School (6th-8th grade)
- Madison West High School (9th-Present grade)

Languages:
- Spanish and English fluently

Advanced, Honors, and Rocketry Related Classes:
- Algebra I (8th grade)
- Geometry Honors (9th grade)
- Biology I Accelerated (9th grade)
- Algebra 2 Trigonometry Honors (10th grade)
- English 10 Honors (10th grade)
- Western Civilization Honors (10th grade)
- Intro to Engineering (10th grade)
- Pre-calculus (Present)
- Principles of Engineering (Present)
- Accelerated Physics (Present)

Interests and Clubs:
- Baseball (10th grade)
- Wrestling (Present)
- Video Games (All time)
- Mock Trial (8th-9th grade)
- Green Club (10th grade)
- Rocket Club (10th-Present grade)

Volunteer Experience:
- North East Senior Coalition (2008-Present)
- Brat Fest Volunteer (2009-Present)
- Peer Tutoring (10th-Present grade)
- Wisconsin Public Television Phone Bank Operator (2008-Present)
- Team Wright (8th grade)

Academic Interests:
- Math

- Science
- Engineering
- Foreign Languages (Spanish)

Achievements:

- Honor Roll (8th-10th grade)
- 4.0 overall G.P.A. (8th-Present grade)
- Panther Pride (6th,7th, and 8th grade)
- Wright Leadership Award (8th grade)
- Academic Excellence Award (8th grade)

Appendix D : Resume for John

John
4713 Sherwood Rd.
Madison, WI 53711
jcraihala@gmail.com

Education:
- Midvale Elementary School (Kindergarten and 1st grade)
- Lincoln Elementary School (grades 3-5)
- EAGLE School of Madison (grades 6-8)
- Madison West High School (currently enrolled in 11th grade), 4.0 GPA

Languages:
- English
- Spanish, currently in 6th year
- Latin, currently in 2nd year

Academic Interests:
- Mathematics
- Foreign Languages
- Physics

Extra Curricular Activities and Other Interests:
Rocket Club, Cross Country, Track and Field, Latin Club, Geography Olympiad, Math Team, Youth Connection at Covenant Presbyterian Church, Running, Piano, Biking, Canoeing

Honors Classes:
- Biology Accelerated
- English 10 Honors
- Shakespeare Honors
- Advanced Writing Workshop Honors
- Western Civilization Honors
- Precalculus Honors
- Calculus AB AP
- Calculus BC AP
- Spanish Language AP

Musical Experience:
- 8 years of piano, currently learning guitar

Achievements:

- Lincoln Elementary Spelling Bee winner, 2004
- Midwest Academic Talent Search Recognition Award, 2005 and 2006
- National History Day State Winner for Dramatic Performance, 2006
- West High Honor Roll since 2007, cumulative 4.0 GPA
- Spanish Honor Society
- Score of 35 on the ACT

Volunteer Work:

- Community service with Covenant Presbyterian Church youth group
- Peer tutoring
- Community service with Madison West Rocket Club
- Brat Fest volunteer

Appendix E : Resume for Jacob

Jacob
2731 Mason St.
Madison WI, 53705

Academic Experience:

- Franklin Elementary School (1998 – 2001)
- Randall Elementary School (2001 – 2004)
- Velma Hamilton Middle School (2004 - 2007)
- International Grammar School; Sydney, Australia (2006)
- West High School (2007 – present; Class of 2011)

Interests:

- Science
- Math
- Technology
- Engineering
- Computers

Activities and Camps:

- Member of the Madison West Rocketry Club (2007 – present)
  - 2008 ,2009 , and 2010 Team America Rocketry Challenge team member
  - 2008 – 2009 10K/W2 team member
- Latin Club
  - Attended the 2009 state Latin Convention as a delegate from West High School to the Wisconsin Junior Classical League
- Attended the 2008 AP Computer Science A class offered by the Wisconsin Center for Academically Talented Youth
- Participant in the 2008 Summer Workshop in Atmospheric, Earth and Space Sciences at the University Wisconsin – Madison
- Participant in the 2007 UW – Green Bay, Space Experience Camp
- Participant in the 2007 UW – Eau Claire Science Institute, Computer Architecture camp

Achievements:

- Participant and finalist at the 2008 and 2009 Team America Rocketry Challenge
- West High School Honor Roll 2007 – present
- Received a *magna cum laude* (with great honor) in the 2009 National Latin Exam
- Received a *corona laurea* (laurel crown) in the 2009 Medusa Mythology Exam

- Award winner in the 2007 Northwestern University Midwest Academic Talent Search

Volunteer service:

- Wisconsin Public Television phone bank (2007 – present)
- Restoration work at the Badger Prairie (2006 – present)
- Helping to teach at Echo Valley about rockets as part of Rocket Club outreach (2008)
- Helping with the Interfaith Hospitality Network/RoadHome (2008)
- Helping set up and take down the Memorial Mile (2008 – 2009)

Appendix F : Resume for Suhas

Suhas Kodali
5015 Sheboygan Ave, Apt# 207
Madison WI, 53705
skodali@westrocketry.com

Academic Experiences:

- St. Francis School (Khammam, India) 1996-1999
- Kennedy High School (Vijayawada, India) 1999-2001
- Blue Ash Elementary School (Cincinnati, OH) 2001-2003
- Lemon Road Elementary School (McLean, VA) 2003-2004
- Velma Hamilton Middle School (Madison, WI) 2004-2007
- Madison West High School (Madison, WI) 2007-Present
- Current Junior, Cumulative GPA: 4.0

Languages: Fluent in English and Telugu, Studied French for four years.

Activities and Interests:

- Academic:
  - Mathematics – Calculus BC
  - Science – Advanced Physics and Advanced Chemistry
  - History – US Government and Politics
  - Computers – Computer Science
  - English – European Literature

- Rocketry:
  - Placed 19th in 2008 TARC National Finals
  - Competed in SLI 2008-09

- Math:
  - Middle School
    - Placed 9th Individually and 2nd Team in State MathCounts 2007
    - State 1st with Perfect Score on American Math Competition 8-2006
    - 5th MATC Middle School Math Competition- 1st Team 2007
    - North South Foundation– Math Bee National Finals 2nd Place 2006
    - Purple Comet Online Meet-Middle School-Honoree 2007
  - High School
    - Wisconsin Talent Search Honoree for 2007, 2008 and 2009
    - Varsity Participant in Memorial, West and East Math Meet 2007-09
    - National Mandelbrot Competition-Third Tier Standings 2007-2009
    - American Mathematics Competitions-10 Participant 2008
    - American Mathematics Competitions-10A State Winner 2009
    - American Invitational Mathematics Examination Invitee 2009
    - Wisconsin Math League – School First, 7th in State 2007-2008
    - Purple Comet Online Meet-High School-Honoree 2008, 09

- Sports
  - Black Belt in Karate 2005-Present
  - Greater Madison Tennis Association- Winter 2007 1st Place- Junior
  - Greater Madison Tennis Association- Summer 2008 3 Singles-1st
  - West High School-Tennis Junior Varsity 4 Singles-3rd Place 08
  - West High School- Tennis Junior Varsity 1 Singles-5th Place 09
  - Wisconsin State Varsity Chess-1st Place Team 2008, 2009
  - Chess SuperNationals K-12 Open Section, 17th Place Team 2009

- Others
  - Battle of the Books 2006-2nd Place in School
  - Kiwanis Club of Madison West 2007
  - American Legion Award 2007
  - Grade Point Average 4.0 2005-Present

Music: Private Lessons for the Piano from 2006-Present

Volunteer Experiences:
- St. Mary's Hospital Volunteer- 2008-09
- Volunteer at Red Cross- 2008-09
- Volunteer for Girl Scouts Rocketry Launch- Fall 2008
- Volunteer at Senior Citizen Center- 2008-09

Appendix G : Resume for Rose

Rose
3 Walworth Ct.
Madison, WI 53705
Phone: (608) 218-0243

DOB: November 14th, 1991

Education:
- Brimhall Elementary School, 1998-2000
- Shorewood Elementary School, 2000-2003
- Hamilton Middle School, 2003-2006
- West High School, 2006-Present
- University of Wisconsin-Madison (Special Student), 2008-present

Academic Interests:
- Physics
- Calculus
- Computer Science

General Interests:
- Photography
- Analyzing Japanese Comics and Animation
- Music Composition
- Competitive Video-Gaming
- Skiing
- Digital Painting

Languages:
- English
- Chinese (Mandarin)
- Intermediate Spanish

Extra-curricular Activities:
- Ping Pong Club, 2002-2003
- Ice Skating Lessons, 2002-2004
- FPS (Future Problem Solvers) club, 2004-2005
- Math Counts, 2005-2006
- Advanced Private Art Lessons, 2002-2005
- Math Team, 2006-2009
- Science Olympiad, 2007, 2009-present
- Biology Honors Club, 2006-2007
- Rocket Club, 2006-present

Music:

- Violin-
  - Violin lessons, 2003-Present
  - WYSO (Wisconsin Youth Symphony Orchestra) Sinfonetta, 2004-2006
  - WYSO Concert Orchestra, 2006-2007
  - WYSO Philharmonia Orchestra, 2007-2009
  - University of Wisconsin Summer Music Clinic, 2009
- Piano-
  - Piano lessons, 2001-2008
    - Federation Piano Competition Solo, 2003-2006
    - National Piano Guild, 2003-2005
    - Participation in Sonatina Festival, 2003-2005
- Other-
  - Self taught Traditional Chinese Flute, 2007-present
  - Self taught Traditional Chinese instrument- Erhu, 2008-present

Achievements:

- Celebration of Youth 1st place Photography Category, 2002
- Battle of the Books participant, 2004-2006
- Velma Hamilton Middle Honor Roll, 2003-2006
- Future Problem Solving State Qualifier, 2004
- Madison West High School Honor Roll, 2006-present
- Spanish Honor Society member, 2008-
- National Honor Society member, 2009-
- TARC 2nd Place, 2007
- TARC finals participant, 2008
- SLI participant, 2008-present
- APPT High School Photo Contest-honorable mention, 2009

Notable Volunteer Service:

- Volunteer at Alicia Ashman Madison Public Library, 2006-present
- Wisconsin Public Television Phone Bank Operator, 2007
- Aftermath of Wenchuan Earthquake Volunteer work (Summer 2008):
  - Fundraising for the "China Conservation and Research Center for the Giant Panda"- Beijing, China
  - Official Volunteer at earthquake effected city- Jiangyou, Sichuan, China
- Art Fair on the Square, 2009

Appendix H : Resume for Yifan

Yifan
3050 Hartwicke Dr.
Madison WI, 53711
yli@westrocketry.com

Academic Experiences:

- Shorewood Elementary School (Madison, WI) 1999-2005
- Velma Hamilton Middle School (Madison, WI) 2005-2008
- Madison West High School (Madison, WI) 2008-Present
- Current Sophomore, Cumulative GPA: 4.0

Honors and Elective Classes:

- Biology Honors
- Algebra 2 trig Honors
- Spanish 1
- Spanish 2
- Spanish 3
- Introduction to Computer Programming
- Writing for Publication
- Public Speaking
- Accelerated Math Physics
- Western Civilization Honors

Languages:

- Fluent in English
- Fluent in Mandarin Chinese
- Studied Spanish for three years

Activities and Interests:

- Rocketry:
  - 2009 TARC National Finalists
  - Co-Designer of 2009 TARC National 1st place rocket
  - 2009 TARC Presentation Competition 1st place

- Math:
  - AMC-8 Participant 2006-2008
  - 5th MATC Middle School Math Competition- 1st JV Team 2007
  - 6th MATC Middle School Math Competition- 1st Team 2008
  - LaFollette, West, East, and Memorial Math Meet, Junior Varsity, 1st Place Team 2008
  - Junior Varsity Participant in Memorial, West and East Math Meet 2008-2009
  - AMC-10 Participant 2009

- AIME Participant 2009

- Sports:
  - Martial Arts 2008-Present
  - UW Rowing Camp 2008
  - Basketball
  - Biking
  - Skiing

- Travel:
  - 16 US States
  - Spain
  - Mexico
  - France
  - Japan
  - China

- Others:
  - 3 Week Chemistry Course through Wisconsin Center for Academically
  - Talented Youth (WCATY)
  - Science Olympiad 2009
  - Placed first in state at Road Scholar Event 2009
  - Velma Hamilton Middle School Honor Roll 2006-2008
  - Hamilton Pride Award 2006-2008
  - Grade Point Average 4.0 2007-Present

Music:

- Bass in school 2004-2007
- Private Lessons for the Piano from 1999-Present
- Superior solo ratings in Federation Piano Competition 2001-2008
- Associated Board of the Royal Schools of Music (ABRSM) 2002-Present
  - Achieved Level 5

Volunteer Experiences:

- WPT Phone Bank 2008-2009
- Reddan Soccer Park renovation 2009
- West High Peer Tutor 2009

Appendix I : Resume for Zoë

Zoë
4906 Fond du Lac Trail
Madison, WI 53705
zabatson@westrocketry.com

Education:
- Franklin Elementary School (Madison, WI)-Grades K to 2
- Randall Elementary School (Madison, WI)-Grades 3 to 5
- Hamilton Middle School (Madison, WI)-Grades 6 to 8
- West High School (Madison, WI)-Grades 9 to present

Languages: Latin

Extra Curricular Activities, Awards and Experience:
- Biology Honors Club (06-07)
- Westside Girls Lacrosse Team (06-present)
- Trees for Tomorrow (06-07)
- Volunteers at Black Hawk Ski Club (05-present)
- Rocket Club- SLI (07-present)
- Wisconsin Junior Classical League State Convention (WJCL)
- Maxima Cum Laude on the National Latin Exam (2008)
- Silver Medal on the Medusa Mythology Exam (2008)
- Awards from WJCL Conventions (see below)
- 2008 Convention
    - First: Roman History
    - First: Greek History and Literature
    - Second: Mythology
    - Second: Latin Literature
    - Second: Certamen (a team trivia game)
    - Second: T-shirt design
    - Third: Roman Private Life
    - Third: Latin Derivatives
    - Fifth: Greek Derivatives and Vocabulary
    - Seventh: Pentathlon
    - Eight: Reading Comprehension
- 2009 Convention
    - Second: Mythology
    - Second: Certamen
    - Sixth: Roman History
    - Eighth: Greek History, Literature and Life
    - Ninth: Greek Derivatives and Vocabulary
- 2009 National Convention
    - Second: Open Certamen

- 16th: Latin Derivatives
- 22nd: Roman Life
- 24th: Roman History
- 26th: Mythology

Work Experience:

- Volunteers at Black Hawk Ski Club, 05-present
- Bagger at Metcalf's Sentry, 07-08

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

Table 17: 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

Table 18: 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

Table 19: Checkpoint consistent with the Web Content Accessibility Guidelines

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

All MSDS sheets are available on our website

http://www.westrocketry.com/sli2010/msds/msds2010n.html

Propulsion and Deployment Ammonium Perchlorate Aerotech Reloadable Motors Aerotech 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) Superglue Accelerator (kicker) Superglue Debonder
Soldering Flux Solder	**Painting and Finishing** Automotive Primer Automotive Spray Paint Clear Coat
Construction Supplies Carbon Fiber Kevlar Fiberglass Cloth Fiberglass Resin Fiberglass Hardener Self-expanding Foam	**Solvents** Ethyl Alcohol 70% **Experiment Chemicals** Sodium Acetate

Table 20: Items requiring MSDS

Appendix N: Bibliography

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[3] VERGARA, A, E CORVINO, G SORRENTINO, C PICCOLO ET AL. *"Crystallization of the collagen-like polypeptide (PPG)(10) aboard the International Space Station." ACTA CRYSTALLOGRAPHICA SECTION D-BIOLOGICAL CRYSTALLOGRAPHY*. 58th ed. N.p.: n.p., 2002. Web. 27 Sep. 2009 <http://www.ncbi.nlm.nih.gov/>.

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